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

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Abstract

This paper studies the causal impacts of contracting structure on a major infrastructure project in a high-stakes public procurement context using natural and experimental variation and granular, independently-collected construction quality data. Kenya's electric utility administered dozens of donor-funded procurement contracts to connect millions to electricity between 2016-2022. Despite largely harmonized procedures, World Bank-funded contracts unbundled contract components—'design-bid-build'—and enhanced monitoring compared to African Development Bank-funded contracts. This delayed construction progress but improved quality. Randomized inspections improve quality without large delays. A principal-agent framework illustrates how planner preferences affect the net benefits of each approach.

JEL codes: D73, F35, H5, L94, O19

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1 Introduction

Government agencies often rely on private firms to supply goods and services: public procurement spending amounts to 12% of global GDP (Bosio et al. 2022). But procuring public goods from private firms may misalign incentives, complicating a government's ability to provide high-quality infrastructure projects at reasonable cost. Regulations can improve project outcomes but may also introduce bureaucratic inefficiencies or inhibit useful contractor discretion (Liscow et al. 2023; Williamson 1999; Hart et al. 1997; Bosio et al. 2022). In low- and middle-income countries (LMICs), contracts between governments and private firms are often financed by multilateral institutions, who also impose specific contracting conditions. Between 2000 and 2022 the World Bank financed more than 311,000 contracts for the procurement of more than $185 billion in goods and services for over 21,000 projects across more than 170 countries.

Despite the importance of this problem, causal empirical evidence on the impacts of contracting practices is scarce. The large scale of infrastructure projects and the fact that government regulations often apply nationwide mean procurement procedures usually cannot be randomized. Existing sub-national variation in regulations may be endogenous to economic, geographic, or political factors that affect the selection and performance of contractors. Much of the empirical work studying contracting focuses on auctions and bid evaluation rather than on how contract structure affects economic outcomes such as quality, timeliness, and cost.

This paper's main contribution is empirically studying the bundling and monitoring of the design, supply, and installation components of a major real-world infrastructure project in a high-stakes public procurement context using granular construction quality data collected independently. We use policy and experimental variation to generate causally identified evidence on this topic in the context of the Last Mile Connectivity Project (LMCP), one of Kenya's largest recent public infrastructure projects. In 2016 the Government of Kenya (GoK) selected 7,492 villages where all unconnected households within 600 meters of the existing grid would be connected to electricity. The program was implemented by Kenya's government-controlled electric utility, Kenya Power, which administered competitive auctions and awarded dozens of contracts to private firms to conduct construction activities.

LMCP construction was funded by the World Bank (WB) and the African Development Bank (AfDB). This continues to be a relevant study context: in early 2025, the WB and the AfDB pledged to spend an additional $48 billion to connect 300 million Africans to electricity by 2030 (WB 2025). However, funders typically do not carry out procurement themselves. Rather, executing agencies in the borrower country follow the procurement procedures mandated by the funders. In the case of the LMCP, Kenya Power staff (representing the GoK) managed all aspects of contracting. Over the past two decades, these procurement procedures have been largely harmonized to consensus best-practices. We complement qualitative interviews with quantitative text analyses of hundreds of pages of procurement guidelines, bid documents, technical specifications, and Kenya Power procurement contracts, to document that WB and AfDB procedures are overwhelmingly either identically worded, or worded slightly differently but very close in spirit.

That said, through dozens of in-depth interviews over more than six years with officials at Kenya Power, the WB, the AfDB, and the private contractors, as well as extensive review of public and internal documentation, we identify two outstanding differences in the procedures used by Kenya Power for the LMCP. The first difference relates to 'unbundling,' or the assignment of project components across contracts ('design-bid-build' for example, unbundles design and construction across two separate contracts). For villages funded by the AfDB, Kenya Power awarded 10 'bundled' contracts that included network designs, materials, and installation. In contrast, Kenya Power awarded 29 unbundled contracts for villages funded by the WB. The second difference relates to the intensity of monitoring for contract outputs. At villages funded by the WB, Kenya Power was required to conduct an additional round of inspections before the network was handed over from the contractor to the utility for operation.

To identify the causal impacts of different donor financing processes on project outcomes, we leverage a useful program feature: LMCP sites were assigned to be funded by either donor in a way that appears arbitrary and can reasonably be thought of as quasi-random and without obvious regard to factors that would influence project outcomes. Two key features of the setting give us confidence that we can interpret differences between WB- and AfDB-funded sites as due to the contracting differences we highlight. First, sites are very similar on observables. Neighboring villages were often funded by different donors: 95% of WB-funded sites in our sample are within 10 km (6 mi) of an AfDB-funded site. A battery of tests using demographic, geographic, satellite, road, census, electoral, and Kenya Power administrative data reveal balance along most dimensions, and what selection there is appears small in magnitude and does not correlate with the outcomes of interest. Still, the econometric analyses include constituency fixed effects to account for local geographic and socioeconomic heterogeneity.

Second, the AfDB and WB both use unbundled and bundled contracting structures in other contexts, and their decision to use two different approaches for the LMCP appears incidental. Below we document the many similarities in procedures mandated by the two funders. Kenya Power staff themselves implemented all auctions using harmonized bidding documents and procedures, and awarded and administered all contracts. Tender documentation listed largely uniform technical specifications for procurement and installation. This is due not only to the fact that a single agency (Kenya Power) was responsible for implementation, but also due to the fact that donors' institutional procedures have converged as a result of targeted efforts to simplify compliance. This began with a 1999 forum for procurement harmonization organized by 10 leading multilateral development banks, which aimed "*to provide a coherent mechanism for procurement cooperation between multilateral development banks...and key development partners*" (AfDB 2014). In 2003, 28 aid recipient countries and over 40 development institutions—including WB and AfDB—signed the Rome Declaration on Harmonisation which aimed "*to harmonise the operational policies, procedures, and practices of our institutions... to improve the effectiveness of development assistance*" (OECD 2003).

The impacts of unbundling and additional monitoring were unclear ex ante. During in-person interviews we conducted, WB representatives argued that they would improve construction out-

comes, while Kenya Power representatives feared that they would lead to administrative costs and delays without delivering substantive project benefits. AfDB representatives in turn agreed with Kenya Power that the latter's extensive experience meant that the more streamlined procedures (without unbundled contracting or additional monitoring) were sufficient to ensure high quality.

The paper presents a simple framework to highlight key trade-offs of and interactions between these two features—unbundled contracting and strengthened monitoring—which may be relevant for a wide range of infrastructure projects. When a Principal (here, Kenya Power) has imperfect information about realized project quality, contract unbundling can enforce minimum firm quality standards, improving project construction quality at the cost of possible delays and additional administrative burden, through changes in either firm selection or firm behavior. However, the framework highlights that strengthened monitoring can potentially enforce similar standards at lower cost, as this structure enables bundled contractors to leverage their private information about subcontractor quality. The framework illustrates how if the Principal is able to exert rigorous monitoring, then additionally using unbundled contracts can under certain circumstances incur costs and delays with little gain in construction quality.

To evaluate the combination of bundled contracts with strengthened monitoring we implemented a randomized auditing intervention (with the support of partners at Kenya Power, the WB, and the AfDB) designed to mimic Kenya Power's additional inspections at WB-funded sites. Through in-person meetings, contractors were informed that key aspects of the completed construction at certain sites (randomly selected by the research team) would be measured and reported back to Kenya Power, the WB, and the AfDB.

An additional contribution of the paper is the collection of detailed and innovative engineering data across hundreds of villages, measuring construction progress, the quality of low voltage grid network and metering components, and electricity connection quality. This builds on a small but growing literature emphasizing the importance of detailed infrastructure measurement (building on for example Olken 2007; Atkin et al. 2017). Field teams tracked construction progress over multiple years for 380 LMCP villages through in-person visits and phone calls to village leaders, and then collected three types of on-the-ground data. First, we measured construction quality for key infrastructure components such as electrical transformers, poles, and wires, following Kenya Power engineering standards. Second, we deployed state-of-the-art sensors to measure minute-by-minute site-level power outages and voltage quality. Third, we conducted socioeconomic surveys to understand connection experiences and energy usage among a representative household sample.

The results indicate that contracting procedures are highly consequential for project outcomes in terms of both costs and benefits. First, in terms of costs, construction at WB-funded sites is far slower and leads to fewer pole installations and household connections. By the end of tracking in May 2022, 70% of AfDB-funded sites had seen construction whereas only 62% of WB-funded sites had. Among sites where there had been construction, there are 12% fewer poles and 18% fewer customer connections per site at surveyed WB-funded sites. Unbundling and additional monitoring also caused significant delays: household meter activation at WB-funded sites is completed on

average 16 months later than at AfDB-funded sites. These results do not appear driven by selection of construction firms into funder, which are largely similar on observables, suggesting the effects are driven more by contracting structure and monitoring.

Second, in terms of benefits, WB procedures improve on-the-ground construction quality by 0.6 standard deviations on average, and 77% of WB-funded sites have higher measured quality construction than the median AfDB-funded site. Specifically, poles at WB-funded sites are 23% more likely to have all key attributes of a high quality pole (namely, a pole cap, no cracks, and a correctly installed strut and stay, when required). There are no measured medium-run differences in electricity reliability and voltage quality, though, and the impacts of WB procedures on household installation quality, cost, and energy usage are positive but modest in size and generally not statistically significant. Rather, the improvements in construction quality appear more likely to improve pole longevity and reduce long-term maintenance costs rather than improve service quality in the short-run.

Could quality improvements be achieved without adding delays by enhancing monitoring without unbundling contracts? To answer this, we turn to the randomized audit experiment. We show that the audits have no impact at WB-funded sites, in line with the fact that those sites already faced additional inspections as well as unbundled contracting. On the other hand, the audits significantly improve installation quality at AfDB-funded sites. Households at these sites experience higher power quality as a result: the audit treatment halves the average gap between experienced and nominal voltage. Contractors installed 18% more poles (and 4% more customer connections, though this latter effect is not significant), and treatment households further report higher household connectivity and energy usage. Importantly, the audits at AfDB-funded sites–which were low cost and led to minimal delays—increase the number of connections. In line with the framework, these results indicate that additional monitoring for projects carried out using bundled contracts can generate similar quality improvements as the combination of contract unbundling and additional monitoring, but with fewer delays and at lower cost.

Finally, we assess the trade-off in costs and benefits for contract unbundling and monitoring. The average cost per new household connection is $563 at AfDB-funded sites and $728 at WB-funded sites (so 30% higher), driven by lower per-site costs and more new connections at AfDB-funded sites. The net impact of the various contract features depends on observable project attributes (such as the delay caused by unbundling) as well as unobservable ones, such as the funder's discount rate and time horizon, and the impact of improved construction quality on long-term maintenance and replacement costs. Under a plausible range of assumptions, the net benefits could range from 7% of project costs in favor of bundling and less-intensive monitoring to a net benefit worth 4% of project costs in favor of unbundling and more intensive monitoring.

These empirical results point to a meaningful intertemporal trade-off. Policymakers may need to evaluate the long-term benefits of unbundled contracting and monitoring against the apparent short-term costs. Those with a higher time discount rate (or a shorter time horizon), or those implementing projects with compounding benefits, might prefer the timelier construction enabled

by a streamlined bundled contracting approach. Conversely, in situations where maintenance costs are expected to rise quickly with poor quality, a delayed start might be worth the improved long-term outcomes. This perspective can also explain why some political agents, facing electoral or other domestic pressures, may prefer to work with donors whose procurement approach enables greater expediency.[1] In our study context, combining contract bundling with enhanced audits delivers improved quality with little additional cost and delay, and might therefore be preferred to either of the AfDB and WB approaches to LMCP funding we examine.

Any relatively short- to medium-run analysis, like ours, has limitations. Procurement procedures may generate additional benefits that we cannot measure, such as enhanced institutional capacity. Like most other research projects, we are also unable to directly measure leakage of funds. However, to the extent that increased leakage at AfDB-funded sites (where there was less stringent monitoring) would have reduced construction quantity, we find limited evidence of this: if anything, AfDB-funded sites have more connections at lower average cost than equivalent WB-funded sites.

In addition to informing the literature on procurement regulations, these findings also contribute to a broader debate about donor conditionality that dates back at least to the 'Washington Consensus' era in the 1980s (e.g. Mosley 1987; Hermes and Lensink 2001; Easterly 2002; Williamson 2009; Temple 2010; Archibong et al. 2021). World Bank (2005) provides a thorough review of the evolution of donor conditions, which increasingly emphasize procedures (rather than policies), though the resulting costs and benefits have been subject to controversy. Recent research suggests procedural conditionality may cause politically motivated delays and incur costs that exceed benefits (Kersting and Kilby 2016; Kilby 2013). And concerns around political interference and corruption remain relevant (even if we cannot directly evaluate them in our setting): Andersen et al. (2022) find that up to 10% of WB financing is transferred to offshore financial havens in the months after a transfer. Related work that empirically evaluates on-the-ground construction of development projects in Africa includes Williams (2017), Marx (2018), Rasul and Rogger (2018), and Moscona (2020).

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

[1]For example, the Chinese government's approach to providing foreign aid includes "not interfering" in local politics (State Council 2014), and streamlining procurement procedures. The resulting limited oversight has generated concerns about construction quality and rampant corruption (The Economist 2017; Mihalyi et al. 2022; Dreher et al. 2021; Isaksson and Kotsadam 2018; Ping et al. 2022; Malik et al. 2021; The Africa Report 2022).

2 The Kenyan government's rural electrification program

Rural electrification in Kenya was spurred by domestic government objectives. In 2006 the Kenyan government passed the Energy Act (2006), which—in addition to separating out a transmission company from Kenya's distribution company Kenya Power—created the independent Rural Electrification Authority (REA) with a mandate to "develop and update the rural electrification master plan" and to "source additional funds for the rural electrification programme." REA's 2008–2012 Strategic Plan (2008) to connect thousands of rural villages to electricity was accompanied by the "Energy (Rural Electrification Programme Fund) Order" (2008) enabling REA to collect money through a REA Levy to be added to the national electricity tariff, as well as "donations, grants and loans." Kenya's Draft National Energy Policy (2014) subsequently targeted universal household electricity access by seeking "funding from development partners."

By May 2015 the ministry of energy had secured funding from two multilaterals, and Kenya's President announced the launch of Kenya's Last Mile Connectivity Project. The LMCP aimed to connect 70% of households to electricity by 2017 and achieve universal access by 2020, starting from 25% in 2009 (KNBS 2009). While these ambitious goals were not met, nationwide household grid electricity access increased rapidly and reached 50% a few years later in 2019 (KNBS 2019).

The LMCP was a single nationwide project, implemented entirely by Kenya Power under a uniform set of specifications. Kenya Power outsourced construction to private sector contractors. Contracts were awarded and wholly managed by Kenya Power: they issued, reviewed, and awarded contracts; managed contractors and consultants; and conducted inspections independently.

2.1 LMCP program features

There are around 60,000 electrical transformers across Kenya, which convert high- and medium voltage power lines to low voltage (LV) lines that connect households. Many transformers are located in rural villages where very few households were connected at the start of LMCP (Lee et al. 2016). Kenya Power consulted with the Ministry of Energy and members of parliament to select 7,492 such transformers for the LMCP, targeting an equitable regional distribution across Kenya.

The objective was to connect all unconnected households located within 600 meters of an LMCP transformer by extending the local LV network; most LMCP sites had between 20 and 100 unconnected households. Connecting all unconnected households in a village at the same time—referred to as 'maximization'—was supposed to generate cost efficiencies by leveraging economies of scale. While informal or illegal electricity connections are common in urban Kenya (for instance, by tapping existing wires), they are rare in the lower population density rural areas where the LMCP was implemented. Appendix D provides additional background information.

Eligible households benefited from a reduced electricity connection price of $150 (down from $350), as well as the ability to pay in monthly installments with no upfront down-payment. Households also had to organize wiring for power sockets and light switches, which could be prohibitively expensive: the household surveys we administered indicate that households connected prior to the

LMCP spent on average $125 on internal wiring. Kenya Power therefore decided to provide low-income households with a 'ready board', a standard electrical panel that would satisfy basic wiring requirements. Yet the roll-out of ready boards was not perfect. Of the 160 households in our survey sample (described below) 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.

3 Contracting for WB and AfDB-funded sites: Similarities and differences

The government of Kenya outsourced the construction of the LMCP to private sector contractors. Kenya Power personnel administered competitive auctions for construction contracts with domestic and international private-sector firms. They developed uniform tender documentation containing detailed technical specifications for the procurement and installation of poles, wire, conductors, fuses, and meters. Kenya Power released their requests for proposals through standard channels, including to many contractors they had previously worked with.

International financial institutions (IFIs) routinely finance projects that they do not implement themselves. Instead, financing flows to a recipient government, who is then in charge of implementation. Importantly for this paper's empirical approach, in the case of the LMCP, the Government of Kenya obtained financing from multiple donors. The AfDB provided $133 million in financing to maximize 4,184 LMCP transformers and the WB provided $154 million in financing for 3,308 transformers (Kenya Power 2017b, 2016b).[2]

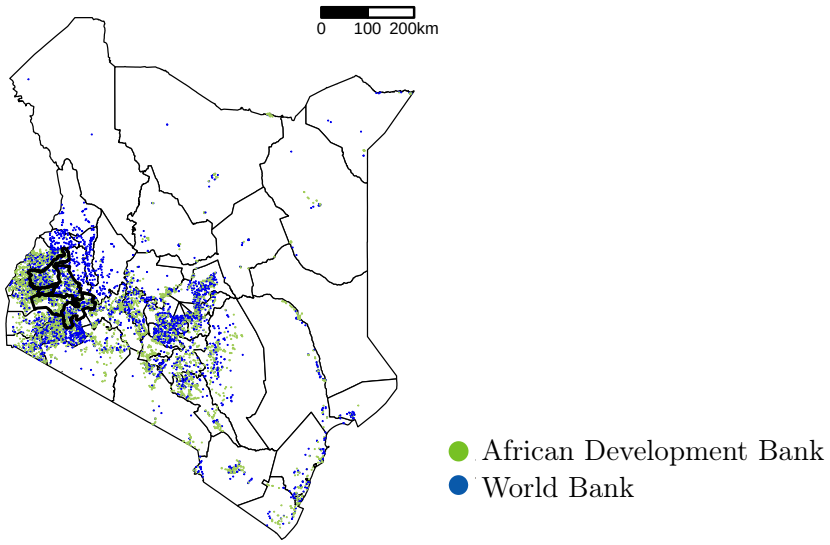
Crucially, LMCP transformers were assigned to be funded by the WB or the AfDB in a seemingly arbitrary and ad hoc manner, with neighboring villages often being funded by different donors. Section 5 discusses the assignment process in detail. Figure 1 shows that AfDB- and WB-funded sites were similarly distributed across the country.

AfDB- and WB-funded LMCP contracts were almost identical along many dimensions, including procurement guidelines, technical specifications, the use of international competitive bidding, the use of single envelope bids, and the use of standardized bidding documents. This was the deliberate result of a coordinated, decades-long harmonization process designed to make it easier for contractors to routinely bid on contracts financed by different donors. Subsection 3.1 describes this harmonization process, and Subsection 3.2 quantifies contract similarity using a large language model.

Our review of procurement procedures and qualitative interviews with stakeholders involved in LMCP contracting identified two key differences between contracts funded by the two donors in the

[2]The WB funded new transformers at 1,000 additional sites. Those projects are excluded from this paper. The number of sites that was publicized differs slightly from the number of observations in the data we received from Kenya Power. For consistency with the analysis, we use the numbers in the datasets throughout the paper. The LMCP later also received support from the European Investment Bank, the Agence Française de Développement, and the European Union (Kenya Power 2016b). This paper focuses on activities funded by the WB and by Phase I of the AfDB, which we refer to jointly as Phase I of the LMCP.

Figure 1: LMCP sites by funding source



Notes: Sites selected for the Last Mile Connectivity Project nationwide. The five counties where we conduct engineering and socioeconomic surveys are marked in bold (detail in Figure 4).

case of the LMCP: the degree of contract bundling, and the extent of monitoring. Subsection 3.3 and Subsection 3.4 discuss these in turn.

One channel through which donor differences could affect outcomes is by affecting the selection of firms into bidding or the selection of winning bids. Subsection 7.5 discusses this in more detail. Finally, Subsection 3.6 explores some threats to identification.

While it is possible that additional differences between AfDB and WB-funded installations exist, those differences did not come up in interviews with stakeholders or our review of technical documents as important and therefore seem unlikely to have major explanatory power.

3.1 Contracting procedure harmonization

To curtail corruption and political abuse, IFIs often mandate extensive procurement regulations when financing investment.[3] Crucially, the regulations imposed by the WB and the AfDB are nearly identical. This was the result of years of efforts by multilateral development banks to reduce the bureaucratic burden of compliance for recipient organizations, which in turn resulted from calls for improvements in aid effectiveness in the late 1990s. These efforts started in 1997, when procurement specialists from the WB and the Inter-American Development Bank started developing a standardized set of documents, and were formalized with the formation of a 'forum for procurement harmonization' in 1999 by a group of procurement directors of multilateral banks that included the WB, the AfDB, and eight others (AfDB 2014; WB 2013). These activities culminated in the 2003

[3]There was widespread (and apparently well-placed) concern that political interference and corruption within Kenya Power could jeopardize LMCP project outcomes (The Star 2018; Kenya Power 2018b, 2020; ESI Africa 2020; Lee et al. 2020). Kenya Power's CEO Ken Tarus and his predecessor Ben Chumo were arrested in July 2018 and—alongside several other senior Kenya Power officials—faced charges relating to corrupt procurement practices and bidding collusion (Reuters 2018; The Nation 2022; Business Daily 2018; The Nation 2021).

Rome Declaration on Harmonisation, endorsed by "Ministers, Heads of Aid Agencies and other Senior Officials representing 28 aid recipient countries and more than 40 multilateral and bilateral development institutions" (OECD 2003).

As a result, WB and AfDB regulations now include harmonized master procurement documents and standard bidding documents (WB 2014, AfDB 2014). A report by the WB's Independent Evaluation Group evaluating harmonization, for example, states:

> "Model documents have been developed for bidding of goods, works (small and large contracts), and plants (design, build, install), for requesting consulting services proposals, and for prequalification of bidders.
>
> "Country surveys found... a high level of harmonization among policies of the [WB] and those of the regional development banks and other major donors, including the [AfDB].
>
> "Not only are the policies harmonized (as set out in the Guidelines), but those procedures reflected in standardized bidding documents are also largely harmonized."

3.2 Quantifying similarities in AfDB and WB contracting procedures

Table 1 presents three examples of regulations pertaining to procurement planning, domestic preference, and evidence of financial viability from the AfDB and WB procurement documentation. The procedures described above greatly harmonized the contracting procedures in use by the AfDB and the WB. For example, 67% of sentences in the two sets of procurement documentation are lexically almost identical. When allowing for differences in exact word choice, the documents have an overall semantic cosine similarity of 0.94. We discuss these methodologies in more detail below.

Our research also included dozens of qualitative interviews with staff at Kenya Power, the WB, and the AfDB, as well as independent construction contractors (Appendix E provides a list of individuals consulted). The goal of these conversations was to identify the similarities and differences between contracting procedures across the two donors. The information provided across all these conversations was that the unbundling of contracts and presence of different monitoring activities were far and away the biggest difference between the donors, and that all other aspects of contracting were very similar as a result of the streamlining process described above. Indeed, the key concern consistently raised by staff at Kenya Power was that—due to the person-hours that go into preparing a bid solicitation document, reviewing bids, and awarding contracts—the large number of WB-funded contracts would require significantly more work. In addition to these qualitative interviews, we carefully reviewed of more than 200 documents—both public as well as confidential—covering procurement guidelines, bidding documents, contracts, and technical specifications.

To more rigorously evaluate similarities across the documentation, we use two standard text comparison measures: Jaccard similarity and Embedding similarity. Jaccard similarity is a purely lexical comparison of words that makes no attempt to interpret meaning and we therefore interpret it as a more conservative measure of similarity. It is calculated by dividing the number of unique words shared by both texts by the total number of unique words appearing in either text. To allow

Table 1: Representative examples of procurement language

(1) World Bank	(2) African Development Bank	(3)
Development and maintenance of a procurement plan		
[1.18[a]] [...] As part of the project preparation, the Borrower shall prepare a preliminary procurement plan, however tentative, for the entire scope of the project. At a minimum, the Borrower shall prepare a detailed and comprehensive procurement plan including all contracts for which procurement action is to take place in the first 18 (eighteen) months of project implementation. An agreement with the Bank shall be reached at the latest during loan negotiations. The Borrower shall update procurement plans throughout the duration of the project at least annually by including contracts previously awarded and to be procured in the next 12 (twelve) months. All procurement plans and their updates or modifications shall be subject to the Bank's prior review and no objection before implementation. [...]	[1.16[b]] As part of the preparation of the project the Borrower shall prepare and, before negotiating the Financing Agreement, furnish to the Bank for its approval, a Procurement Plan acceptable to the Bank setting forth: (a) the particular contracts for the goods, works, and/or services required to carry out the project during the initial period of at least 18 months; (b) the proposed methods for procurement of such contracts that are permitted under the Financing Agreement, and (c) the related Bank review procedures. The Borrower shall update the Procurement Plan annually or as needed throughout the duration of the project. The Borrower shall implement the Procurement Plan in the manner in which it has been granted the approval by the Bank.	0.85
Preference for domestic suppliers		
[2.55[a]] At the request of the Borrower, and as stipulated in the agreed Procurement Plan and set forth in the bidding documents, a margin of preference may be provided in the evaluation of bids for: (a) goods manufactured in the country of the Borrower when comparing bids offering such goods with those offering goods manufactured abroad; and (b) works in member countries below a specified threshold of GNP per capita, when comparing bids from eligible domestic contractors with those from foreign firms.	[2.55[b]] At the request of the Borrower, and under conditions to be agreed under the Financing Agreement and set forth in the bidding documents, a margin of preference may be provided in the evaluation of bids for: (a) goods manufactured either in the country of the Borrower (domestic), or in a country which has joined the borrowing country in a regional economic institutional arrangement (regional), when comparing bids offering such goods with those offering goods manufactured abroad; and (b) contractors either from the country of the Borrower (domestic), or from Member Countries which have joined the borrowing country in a regional economic institutional arrangement (regional), when comparing bids from eligible domestic/regional contractors with those from foreign firms.	0.89
Evidence of financial sustainability		
[3.1.a.i[c]] Historical financial performance; by Submission of audited balance sheets or if not required by the law of the bidder's country, other financial statements acceptable to the Employer, for the last five (5) years to demonstrate the current soundness of the bidders financial position and its prospective long term profitability.	[2.3.1[d]] Historical financial performance; Submission of audited balance sheets or if not required by the law of the bidder's country, other financial statements acceptable to the Employer, for the last five [5] years to demonstrate the current soundness of the bidders financial position and its prospective long term profitability.	0.99

Three examples of language from the contracting bid documentation, procurement guidelines, and technical specifications, with their corresponding Embedding Score in Column (3). Sources: [a]WB (2014), [b]AfDB (2012), [c]Kenya Power (2016), [d]Kenya Power (2015). Table A8 provides additional examples of key contracting components. Table A25 provides additional examples of text comparison scores.

for differences in exact word choice, we use OpenAI's embedding model `text-embedding-3-large` to calculate Embedding scores. This captures similarities in semantic content outside of variations in wording or syntax. As examples, the sentences "Any additional information clarification correction of errors or modifications of bidding documents shall be sent to each recipient of the original bidding documents in sufficient time before the deadline for receipt of bids to enable bidders to take appropriate actions" (from AfDB 2012) and "All modifications of bidding documents information clarifications and corrections of errors shall be sent to each recipient of the original bidding documents and all bidders on record in sufficient time before the deadline for receipt of bids to enable bidders to take appropriate actions" (from WB 2014) have a Jaccard similarity of 0.71 and an Embedding similarity of 0.93. Appendix F provides more detail on these two methodologies.

As Table 2 shows, more than two-thirds of sentences in the AfDB procurement regulations have

Table 2: Text Similarity Between World Bank and AfDB procurement regulations

Section	Number of sentences in AfDB (2012)	Number of sentences in WB (2014)	(1) Jaccard overlap	(2) Embedding similarity
I. Introduction	55	69	62%	0.90
II. International competitive bidding:				
- General	35	39	63%	0.87
- Bidding documents	108	110	71%	0.99
- Bid opening, evaluation, award of contract	66	67	76%	0.98
- Modified international competitive bidding	16	15	88%	0.98
III. Other methods of procurement	71	92	54%	0.91
Aggregate	351	392	67%	0.94

This table shows results from a text analysis comparing sections of WB (2014) and AfDB (2012) procurement regulations. Column 1 reports the percentage of sentences in the AfDB procurement regulations that have at least one sentence in the WB regulations with Jaccard similarity greater than 0.8. Column 2 reports Embedding similarity scores, which allow differences in word choice and syntax. Appendix F provides more detail on these methodologies.

a corresponding sentence in the WB document with which it has a Jaccard score greater than 0.8, meaning they are word-for-word almost identical. The six individual sections have an overall Embedding similarity of 0.94. Similarities are particularly high—over 0.98—in sections describing procurement auctions and bidding documentation, which were used to select LMCP contractors and which were the target of much of the harmonization efforts in recent decades.

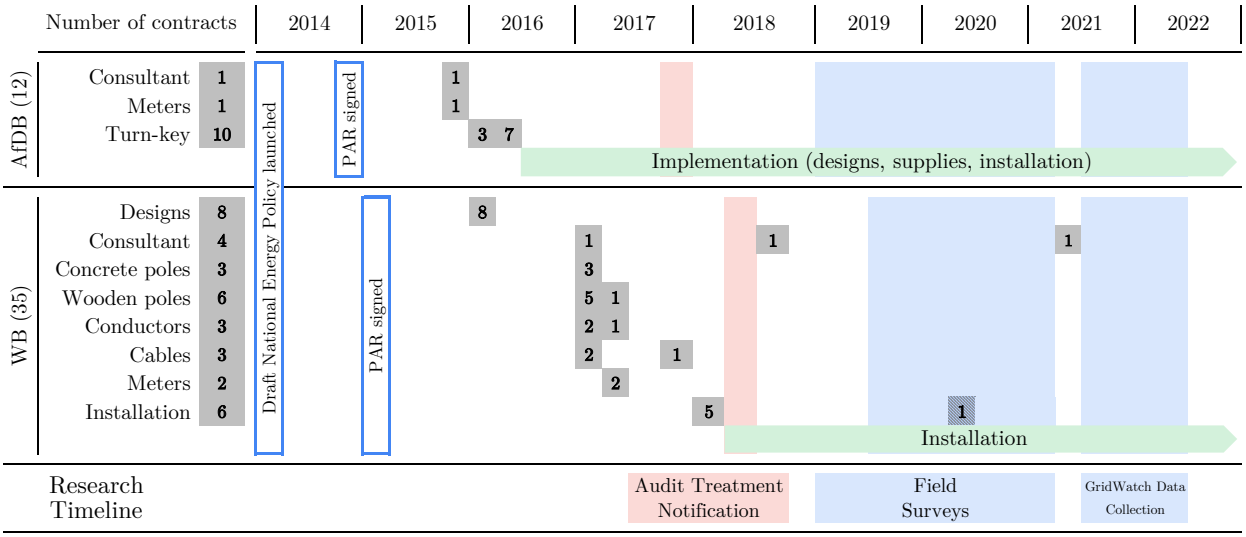
3.3 Key difference I: Contract bundling

Kenya Power awarded 47 LMCP contracts: 39 for implementation, five for consultants to manage contractor relationships, and three for uniform electricity meters.

For sites funded by the AfDB, Kenya Power used a bundled contracting approach often referred to in this context as 'turn-key' (sometimes referred to as 'design-and-build'), which "provides for full design, supply, erection and commissioning of the works by a single contractor at a fixed lump sum price" (AfDB 2018). Kenya Power auctioned and awarded ten turn-key contracts, each of which comprised the entire construction process of all LMCP sites in one of ten geographical clusters of counties. This process included designing an extension of the LV network to reach unconnected households, procuring the necessary materials, and installing these materials. Along with a metering contract and a consulting contract, Kenya Power awarded 12 contracts funded by the AfDB.

For sites funded by the WB, Kenya Power used an unbundled contracting approach. Kenya Power first auctioned and awarded eight contracts for designs detailing the proposed LV network extensions across eight geographically clustered sets of sites. They then issued 15 contracts to procure materials: six for wooden poles, three for concrete poles, three for conductors, and three for cables. Finally, they issued six contracts for installation at all LMCP sites located in one of six geographic clusters of counties. Kenya Power also awarded two metering contracts and four consulting contracts, for a total of 35 contracts funded by the WB.

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



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

These procurement structures are not fixed by donor across all the projects or sectors they finance globally: the WB often finances bundled contracts, and vice versa. The AfDB and WB decisions to use bundled and unbundled contracting, respectively, for the LMCP were made independently ex ante, informed by discussions with Kenya Power and the donors' experiences in Kenya. WB (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]". AfDB (2018) similarly states that, "In complex cases, a 'turnkey' or 'design-and-build' approach may be more appropriate." Neither funder specifies a strict rule on how this decision is to be taken, but in this case—fortunately for the analysis in this study—they reached different conclusions about the appropriateness of particular contracting approaches.

Figure 2 presents a timeline of contracting activities. The AfDB WB Project Appraisal Reports (PARs), which indicate the availability of financing, were signed within five months of each other—in October 2014 and March 2015, respectively—and the projected end dates were within six months of each other—in December 2019 and June 2020, respectively (AfDB 2014; WB 2015). As per the proposed timelines, by mid-2016 Kenya Power had signed all 12 AfDB-funded contracts and the six WB-funded design contracts (Kenya Power 2015b). However, the unbundled materials and installation contracts funded by the WB could only be processed once the designs had been completed, and as a result were only signed starting February and November 2017, respectively.

3.4 Key difference II: Monitoring and oversight

The WB and the AfDB use standardized definitions for what behaviors constitute fraud and corruption and thus warrant sanctions. Debarment agreements across donors have formalized the practice of agencies recognizing debarments by other agencies. Under-performance can therefore lead to disqualification from contracts by other donors, in other sectors, and even in other countries. Independent audits can therefore be a meaningful threat for contractors, which we exploit in the randomized audits treatment discussed in Subsection 5.2.

The research team conducted extensive qualitative research to determine the monitoring and oversights mechanisms in place for the LMCP, both by speaking directly with representatives from Kenya Power, the WB, the AfDB, and the contractors, as well as by reviewing public and internal documentation. In the context of the LMCP, oversight can be split into four channels (listed out below). While Kenya Power conducted similar monitoring across all sites for the first three channels, it conducted an additional round of inspections at sites funded by the WB as part of the fourth.

In terms of largely comparable channels, first, each donor required similar materials inspections. A team representing Kenya Power's supply chain, operations, and LMCP departments visited contractors' facilities to inspect materials.[4] The only difference here was that the WB required that each pole be physically marked such that they could be easily verified upon arrival at Kenya Power storage facilities. However, this does not appear to have had much impact: according to Kenya Power staff, spot checks approved more than 99% of poles procured through both WB and AfDB contracts.

Second, Kenya Power directly monitored contractor activities. Contractors submitted monthly progress reports to Kenya Power, and Kenya Power would combine and summarize these to share with funders. At least twice per year, each funder conducted a similar week-long 'supervision mission' consisting of meetings with senior Kenya Power and Ministry of Energy officials in Nairobi and site visits in nearby regions, resulting in a 'supervision mission report'.

Third, the AfDB and WB both required 'no objection' approvals at key stages to make sure Kenya Power processes matched the procedures set forth in the funders' guidelines. Interviews with Kenya Power staff suggest that the WB's checks were slightly more intensive, but that WB and AfDB checks largely achieved the same compliance goals.

Fourth, once construction at a site was complete, the consultant, the contractor, and a Kenya Power representative would conduct a joint, on-the-ground inspection of the site and sign a "Joint Measurement Certificate" (JMC) to certify that construction was complete and that the site could be handed over to Kenya Power for activation. However, WB and AfDB inspection procedures contained one notable difference. Prior to the inspection that would produce the JMC, WB procedures required the consultant to conduct an additional on-site inspection with the contractor (but without a Kenya Power representative) to produce an "Inspection Report" (IR), listing any observed construction issues or deviations. Comments from the IRs include, for example, "pole caps are poorly installed" and "the strut pole bolt is not secured with nut and washers," often accompanied by a

[4] These were conducted over Zoom during the COVID-19 pandemic period.

photograph. IRs were usually conducted ahead of the JMC, allowing contractors to fix remaining issues before the JMC visit.

3.5 Selection of contractors and subcontractors

One might also be concerned that selection of different firms into donors can affect outcomes. Specifically, differences in donor practices could cause firms with certain characteristics to be more likely to bid on certain types of contracts. Speculatively, projects with more stringent requirements could attract firms with more efficient operations or better compliance teams. However, in this context we view this as a mechanism through which procurement regulations could affect project outcomes. Part of the goal of more stringent regulations is to incentivize only firms who are able to meet those regulations to submit bids. The conceptual framework (Section 4) illustrates this further.

Kenya Power awarded the 47 contracts to 41 unique contractors (as six contractors won two contracts). Other than a single metering contractor for the purposes of easing integration with Kenya Power's technological systems, there was no overlap between bundled and unbundled contractors.

As is common under bundled contracting, turn-key contractors often procured designs, materials, and installation from subcontractors. There was partial overlap between the contractors awarded WB-funded supplies contracts and the subcontractors from which AfDB-funded turn-key contractors procured goods or services (Subsection 7.5 describes this in further detail). While this overlap could have affected the timing or quality of procured supplies, this does not appear to have been a meaningful issue in practice.[5] Reflecting the similarities in procurement procedures, the contractors winning WB-funded contracts and the subcontractors being approved for AfDB-funded contracts are similar in terms of country of origin, with around two-thirds being Kenyan, 10% Indian, and 10% Chinese, and the remainder from other countries (Figure A11).

3.6 Threats to econometric identification

While Figure 2 shows that the WB and the AfDB completed the initial Project Appraisal Report (PAR) at approximately the same time, one may be concerned that the later roll-out of WB sites improved outcomes at WB sites. For instance, if there had been significant learning, construction at WB sites should also have been significantly quicker—yet, we see the opposite in the data below.

There may also have been selection in which sites were allocated to each donor. We test for this extensively in Subsection 5.1, at the site (transformer level) as well as at the ward level, using OLS and machine learning methodologies. We find no clear evidence that baseline characteristics influence the allocation of sites to either funder.

[5]For instance, if AfDB-funded contracts monopolized high-quality poles, this could in theory affect procurement for poles at WB-funded sites. However, securing supplies does not appear to have been a source of delay: if anything, in our conversations with contractors storage appears to have been more of a concern. Many of the plausible concerns here would go against our results.

4 Framework for contract (un)bundling and monitoring

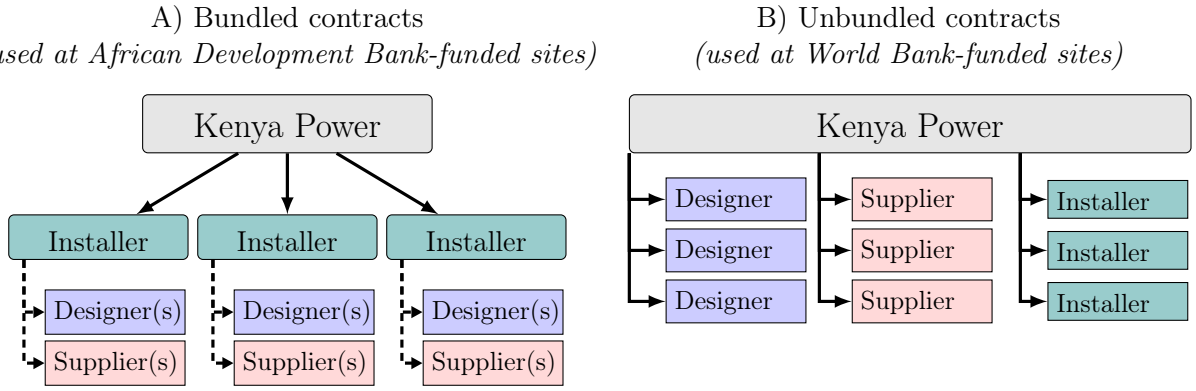
To elucidate how the degree of contract bundling and the extent of monitoring can affect outcomes, we present a simple framework through which to analyze these contracting structures. A large economics literature has studied the public procurement of goods and services from the perspectives of contract theory (Hart et al. 1997; Bosio et al. 2022; Tadelis 2012; Levin and Tadelis 2010; Williamson 1999) and auction mechanism design (Kaplan and Zamir 2015; Bergemann and Välimäki 2019; Hortaçsu and McAdams 2018). However, few have studied how the multiple components that many projects consist of—such as design and construction—should be organized into contracts. For example, these could be bundled into one contract (known as 'design-and-build' in some contexts) or a principal could unbundle these and have one contractor create the design and a different contractor build the resulting design (known as 'design-bid-build'). A somewhat related literature studies bundling in contexts where the bundling decision is made by the seller in response to heterogeneous buyer preferences (Daskalakis et al. 2017; Manelli and Vincent 2006; Rochet and Stole 2003). However, research on bundling by the buyer, as in our setting, is scarce (Hoppe et al. (2013)'s experiment among 400 university students is one notable exception). Empirical evidence from realized projects is also relatively scant, despite the ubiquity and importance of this decision in public procurement. Makovšek and Bridge (2021) state, "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." We view our main contribution to this literature as empirically studying the bundling of the design, supply, and installation components of a major real-world infrastructure project in a high-stakes public procurement context using natural and experimental variation and granular, independently-collected construction quality data.

Here we first lay out a framework that highlights the key conceptual issues and potential tradeoffs inherent in the LMCP setting, where contracts can be either bundled or unbundled, and where a principal can choose to exert either low or high levels of monitoring. The insights from the framework then motivate the econometric analysis.

Consider a principal who has a project that it wants to contract out to one or more firms. The project consists of three components: design, obtaining supplies, and installation. Figure 3 shows this framework in our context. 'Bundling' is the case where the principal only awards installation contracts, and installers are responsible for procuring designs and supplies through subcontracts (Panel A). 'Unbundling' is the case where each contract contains only one component (Panel B).

Unbundling could affect outcomes in numerous ways. For example, under unbundling, designs must be fully specified to enable procurement of appropriate supplies. Such full specification may be inefficient, as contractors may benefit from having some discretion: under bundling, installers can adjust designs and supplies if unforeseen issues arise. Bundling also avoids the double mark-up problem, though at the same time it may reduce competition if entry requirements are set higher for larger contracts (such as those under the bundling approach). In some contexts, the contractor operates the infrastructure for a fixed period prior to transferring ownership back to the principal, which brings additional considerations (not relevant here since all sites were handed over to Kenya

Figure 3: Bundled and unbundled contracting structures



Notes: Schematic of the two types of contracting methods used for the Last Mile Connectivity Project. In the bundled method (Panel A), the principal contracts with installers who procure designs and supplies. 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 installer. In the study setting, the principal (Kenya Power) used a bundled structure at African Development Bank sites (awarding 10 bundled contracts plus 2 for consulting and meters) and an unbundled structure at World Bank sites (awarding 29 unbundled contracts for designs, supplies, and installation, plus 6 for consulting and meters).

Power for operation upon completion). In other cases a principal can choose to conduct activities in-house rather than contracting them out. For tractability we limit the framework to the features at play in our empirical context and leave research on these remaining mechanisms for future work.

4.1 Conceptual framework

To fix ideas, assume the principal wants the three components (designs, supplies, and installation) to be carried out by three firms selected from a continuum of firms $\gamma_i \in [0, \infty)$ defined by firm type, where higher types produce higher quality at higher cost. Firms are selected through an auction, and only firms exceeding an exogenously set firm type threshold $\bar{\gamma}$ are eligible to bid (in our setting, bidders must meet uniform global WB and AfDB documentation requirements).[6] Each firm also chooses how much effort $e_i \in [0, \infty)$ to exert. The quality of each component is determined by the firm type and the effort that firm exerts: $q_i = \gamma_i + e_i$.

Increasing firm type γ_i and effort e_i incurs convex costs $c(\gamma_i)$ and $d(e_i)$. For a given level of quality q, denote $\gamma^*(q)$ and $e^*(q)$ to be the cost-minimizing combination of effort and firm type, with $\gamma^* > \bar{\gamma}$. We assume perfect competition, with firms bidding to cover their costs, $b_i = c(\gamma_i) + d(e_i)$ (a reasonable approximation in our context, where most auctions attract a large number of bids from many local and international firms).

The principal faces two problems. First, it has imperfect information about firm types, and can only observe whether a firm exceeds the minimum threshold (installers, on the other hand, have perfect information about designer and supplier types[7]). Second, since firms decide how much effort

[6] An alternative model could endogenize this threshold: lower monitoring or contract unbundling might change the optimal threshold. We omit that here as the threshold is exogenously set by donor policy in this context.

[7] Conducting installation using another firm's designs and supplies provides a level of insight into that firm's type and effort that cannot be achieved by the principal through even very careful monitoring. Furthermore, in practice

to exert after contracts have been awarded, the principal must find a way to incentivize effort.

The principal has two contracting tools. First, it can choose to offer either one bundled contract ($t = 1$) or three unbundled contracts ($t = 3$). Second, the principal can implement either low ($m = L$) or high ($m = H$) monitoring. Under low monitoring, all contractors are paid regardless of realized quality. In this case, firms exert no effort, and quality simply corresponds to their firm type: $q_i = \gamma_i$. Under high monitoring, contractors are only paid if the quality of the component(s) included in their contract meets a quality threshold. The principal implements the auction as follows, where P and A denote decisions taken by the Principal and Agent (firms), respectively (Appendix C presents this framework more formally):

(P1) The principal sets the auction parameters (t and m). For unbundled contracts, the principal runs three sequential auctions. For bundled contracts, the principal runs one auction.

(A1) Each eligible firm decides whether or not to bid. If a firm chooses to bid, its bid amount corresponds to its type and the level of effort it will want to exert: $b_i = c(\gamma_i) + d(e_i)$.

(P2) The lowest eligible bid(s) wins the auction. If the contract is bundled, the winner selects a designer and supplier with full discretion (they can choose firms below the threshold: $\gamma_i < \bar{\gamma}$).

(A2) Each firm chooses an effort level and realizes their component quality.

(P3) With low monitoring, all firms are paid regardless of realized quality. With high monitoring, the principal pays each contractor if the quality of their component(s) meets the relevant threshold (for bundled contracts, all three component thresholds must be met).

While unbundling and higher monitoring may improve quality, they incur administrative costs $\kappa(m, t)$, which are increasing in both arguments. Furthermore, monitoring incurs delays both directly (the monitoring itself takes time) and indirectly (incurring greater effort may cause firms to complete activities more slowly), and unbundling causes delays by adding administrative and coordination tasks associated with conducting three sequential sets of auctions rather than a single set of auctions. These delays lower the project's future welfare gains W according to a function $D(m, t, \delta) < 1$, where δ denotes the principal's intertemporal discount rate. When selecting t and m the principal wishes to maximize net benefits, factoring in these costs and delays, contract costs b_i, and long-term maintenance costs M, which decrease with aggregate project quality Q (the sum of the qualities of the three components: $Q = q_a + q_b + q_c$). Maintenance costs can be thought of as the expenses needed to maintain project benefits at level W over the lifetime of the project (from year $y = 1$ to Y); higher quality construction lowers these expenses.

$$\text{Project Net Benefits} = \underbrace{D(m,t,\delta)W}_{\text{Welfare gains}} - \underbrace{\kappa(m,t)}_{\substack{\text{Administrative}\\ \text{costs}}} - \underbrace{\sum_{i=1}^{t} b_i(m,t)}_{\substack{\text{Contract}\\ \text{costs}}} - \underbrace{\sum_{y=1}^{Y} \delta^y M(Q(m,t))}_{\substack{\text{Long-term}\\ \text{maintenance costs}}} \tag{1}$$

The principal's optimal choice of monitoring and (un)bundling will depend on, for example, the delays incurred, their discount rate, and the effect of quality on long-term maintenance costs.

many installers collaborate with the same designer or supplier much more frequently than the principal does.

4.2 Framework implications

This framework provides two intuitive implications, which we derive formally in Appendix C and illustrate graphically in Figure A1. The first is that, compared with bundled contracts that receive low monitoring, unbundled contracts that receive high monitoring unambiguously result in higher type firms and higher effort, which generate higher project quality, incur more delays, and increase the cost of the minimum bid.[8]

A perhaps less immediate implication is that, conditional on being accompanied by high monitoring, bundled contracting will unambiguously incur fewer delays than unbundled contracting while still attaining similar quality. The intuition for this is straightforward. In the absence of high monitoring, bundled contractors choose cost-minimizing design and materials firms. However, when faced with high monitoring, bundled contractors have an incentive to select design and materials firms of type γ^* to minimize costs (and use their private information and discretion to do so). Meanwhile, under high monitoring, unbundled contractors with the cost-minimizing firm type and effort for the given quality threshold (γ_i^*, e_i^*) will offer the cheapest bids. The bundled and unbundled auctions would thus both select optimal firm types and incentivize optimal effort levels for all three components, resulting in identical project quality despite the additional delays caused by unbundling. Put differently, the effect of high monitoring is so much greater under bundled contracts that it compensates for the fact that bundling generates worse outcomes under low monitoring.

This paper uses natural policy variation to empirically study the first implication. To study the second implication, we implement a randomized monitoring intervention (stratifying across the policy variation induced by the different donors) that allows us to observe bundled contracts in a high monitoring setting. Section 5 describes these identification strategies in more detail and Section 8 uses the empirical results to quantify the trade-offs from Equation 1 in the study context.

This framework can be used to evaluate alternative incentive structures that we do not observe in our setting. For example, a principal might consider only monitoring after project completion. According to the framework, unbundling would generate worse quality than bundling in this case (in addition to incurring higher administrative costs) because it would not incentivize the design or supply firms to exert effort. Subsection 8.3 touches on these additional implications.

5 Research Design

Figure 1 presents the nationwide distribution of LMCP sites. To estimate the causal impact of contracting structure on project outcomes, we exploit the quasi-random assignment of sites to being constructed through contracts funded by either WB or AfDB. To disentangle how monitoring

[8] High monitoring incentivizes effort since firms will not get paid if they do not meet the quality threshold. It also allows the principal to identify firms of type γ^* because they will have the cheapest bids (lower type firms would need to incur significantly higher effort costs to realize the same quality). Note that the more direct effect of unbundling (allowing the principal to directly constrain design and materials firms to only those that meet the eligibility threshold) becomes obsolete when unbundling is combined with high monitoring, as lower type firms would have to expend significant effort to compensate for their low types and thus will not have the lowest bid.

affects project outcomes, we implement a randomized audits scheme. We discuss these sources of identification in turn below.

5.1 Quasi-random assignment of sites to donors

During Phase I of the LMCP, each site was assigned to be constructed through contracts that were financed by either the WB or the AfDB.[9] Geographic clustering might have generated economies of scale: for example, if the WB had funded sites only in the North-Western half of the country and the AfDB only in the South-Eastern half, contractors might have saved on coordination and transportation costs. However, in this instance, the funders chose to each fund a set of sites distributed across the country. While there is no justification of this decision in any of the project documentation, qualitative interviews suggest each donor wanted to avoid perceptions of political bias that might result from funding work in some parts of the country and not others.

As a result, every region (i.e., former province) of Kenya has sites funded by both the AfDB and WB. Of Kenya's 290 electoral constituencies, 265 contain at least one LMCP site, of which 210 contain at least one AfDB-funded site and one WB-funded site.[10]

We also observe extensive geographical overlap between sites funded by the two aid agencies within a five-county area where we collected detailed on-the-ground assessments. Of the 7,492 LMCP sites shown in Figure 1, 1,099 are located in the five-county area consisting of Kakamega, Kericho, Kisumu, Nandi, and Vihiga, magnified in Figure 4. These five counties comprise 36 constituencies, of which 35 have at least one WB-funded site and one AfDB-funded site. There does not appear to be spatial clustering by donor: 95% of WB-funded sites in this sample are located within 10 km of an AfDB-funded site (and vice versa). We randomly select 380 of these 1,099 sites as the study sample, stratifying selection by constituency and funder to improve statistical power. Analyses below include constituency fixed effects.

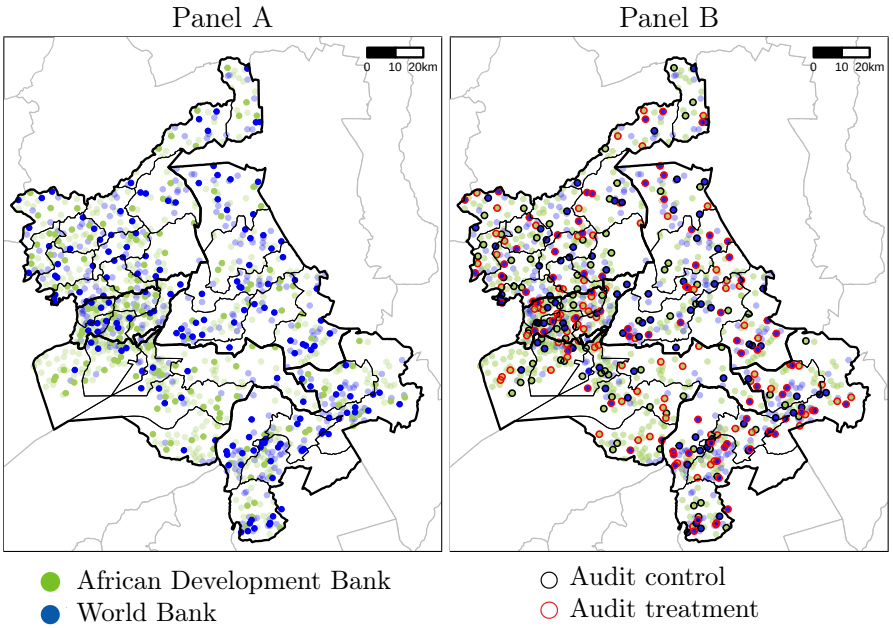
The deliberate allocation of sites to WB or AfDB funding by Kenya Power employees on the basis of site characteristics that influence the quality or timeliness of construction could be a threat to identification, for example if sites were allocated to one funder or the other in order to achieve faster construction or higher construction quality in specific areas for electoral or economic reasons, or for personal favor.

Yet the same patterns revealed in the qualitative interviews emerge when analyzing the data. These data analyses are intended to support two related identification assumptions. First, we examine the assumption that the *nationwide* assignment of LMCP sites to construction contracts funded by either the WB or the AfDB was not systematically done in a way that correlates with site characteristics that influence the outcomes of interest. Second, we examine the assumption that sites *within the study sample* are balanced, such that any differences in the outcomes we measure can be attributed to the contracting structures rather than to any other underlying differences. To support

[9] As noted in Section 3, Phase II of the LMCP later received additional funding from the AfDB as well as the European Investment Bank, the Agence Française de Développement, and the European Union.

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

Figure 4: Sites by funding source and audit treatment status



Notes: Panel A enlarges the five counties bolded in Figure 1 and adds within-county constituency boundaries. There appears to be limited spatial clustering by donor. Dark (light) sites are (not) included in our sample. Panel B shows audit treatment and control sites circled in red and black, respectively. Uncircled sites are not in the RCT sample.

these assumptions, we first conduct standard site-level balance tests (Table 3). We supplement this with machine learning methods—in particular, Least Absolute Shrinkage and Selection Operator (LASSO) and Decision Trees—to identify site characteristics that are most predictive of assignment (Mullainathan and Spiess 2017; Varian 2014). We conduct additional ward-level balance tests using a wider range of socio-economic, electoral, and ethnic characteristics (Table A3).

Across all methods, we find that the assignment of LMCP sites to be awarded contracts funded by either the WB or the AfDB was conducted in a way that appears arbitrary and uncorrelated with observable characteristics. The variables that would be most likely to have biased site selection by Kenya Power staff or members of parliament—such as electoral outcomes, ethnic composition, and economic activity—are not significantly different across sites. While some variables are statistically different across the two funders, these differences are economically small and we show below that these variables are weakly correlated with the outcomes of interest. Taken together, it seems unlikely that these differences meaningfully affected the main results. The following sections discuss the qualitative evidence as well as these various identification checks in turn.

5.1.1 Qualitative descriptions

From June 2016 through July 2022, members of the research team met extensively with dozens of key Kenya Power personnel. This included the General Manager for Connectivity, who was responsible for all of Kenya Power's new electricity connections, as well as the the two Project Managers who oversaw the nationwide LMCP. It also included key managing staff in Kenya Power's office for

Table 3: Geographic balance of World Bank- and African Development Bank-funded sites

	Road Distance		VIIRS Radiance	Land Gradient
	(1)	(2)	(3)	(4)
World Bank (=1)	1.58**	0.63	-0.01	-0.00
	(0.74)	(0.45)	(0.02)	(0.07)
Observations	6130	6130	337205	6131
Month FE	No	No	Yes	No
Constituency FE	Yes	Yes	Yes	Yes
AfDB Mean	54.07	34.58	.58	4.24
Outcome variable	Minutes	KM		

Notes: Balance across all sites (Table A1 shows only study sites). All regressions include constituency FE. Columns (1) and (2) estimate road distance from each site to the nearest 'major town' (WRI 2007; HERE 2022). Column (3) estimates monthly average site-level nighttime radiance from July 2012 through January 2017 measured using VIIRS averaged across the 600 meter radius with SE clustered by site (Elvidge et al. 2017). Figure A2 (Figure 9) shows the time series at all sites (at study sites only). Column (4) estimates average site-level land gradient recorded using the 90-meter Shuttle Radar Topography Mission Global Digital Elevation Model. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

connectivity, including the senior managers responsible for the WB contracting and the managers responsible for the AfDB contracting. Appendix E provides a full list of individuals consulted. We read direct correspondence between Kenya Power and dozens of members of parliament: hundreds of letters deciding which transformers each phase of the LMCP would include.

Throughout these exercises, our explicit goal was to identify a methodology, reason, or process that Kenya Power had used to assign specific sites to be covered by either the WB contracts or the AfDB sites. We were consistently informed that the assignment process among the donors was ad hoc and did not follow any particular allocation rule. Given that the overall mandate—to connect all households within 600 meters of a transformer—was identical regardless of which donor funded a site, Kenya Power and the GoK did not appear to see any obvious strategic benefit in having a particular transformer funded by one donor or the other.

For both the WB and AfDB components, Kenya power employed one full-time staff member to manage the contracting components and a handful of employees to oversee implementation. The staff who held these positions were all certified electrical engineers with similar skill and education levels, all holding at least a bachelor's degree in electrical engineering.

5.1.2 Site-level balance tests

Table 3 tests for site-level balance using three independent datasets. Columns (1) and (2) show that there is a slight (around 2–3%) difference in road distance to the nearest town by financing source. However, this difference is sufficiently small that it is unlikely to explain our results unless there are significant unobserved non-linearities in how road distance affects construction quality and timeliness. Furthermore, this difference does not persist within our study sample (Table A1). Any differences that we estimate therefore seem unlikely to result from this difference.

Columns (3) and (4) show that sites are balanced by pre-LMCP nighttime radiance levels (which

reflect local electricity usage and economic activity; Figure 9 shows pre-LMCP trends) and by land gradient. There also does not seem to be a consistent pattern in funder assignment by the transformer's nearby public facilities (Table A4).

There is a small correlation between land gradient and WB selection within our study sample (Table A1). However, land gradient does not predict construction outcomes, and differences between WB- and AfDB-funded sites shown in the main results presented below are constant across the entire support of land gradient (Subsection 7.7). The magnitude of the correlation between land gradient and the outcomes of interest is furthermore sufficiently small that it would be unable to explain results of the magnitude that we find: an average difference of 0.57 of a degree is unlikely to strongly affect construction costs. Still, all site-level regressions include land gradient as a control.

5.1.3 Machine Learning assignment predictions

We use linear LASSO, logistic LASSO, and Decision Tree methods to evaluate whether any of the variables we consider can predict assignment to WB or AfDB funding. We include a wide range of both ward and site level variables, including socioeconomic characteristics, electoral outcomes, ethnic composition, geographic characteristics, and baseline electrification. Both models are trained on a 75% sub-sample and then tested on a 25% sub-sample (stratified on constituency) of the 6,132 nationwide transformers for which we have GPS coordinates.

Table 4 shows the results, with and without constituency fixed effects. Across all six approaches, the out-of-sample R^2 is consistently below 0.1. The classification accuracy rate—of sites to funders—is on average 63%: only slightly higher than 57%, which is what would result from simply assigning all sites to AfDB, since around 57% of sites in this sample are constructed through AfDB-funded contracts. Even this numerous and broad set of variables cannot accurately predict assignment.

The most predictive coefficients are baseline electricity access (in the LASSO method) and Kenyatta vote share in the 2013 presidential election (in both methods). However, a standard balance test detects no statistically significant differences along these dimensions (Table A3).

5.1.4 Ward-level balance tests

The fraction of sites in a ward that are funded by the WB is not correlated with most pre-LMCP ward-level socioeconomic characteristics, with electoral outcomes, or with ethnic composition (Table A3). In particular, baseline electrification rates and presidential vote share are uncorrelated with use of WB funding. These are the two variables deemed most likely to have biased assignment from the machine learning exercise. Balance in electrification rates runs counter to the idea that AfDB funding could have targeted sites where it was especially easy to connect large numbers of households. Balance in presidential vote share runs counter to the idea that AfDB (or WB) funding could have targeted politically favored regions. Some of the other coefficients are statistically significant, however these are very small in magnitude: for example, shifting from 0% of sites in a ward being WB-funded to 100% of sites in a ward being WB-funded is associated with 4% fewer people with high-quality roofs. A joint F-test cannot reject that the sites are the same along all

Table 4: Machine learning methods to predict assignment of LMCP sites

	LPM LASSO Coefficient		Logit LASSO Coefficient		Decision Tree Importance	
Predictor	(1)	(2)	(3)	(4)	(5)	(6)
2013 Kenyatta Share	0.059	0.058	0.246	0.238	107	51
Age 14 or Under	-0.051		-0.235		58	29
Consumption	0.002	-0.004	0.012	-0.016	55	
Drive Distance	0.014	0.015	0.064	0.057	29	
Drive Time		0.001		0.022	17	
Electricity	-0.068	-0.006	-0.319	-0.026	42	
Ethnically Kalenjin-aligned	0.055	0.026	0.232	0.132	73	41
Ethnically Kikuyu-aligned		0.014		0.087	14	
Ethnically Luo-aligned	-0.013		-0.06		2	
High-Quality Roof	-0.023	-0.002	-0.103	-0.011	48	17
High-Quality Wall	-0.01		-0.049		49	
Land Area			0.003		45	
Land Gradient	0.016	0.006	0.07	0.033	2	9
Population	-0.007	-0.006	-0.032	-0.032	19	
Primary Education	0.037	0.022	0.168	0.107	43	
Secondary Education		-0.005		-0.034	53	
Solar Home System	-0.033	-0.008	-0.149	-0.044	25	
VIIRS Radiance	0.018	0.009	0.086	0.072	12	
Voted pro-MP in 2013	-0.021	-0.014	-0.096	-0.067	2	
Const FEs?	No	Yes	No	Yes	No	Yes
Test RMSE	0.474	0.512	0.474	0.517	0.471	0.472
Test MAE	0.454	0.47	0.453	0.469	0.431	0.429
OoS R2	0.087	-0.066	0.088	-0.086	0.099	0.093
Class Rate	0.633	0.579	0.637	0.579	0.653	0.669

Notes: Sample: all sites for which we have GPS coordinates (2,648 WB and 3,484 AfDB). Columns 1–2 show coefficients from LASSO with a standard Linear Probability Model (LPM). Columns 3–4 show coefficients from a LASSO model with a logit link function. Columns 5–6 show variable importance from a classification tree model. Missing data imputed with the mean. Table A2 only includes sites for which we have all data—results are similar.

these characteristics. The correlation between baseline socioeconomic and political characteristics and the assignment of sites to a specific funder appears modest and not related to the outcomes that we study.

Among the sample in the five study counties, there is some imbalance driven by 2009 electrification rates and ward land area (Table A5). The differences are small in magnitude—for example, going from 0% sites in a ward being WB funded to 100% of sites being WB funded is associated with 4 percentage points higher electrification rate in 2009. Baseline electrification rates could in theory affect construction costs. However, we do not find evidence that 2009 electrification rates predict construction outcomes, or that differences between WB-funded and AfDB-funded sites differ by 2009 electrification rate (Figure 10 and Figure A3).

5.2 Randomized audits

To disentangle the impacts of unbundling and additional inspections, we implemented a randomized audit treatment closely mirroring the Inspection Reports that Kenya Power completed at sites whose contracts were financed by the WB (as discussed in Subsection 3.4). Just like those inspections, contractors were informed prior to construction that these audits would take place.

After construction at a site was completed, enumerators hired by the research team visited each site to inspect the electricity network according to specifications we developed in collaboration with retired REA electrical engineers. These inspections were conducted as an additional measure, on top of existing steps for verifying contract outputs that contractors were already aware of. Of the 380 study sites, we randomly assigned 190 to treatment and 190 to control, stratifying by constituency and funder. Panel B of Figure 4 maps treatment and funder assignments. Figure 5 shows the structure of randomized treatments and data samples.

The randomized audits were implemented in collaboration with Kenya Power and the two funders as follows. During in-person meetings set up for this purpose, senior Kenyan research personnel notified contractors that an independent, international team of engineers would audit specific sites once construction was complete. They provided a written notice to this effect, signed by senior management at Kenya Power, the WB, and the AfDB (Figure 11), and attached a list of sites in their contract region that would be audited. The letter also specified four technical aspects of construction that would be inspected: the distance between poles, line sag, the quality of connection between transformer and LV wiring, and power reliability.

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 endline engineering surveys (described in Subsection 6.1). Given the random selection of sites communicated to the contractors, any difference in construction outcomes between the sites about which contractors were notified and the control sites can be attributed to contractors' response to the audits. Figure 2 displays the timeline of audit treatment notification and the engineering surveys.

In communications with WB officials (in both Washington DC and Nairobi), the WB indicated they would take contractor-level outcomes at both WB- and AfDB-funded sites into account in future contracting. This setup can therefore be thought of as a repeated game environment where there are real consequences to contractor performance: many contractors depend on their ongoing relationships with international donors.[11] To remind contractors of this incentive, the notification letter emphasizes the issue of future contracts.

While the research team did not widely share its activities, it is possible that some contractors (correctly) believed that control sites might also be audited. If treatment impacted a contractor's general operations across treatment and control sites, this would cause us to underestimate the impacts of the audit treatment. Conversely, audit effects may be overestimated if contractors shifted construction effort from control sites to the audit treatment sites. However, such spillovers onto

[11] While the framework described in Subsection 4.1 is a one-off game, one could conceptualize equilibrium in this setting as a repeated game where each round is played as described and each player pursues a grim trigger strategy.

the control sites are likely to be small: on average, only 7.6% of a contractor's sites were randomly selected for audits.[12]

5.3 Treatment interactions

The interaction of experimental and natural policy variation allows us to empirically investigate how unbundling and monitoring may interact, as discussed in the framework presented in Section 4. Comparing AfDB-funded sites in the audit control with AfDB-funded sites in the audit treatment allows us to directly estimate the effect of additional monitoring in a setting with low baseline monitoring and bundled contracting. Comparing WB-funded sites in the audit control with WB-funded sites in the audit treatment allows us to estimate the effect of enhanced monitoring in a setting with (already) high monitoring and unbundled contracting.

While the randomized audit treatment was not identical to the enhanced monitoring required at WB-funded sites, we can look at the interaction term to approximate the impact of unbundling per se. If the monitoring at WB-funded sites had the same impacts as our experimental monitoring, the effect of the WB's unbundled contracting can be recovered by subtracting the audit treatment effect among AfDB-funded sites from the aggregate WB versus AfDB difference among audit control sites (i.e., $\beta_1 - \beta_3$ in the regression below). However, we interpret this calculation with some caution, as there are modest differences between the inspections Kenya Power implemented at WB-funded sites and the audits our research team conducted. Subsection 7.4 discusses this more. We use the following regression specification:

$$y_i = \beta_0 + \beta_1 \text{WB}_i + \beta_2 \text{Treat}_i \cdot \text{WB}_i + \beta_3 \text{Treat}_i \cdot \text{AfDB}_i + \boldsymbol{\Gamma_i} + \epsilon_i, \tag{2}$$

where WB_i and AfDB_i indicate whether site i is WB-funded or AfDB-funded. β_1 measures the impact of WB procedures among audit control sites. Treat_i indicates whether the site is an audit treatment site, such that β_2 and β_3 allow us to estimate the impact of enhanced monitoring among WB- and AfDB-funded sites, respectively. $\boldsymbol{\Gamma_i}$ is a vector of fixed effects (including constituency fixed effects) which vary somewhat across specifications as discussed below and in the table notes. Standard errors are clustered by site in all regressions except those run at the site level.

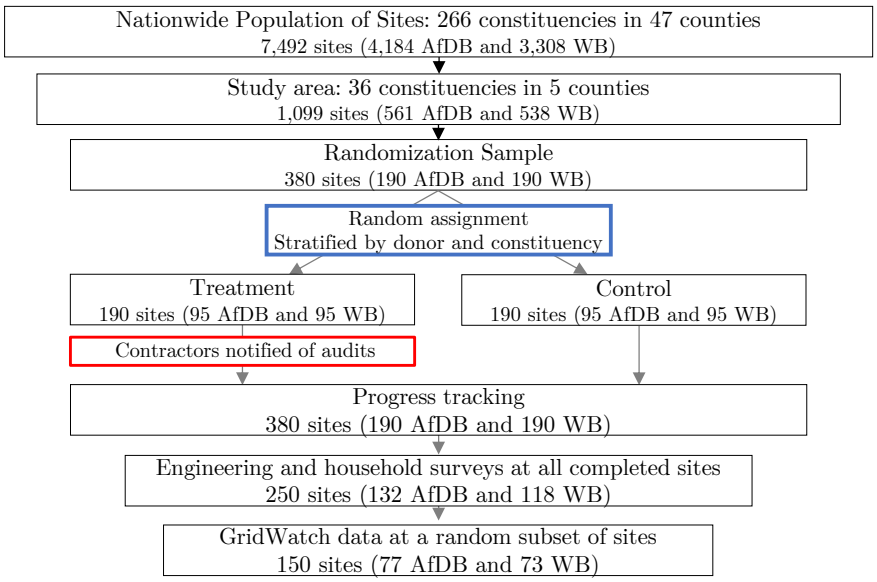
6 Data

Figure 5 provides an overview of the study samples. Enumerators employed by the research team conducted repeated short phone or in-person surveys with village representatives at all 380 sites in the study sample to track construction progress, yielding a site-level panel dataset of construction progress. Reassuringly, nighttime radiance increases in the 12 months after household electricity metering (Figure A4), but not after the start of construction and stringing alone.

We conduct on-the-ground engineering assessments and socioeconomic surveys at all 250 sites where construction had made significant progress by the end of the main field activities in May 2021.

[12] Treatment effects do not vary meaningfully by how many of a contractor's sites were audited (Table A23).

Figure 5: Project design



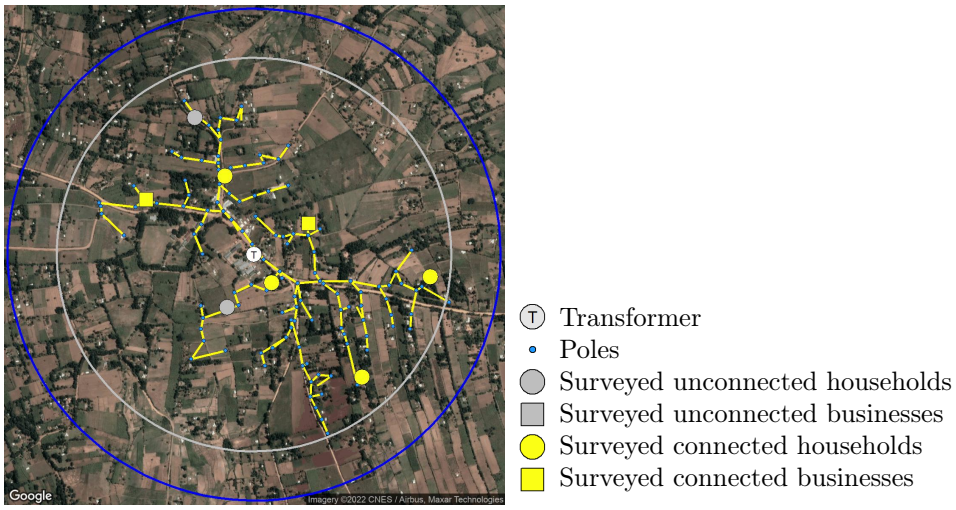
Notes: Sample selection and randomization, starting with the nationwide sample of African Development Bank- and World Bank-funded sites selected for the Last Mile Connectivity Project. We randomly select 380 out of the 1,099 sites located in the five study counties and then randomly assign each to control or treatment. Contractors were notified in 2017-2018 and assessments and surveys were carried out in 2018-2021. Engineering assessments and household surveys were completed at all 250 sites where there had been meaningful construction by the end of surveying activities in mid 2021. Construction progress tracking at the remaining sites continued through mid 2022.

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

6.1 Engineering assessments

The engineering surveys conducted at these 250 sites were developed in collaboration with recently retired Kenya Rural Electrification Authority engineers with expertise on the technical specifications of Kenya's electricity grid. Data collection consisted of two main parts. In the initial infrastructure census, enumerators recorded the locations of all poles in the low-voltage network, as well as their connectivity, up to 700 meters from the central transformer. Only households within 600 meters of the transformer were eligible for an LMCP connection: the 700 meter radius allows us to test whether construction was completed beyond the eligible region, for example in exchange for informal side payments from households. Enumerators also recorded the number of drop-down cables (connections between an electricity pole and a customer) connected to each pole, whether drop-down cables connected to a household or a firm, and any unconnected compounds located near the pole. This provides a measure of the total numbers of connected and unconnected households and firms at

Figure 6: Infrastructure data collected (example site)



Notes: Construction data collected at an example site (Figure A5 shows additional examples). The grey (blue) line denotes 600 (700) meters from the transformer. The engineering surveys record the locations of poles (blue dots), conductors (yellow lines), and infrastructure quality. At each site, between 4 to 9 connected and unconnected residential compounds and firms were randomly selected to participate in the socioeconomic survey (Subsection 6.2) and to receive GridWatch devices to measure power quality (Subsection 6.3): these are marked with yellow and gray circles and squares. (Note that random spatial noise has been added to preserve respondent anonymity here.)

each site. Figure 6 displays network data recorded at an example site.[13]

In the second part of the engineering assessment, enumerators recorded characteristics of every pole and the conductors that connect them, focusing on outcomes most likely to affect grid quality and longevity. For instance, pole measurements included the angle relative to the ground (as tilting poles are more likely to fall), whether it was wood or concrete, whether it was firmly placed in the ground, whether it had a pole cap, whether it had any visible cracks, and whether it had the appropriate grounding wires, stay wires, and struts. For a random subset of poles, enumerators collected additional data on pole height, circumference, and characteristics of each strut or stay supporting that pole.[14] Measurements of conductors included whether it had appropriate clearance (from the ground, trees, brush, or structures) and whether any electric lines crossed. Measurements of drop-down cables included the distance between the pole and the customer's structure and whether the cable ended at a meter. Enumerators also noted whether it appeared to be an illegal connection, although this is very rare in the rural study setting (in contrast to some urban and peri-urban settings in Kenya and elsewhere). Finally, measurements of the transformer included whether the poles on which the transformer was mounted were leaning excessively, the number of missing or bypassed fuses, and whether the transformer had any other visible defects.

Overall construction quality is mixed in the study sample. About a quarter of surveyed poles

[13] If the network was too large to map in one day, enumerators would assess a random subset of branches. Scaling measured quantities up in proportion to the fraction of the grid surveyed yields an unbiased estimate of total quantities at that site. As an example, in the bottom right site shown in Figure A5 only the southern half of the site was surveyed. At 93% of sites at least 50% of the entire LV network was surveyed.

[14] At smaller sites, enumerators would conduct detailed measurements of every third or fourth pole, while at larger sites (of 120 or more poles) enumerators would conduct detailed measurements of every sixth pole.

had a large crack, and 47% of poles were missing a cap (Table A6 provides additional detail). At least one fuse was missing or had been bypassed in around a quarter of transformers surveyed: this could reduce transformer longevity as it is exposed to high-current events.

Of the 250 sites surveyed, 26 were located within 1,200 meters of each other (Figure A6 shows an example). This raises two potential concerns. First, poles or respondents located within 600 meters of two different surveyed transformers might be double counted. The survey methodology is robust to this potential source of error: LV networks in this area are constructed using a radial structure where no household is connected to more than one transformer. Second, if construction took place earlier at one transformer, then a neighboring transformer with later construction might require less expansion of the LV network to reach remaining households. Robustness checks show that the results reported below hold when dropping these sites (Subsection 7.7).

6.2 Household and firm survey data

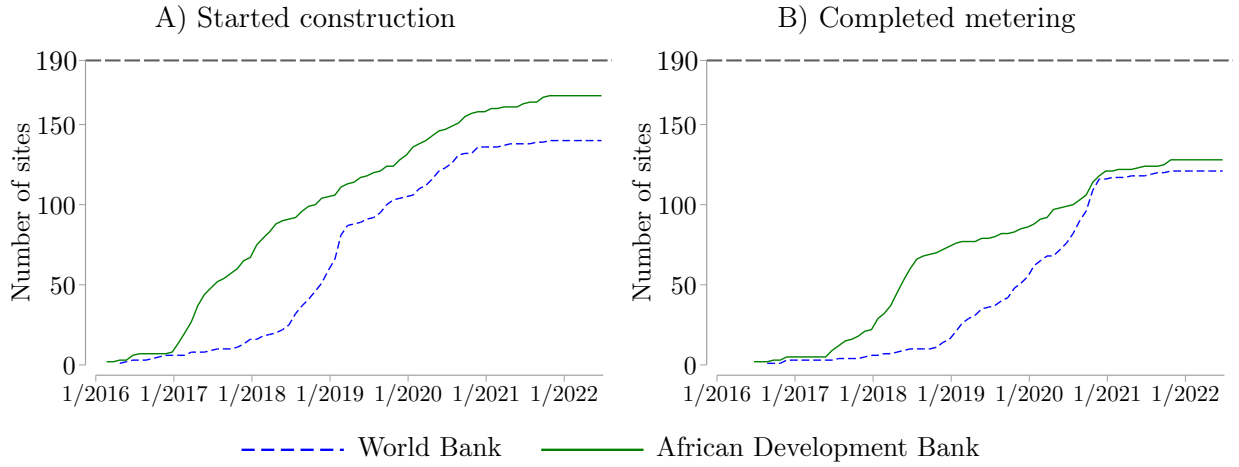
After the infrastructure census, enumerators invited a random subset of connected and unconnected compounds and firms to complete a socioeconomic survey about the construction process, electricity connection quality and usage, their knowledge about future costs, experiences around safety and power reliability, and socioeconomic outcomes. 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, informal field observations indicate that Kenya Power occasionally installs multiple meters within a single home compound, overstating the total number of households that are connected nationwide (perhaps in order to create inflated public perceptions of program progress). To disentangle this phenomenon from compound residents' genuine preference for having multiple electricity meters (for instance, if multiple separate households shared a residential compound), the survey asked not just how many meters were installed but also how many they had requested.

6.3 Power quality: outages and voltage

Improved construction quality could reduce power outages and increase reliability, which could have tangible benefits for household well-being and firm performance. To measure reliability and voltage we deployed the GridWatch technology (Klugman et al. 2021; Klugman et al. 2019) with a subset of surveyed households and firms. GridWatch measures minute-by-minute power state and voltage and can be installed by plugging a PowerWatch device (Figure A7) into a power outlet. We aggregate these high-frequency measurements to an hourly measure of average voltage and a daily measure of hours of electricity. We collected these data across 150 sites for two months each, staggered between June 2021 and June 2022, deploying four PowerWatch devices per site at a time.[15]

[15] The sample was reduced from 250 to 150 sites due to logistical challenges associated with the COVID-19 pandemic.

Figure 7: Construction progress by funding source



Notes: Data for 190 African Development Bank sites and 190 World Bank sites collected through phone surveys with village representatives. Figure A8 displays progress for pole installation and stringing. Figure A9 graphically presents results by audit treatment status.

7 Results

Subsection 7.1 first documents patterns in construction delays. Subsection 7.2 then analyzes the quantity of construction. The next two subsections examine the quality of construction: Subsection 7.3 examines power outages and voltage quality, and Subsection 7.4 presents results that use the on-the-ground household and engineering assessments.

We identify three key patterns in the results that speak to the framework presented in Section 4. First, construction completion delays are significant at WB-funded sites, and are more modest but still meaningful at audit treatment sites. Second, WB-funded sites see a considerably higher quality of construction. Third, audit treatments improve the quality of construction along some dimensions at AfDB-funded sites but not at the WB-funded sites.

7.1 Construction timing and site completion

Of the 380 LMCP sites tracked by the survey team, 250 saw significant pole construction by the end of field surveying in May 2021. Construction varies significantly by funder: 70% of AfDB-funded sites saw construction whereas only 62% of WB-funded sites did, and this difference remains significant even when including constituency fixed effects. Sites with higher baseline nighttime radiance or with a higher land gradient (steeper sites) were less likely to be completed (Table A7). While WB-funded sites are on average steeper (Table 3), the primary outcome regressions presented below control for land gradient so these differences do not appear to be driving the findings.

Even conditional on completion, construction progress at WB-funded sites lagged significantly behind AfDB-funded sites. Panel A of Figure 7 demonstrates that this lag is driven by the initial delay in starting construction, likely driven by the ex ante administrative burden involved with contract unbundling. Construction at WB-funded sites started on average 10.2 months later than at

AfDB-funded sites (Table 9): in mid-2018, as construction at WB-funded sites was just beginning, AfDB-funded sites reached 50% metering completion.[16] However, once construction started, it proceeded more quickly at WB- than at AfDB-funded sites, possibly because by that time all designs had been completed and materials supplied. The delay in stringing completion is therefore slightly less, at 9.5 months. However, the delay is then again exacerbated at the final household metering stage, at which the average lag is 16 months. Recall that the AfDB teams did not always inspect whether meters were functioning prior to issuing a JMC (Subsection 3.4). The more stringent WB inspection reports, which happened between stringing completion and metering activation, may explain why the delays were exacerbated at this final stage. Finally, all sites lagged significantly behind the initial contracting timelines: project appraisal documents for both AfDB-funded and WB-funded sites originally planned for construction to be completed by early 2019.

The audit treatment caused some delays, but these are substantially smaller than the average delay at WB-funded sites: metering is completed on average 4.7 months later at audit treatment sites than at audit control sites. To isolate the impact of the unbundling directly, we estimate the impact of WB contracting and subtract the audit treatment effect ($\beta_1 - \beta_3$). This analysis indicates that unbundling per se caused a delay of 11 months ($p\text{-}val < 0.001$; see Table 9).

7.2 Quantity of construction

Household metering had been completed at 71% of both AfDB and WB-funded sites at the end of survey data collection in July 2022, more than five years after the start of contracting. At that point, a key remaining difference by funder was that construction had been only partially completed at 24% of AfDB-funded sites where construction had started, compared with only 14% of equivalent WB-funded sites. The large share of partially completed public projects in contexts with limited resources and administrative capacity is in line with previous evidence from low- and middle-income countries (Williams 2017; Rasul and Rogger 2018). If these sites are not eventually completed, it would signify that a substantial share of project spending was wasted on non-functional construction, with a substantially higher share in AfDB-funded sites.

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 5 shows that WB-funded sites saw fewer poles and fewer customer connections (the equivalent regression coefficients from Equation 2 are marked β_1, β_2, and β_3). There are on average 99 poles at AfDB-funded sites and 88 poles at WB-funded sites ($p\text{-}val = 0.055$), and on average 76 new LMCP customer connections at AfDB-funded sites and 61 at WB-funded sites ($p\text{-}val = 0.041$). There are several potential explanations for these differences, but one likely explanation is that installers at WB-funded sites might have been constrained by the quantity of materials that had earlier been purchased through the separate supply contracts, whereas bundled contractors (at AfDB-funded sites) could procure additional materials as needed during the installation phase.

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

Table 5: 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
F-test $\beta_2 = \beta_3$ (p-val)		0.10		0.75		0.24		0.24

Notes: β_1, β_2, and β_3 are estimated as per Equation 2. All regressions include constituency fixed effects. Standard errors shown in parentheses. The sample size in columns 5–8 is slightly lower due to field logistical complications. We calculate the quantities of poles and connections at these sites using the engineering survey, but since we do not have their GPS coordinates, we exclude them from columns 5–8. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Column (2) of Table 5 shows that the audit treatment increased the number of poles constructed at AfDB-funded sites but not at WB-funded sites. This indicates that unbundling contracts and monitoring may be substitutes, for example because bundled contractors (at AfDB-funded sites) had more discretion in changing site designs or supplies in response to the audit treatment, whereas installers at WB-funded sites were constrained by their assigned designs and previously procured supplies. Alternatively, the audit treatment may have had a limited impact at WB-funded sites due to the diminishing impact of enhanced inspections, above and beyond the additional inspections that Kenya Power had already carried out.

Columns (5) through (8) indicate that there was some construction between 600 to 700 meters from the transformer, despite the official guidelines indicating that construction was supposed to have extended only up to 600 meters.[17] WB-funded sites saw significantly less construction outside the boundary, possibly due to more stringent adherence to official LMCP rules. This could be viewed as a positive outcome (especially if some of these connections are made in exchange for bribes), but does contribute to fewer connections per site. That said, the household survey data indicate similar rates of requests for informal side payments—at approximately 8%—for households and firms inside versus outside the 600 meter boundary. Voltage decreases with distance from the transformer, as expected, but this decrease is not correlated with the funder (Subsection D.9).

We estimate $\beta_1 - \beta_3$, the impact of WB contracting minus the additional audit treatment, to isolate the impact of contract unbundling directly, as distinct from the WB's enhanced monitoring activities. Using this method, unbundling decreased the number of poles by 18.5 ($p\text{-}val = 0.06$) and the number of connections by 22 ($p\text{-}val = 0.04$). We interpret these numbers with some caution,

[17] Kassem et al. (2022) find that 30% of LMCP households live more than 600 meters from the transformer. Our numbers may be lower because enumerators only surveyed households and firms out to 700 meters and not beyond.

as the inspection reports that Kenya Power completed at WB-funded sites differed from the audit treatment in some nuanced but important ways (as we discuss in Subsection 7.4 below), and thus they may not be fully equivalent.

Despite the LMCP mandate to connect all households and firms within 600 meters of the transformer, 10% of households in each village where construction was completed did not have a physical electricity connection.[18] Several factors likely contributed to this. Among both WB- and AfDB-funded sites, 30% of unconnected households noted that they were absent on the day on which Kenya Power enrolled households or when construction happened. 22% of households who did not get connected reported the key barrier as up-front costs: 16% name internal wiring costs and 9% of connected households report having been asked to pay a bribe. This is noteworthy because, according to LMCP media information campaigns during this period, there was not supposed to be any up-front cost (Kenya Power 2016b): ready boards were supposed to have been made available to households who were unable to pay the upfront wiring costs, and of course bribes are illegal.

7.3 Power outages and voltage quality

The GridWatch devices recorded an average of 61 minutes of power outage per day, a substantial amount by any standard. Users also experience poor voltage quality: Kenya's nominal voltage is 240V, but voltage in the audit control group is on average only 233V.[19] This gap could affect day-to-day appliance use and damage appliances in the long run.

Table 6 indicates that WB procedures did not cause statistically or economically meaningful reductions in power outages or improvements in voltage quality over the time period studied. The results are similar when estimating daily or monthly coefficients (Figure A10).

The audit treatment had no measurable impacts on power outages or voltage at WB-funded sites (although point estimates are positive). However, audits had a statistically and economically meaningful effect on voltage quality at AfDB-funded sites: those that received the audit treatment experienced average voltage of 238V, significantly closer to nominal voltage of 240V than the control mean of 233V. While we cannot reject $\beta_2 = \beta_3$, taking this suggestive evidence together with the results in Subsection 7.2 (and with the results on engineering and socioeconomic outcomes discussed below) points to the substitutability of contract unbundling and enhanced monitoring in this context.

7.4 Engineering assessment and survey results

While the data just presented showed that WB procedures had no detectable impact on electricity quality, they appear to have improved construction quality in ways that could generate long-term benefits. Table 7 presents results using primary outcome indices pre-specified in the pre-analysis plan (Berkouwer et al. 2019). Outcomes 1–3 use site-level observations (largely from the engineering

[18] Furthermore, approximately 13% of households with a physical electricity connection had never seen electricity actually flow through this connection.

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

Table 6: 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	2.86
	(0.21)	(0.22)	(2.34)	(2.72)
Treatment for WB Sites	-0.00	0.33*	3.46	1.40
	(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	645655
Fixed effects	No	Yes	No	Yes
Control Mean	23.10	23.10	232.63	232.63
F-test $\beta_2 = \beta_3$ (p-val)	0.63	0.42	0.77	0.25

Notes: Columns (1) and (2) display daily hours of power per site. Columns (3) and (4) display hourly voltage per respondent (some observations are dropped in Column (4) in cases where there is only one observation in a fixed effects cell). 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). β_1, β_2, and β_3 are estimated as per Equation 2. Power quality is measured using GridWatch devices. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

assessments) while outcomes 4–8 use respondent-level observations (largely from the household and firm surveys). All indices are standardized to have a mean of zero and a standard deviation of one.

In one of the central results of this study, Column (1) of Table 7 (β_1) shows that overall construction quality (Outcome 1) was on average 0.64 standard deviations higher at WB-funded sites. This is driven by increased presence of pole caps, struts, and stays on poles at WB-funded sites (Table A9): recall that these are the technical components emphasized in the WB inspection reports. While Subsection 7.3 shows that these features apparently had limited impacts on power quality over the five years we observe, they can reasonably be expected to increase the lifetime of the poles—and thus the entire local LV network—over the longer term. Engineering research suggests that capped poles generally experience inner-pole moisture levels between 8–20% whereas uncapped poles experience levels between 30–80%, well above the threshold of 28–30% "considered necessary for fungal attack" (UPRC 2018).

Columns (2) and (3) of Table 7 estimate the audit treatment effect among WB- and AfDB-funded sites, respectively (β_2 and β_3). The estimate in Column (3) corresponds to the impact of enhanced monitoring among sites with bundled contracts. Additional audits did not affect outcomes at WB-funded sites. However, they did increase household installation quality among AfDB-funded sites (Outcome 4), driven by earlier meter activation and higher likelihood of having a working meter (Table A11). This substitutability is in line with the extensive margin effects discussed in Subsection 7.2 and the positive impact on voltage quality result presented in Subsection 6.3. The improvements in voltage quality and household installation quality likely contributed to the increase in household electricity access and usage estimated here (Outcome 8; Table A15). Outcomes 5, 6, and 7 (household cost and experience; reliability and safety; and knowledge) show little difference across WB- and AfDB-funded sites or due to the audit treatment (Table A12, Table A13, Table A14).

To isolate the impact of contract unbundling, we estimate the impact of WB contracting minus the audit treatment effect ($\beta_1 - \beta_3$). This yields an increase of 0.67 standard deviations (*p-val*

Table 7: 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	-0.04	0.19	-0.08	244
	(0.16)	(0.16)	(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)	

Notes: 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. β_1, β_2, and β_3 are estimated as per Equation 2. Column (1) displays the impact of World Bank (WB) funding relative to African Development Bank (AfDB) funding. Columns (2) and (3) display the audit treatment effect among WB- and AfDB-funded sites, respectively. In rows 1–3, observations are sites. In rows 4–8, observations are occupants of connected compounds. All regressions control for site land gradient and public facility type (given some baseline imbalance along these dimensions) and include constituency fixed effects. Standard errors are clustered by site and shown in parentheses. Table 10 reports the version with interaction terms. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$. The sub-components for each index are presented in Table A9 through Table A15. Table A16 through Table A18 present results on additional secondary outcomes specified in the pre-analysis plan (Berkouwer et al. 2019).

= 0.001) on the construction quality index and a –0.61 effect ($p\text{-}val < 0.001$) on the timing index. This suggests that unbundling contracts has substantial impacts on multiple important project outcomes.

The fact that the audit treatment differed somewhat from the WB inspection reports does not appear to drive these results. First, the audit treatment was delivered after contracts had been awarded, while contractors would have known about the inspection reports before bidding—unlike the inspection reports, the audit treatment therefore could not have operated through a selection effect. In practice, however, the contractors and subcontractors responsible for WB and AfDB funded sites are largely similar on observables (Subsection 7.5). Second, the inspection reports (Subsection 3.4) investigated more technical components of LV network construction (such as pole quality) whereas the audit treatment (Subsection 5.2) also emphasized the quality of household connections. This could explain why WB procedures affected core engineering components (Outcome 1) whereas the audit treatment at AfDB-funded sites primarily improved household installation quality (Outcomes 4 and 8), and why WB procedures did not have an impact on voltage quality while the audit treatment did improve voltage quality at AfDB-funded sites (Subsection 7.3), however is unlikely to have affected the relevant interactions.

In some contexts, bundling might incentivize excessively frugal designs so that the installing firm can save on supply and installation costs. In our context, this would show up as a lower number of poles in the designs. We do not find evidence of this in the aggregate (Outcome 2 of Table 7) or looking at specific design features individually (Table A10).

7.5 Selection of firms

One channel through which unbundling may have operated is through the selection of higher-type firms. The selection process for subcontractors by installers featured significantly less oversight than Kenya Power's official auctions. We investigate whether these distinct mechanisms led to differences in provider selection. Twenty-one companies were directly awarded at least one unbundled supplier contract and 29 companies were listed as a subcontractor for an AfDB-funded installer.[20] In addition to the winning bids, 185 competing bids for WB-funded supplier contracts were considered eligible. We focus on poles, cables, and conductors, which were procured through competitive auctions for unbundled WB-funded contracts but subcontracted out by AfDB-funded installers.

Firm types do not appear to differ substantially across the two contracting structures, at least along basic characteristics; of course, we cannot directly measure underlying firm quality, the theoretically relevant quantity. First, there is considerable direct overlap in the firms themselves: seven of 21 WB-funded contractors were also selected as subcontractors by AfDB-funded installers, and over half of the AfDB-funded subcontractors (15 out of the 29) appear on the bidder list, indicating that many firms actively sought to be funded by both donors. Second, while there is limited information available about these design and supply firms, the providers selected under AfDB and WB regulations appear to be similar along several observed dimensions. Approximately two-thirds of (sub)contractors were from Kenya, 10% were from China, and 10% were from India (Figure A11), and these proportions are similar for those awarded contracts with either WB or AfDB. 48% of WB contractors and 22% of AfDB subcontractors had also been awarded at least one other WB procurement contract prior to the start of the LMCP.

7.6 Discussion in the context of the theoretical framework

The results presented above broadly follow the conceptual framework implications outlined in Section 4. Combining unbundling and high monitoring generates unambiguously higher construction quality but incur additional delays (as observed by comparing WB-funded to AfDB-funded sites). From a benchmark of bundling and low monitoring, enhancing monitoring generates sizeable quality improvements, even though unbundling generates significantly higher costs and delays. Speculatively, under bundled contracting, installers can respond more effectively to the specific incentives generated by the additional inspections. Given that the additional inspections implemented by Kenya Power targeted slightly different dimensions than those implemented by our research team

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

(theirs focused more on construction whereas ours focused more on household connections), this is consistent with the fact that the quality improvement comes through in the construction quality index for WB-funded sites but the household installation index for treated AfDB-funded sites. These modest on-the-ground differences can explain why the quality levels achieved are not identical (as was predicted in the conceptual framework).

As noted above, the fact that the audit effects were limited at WB-funded sites could be due to two distinct reasons. First, this could be because unbundling and monitoring are substitutes rather than complements, and the WB procurement approach already includes unbundling. Second, it could be due to the diminishing marginal benefits of increased monitoring, since the WB already mandated an additional layer of inspections beyond those used at AfDB-funded sites.

7.7 Robustness

We conduct numerous robustness tests to confirm these results (Subsection D.7). All results in Table 7 control for land gradient and facility type, but not doing so does not qualitatively affect the results. Construction outcomes are generally not correlated with land gradient (Figure 10 and Figure A3) or with facility type (Table A4, Table A19, and Table A20). We also explore heterogeneity in the time between construction and power measurement (Subsection D.9), omit an ambiguous ready board question in the survey (Table A11), exclude one particular contractor that experienced unusual financial circumstances and a legal case[21] (Table A21), and drop sites that are located within 1,200 meters of another site (Table A22). None of these adjustments qualitatively affects the results described above.

8 Cost effectiveness

The improvement in overall construction quality at WB-funded sites at the cost of delays is a central finding of this study. This section examines the WB contracting structure's impacts on costs and cost effectiveness. One argument in favor of contract unbundling in this context (given to us informally by WB officials) is that it could generate cost efficiencies, specifically in that pooling the procurement of materials would generate purchaser market power that could lead to cost savings. Subsection 8.1 therefore investigates program costs, and Subsection 8.2 then investigates the trade-off between the costs of short-term construction delays versus the potential long-term benefits from greater infrastructure resilience (based on the framework from Equation 1 presented in Section 4).

[21] See *AEE Power SA v Kenya Power & Lighting Company Ltd* (2020).

Table 8: Site, connection, and materials costs by donor

		African Development Bank	World Bank	Percent Difference
(1)	Sites planned	4,184	4,308	+3%
(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%

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

8.1 Cost analysis

Kenya Power awarded $154 million in contracts for AfDB-funded sites and $133 million in contracts for WB-funded sites.[22,23] Table 8 presents project costs by donor. 4,184 AfDB-funded sites and 3,308 WB-funded sites had originally been slated for maximization, but only 71% of LMCP sites actually saw construction, according to survey data and conversations with Kenya Power personnel. The survey team identified on average 72 new LMCP household connections at AfDB-funded sites and 58 at WB-funded sites, implying that the average cost per household connection is $563 for contracts for AfDB-funded sites while it is $728—30% higher—for contracts for WB-funded sites.[24] Furthermore, these cost estimates exclude any additional Kenya Power staff labor hours associated with the WB's administrative and monitoring costs (i.e., in setting up additional contracts and bidding processes, etc.), which could exacerbate this cost difference. In sum, it does not appear that the WB was able to carry out lower-cost projects overall: in line with the conceptual framework, contract unbundling increased average costs per connection in this setting.

These cost estimates are slightly lower than the $739 average total cost per connection that Lee et al. (2020) estimate under a 100% electrification scenario in rural Kenya using data collected in 2014. The difference can be reasonably attributed to implementation efficiencies derived from nationwide coordination and general learning about rural electrification construction since 2014. In line with Lee et al. (2020), the observed costs exceed the value of rural electrification as measured through simulated willingness-to-pay ($293) and revealed preference ($147) approaches.

Taken at face value, the cost per pole enumerated in rows (6) and (7) of Table 8 would suggest that WB-funded contracts did secure poles more cheaply than AfDB-funded contracts. However,

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

[23]To the best of our knowledge, there are no cost overruns that would create a wedge between contracted and realized costs. Rather, increased costs per unit result in a lower quantity of output.

[24]The average cost per connection would have been $687 at AfDB-funded sites and $571 at WB-funded sites when using Kenya Power's initial public targets of on average 59 new connections at AfDB-funded sites and 74 at WB-funded sites (Kenya Power 2016b). Assuming 80 new connections at all sites would yield a construction cost of approximately $506 per household connection at AfDB-funded sites and a nearly identical $528 at WB-funded sites.

the contract amounts listed in bundled contracts may not reflect true procurement costs: our conversations with implementation contractors suggested that they sometimes shift labor costs onto materials on paper, as these invoices are paid sooner, generating additional liquidity. In contrast to the case of unbundled contracting, where the principal can observe each component's purchase cost, these practices are not observable to the principal when they are based on subcontractor relationships. This is an example of the opacity that bundled contracting can create for the principal.

As another example of gaps between reporting to the principal and on-the-ground measurements, there appear to be disparities between contracted and built quantities. According to the procurement contracts, 18% of poles at WB-funded sites and 50% of poles at AfDB-funded sites were concrete—however, according to our on-the-ground surveys of all poles in our sample sites, only 3% of poles at WB-funded sites and 25% of poles at AfDB-funded sites were concrete.[25]

8.2 Cost-benefit analysis

The delays and 30% higher cost per electricity connection for contracts funded by the WB documented above might be worth it if the gains in construction quality are sufficiently large. We thus next evaluate the gains in quality against the cost per connection and the estimated impacts of construction delays on welfare to shed light on the key conceptual trade-off represented by Equation 1 in Section 4.

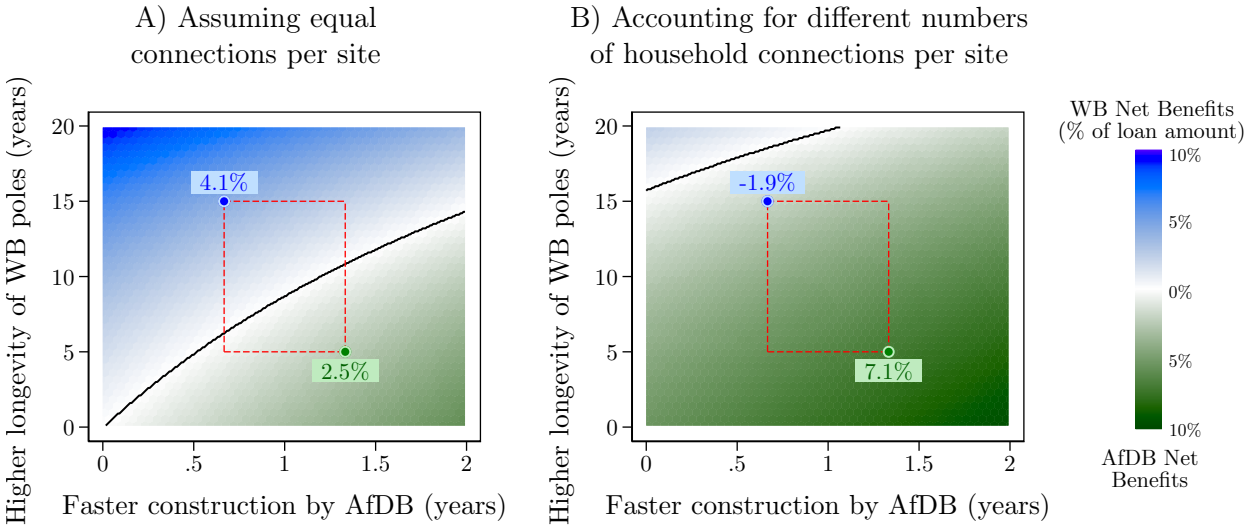
AfDB-funded sites reached construction milestones 8 to 16 months earlier than WB-funded sites on average, increasing the net present value of new connections. WB-funded sites saw improved pole and pole installation quality, potentially increasing pole longevity by an estimated 5–15 years and reducing long-term repair and replacement costs for Kenya Power (UPRC 2018). We also factor in that only 71% of sites were completed, and assume that households discount delayed electricity access at a 10% annual discount rate while the social planner discounts future maintenance costs at 5% per year (Figure A12 presents alternative scenarios). This analysis focuses on audit control sites to avoid confounding these differences with the audit treatment's heterogeneous impacts; we separately assess the costs and benefits of the audit treatment below.

Figure 8 presents the results in two panels to emphasize the role of one important attribute, namely, the number of household connections. Panel A supposes that WB- and AfDB-funded sites both benefit from 80 new household connections. Panel B reflects our count of LMCP household connections on the ground, which average 72 at AfDB-funded sites and 58 at WB-funded sites among audit control sites. These additional connections sway the net benefits calculations heavily in favor of AfDB procedures.

In each panel, the gradient illustrates the estimated net benefits of using WB versus AfDB contracting approaches. Moving upwards on the vertical axis represents decreased present-discounted costs due to improved infrastructure longevity at WB-funded sites (corresponding to a reduction of long-term maintenance costs in Equation 1). Moving to the right on the horizontal axis repre-

[25] We interpret this result with some caution since we cannot distinguish existing poles from poles those constructed during LMCP. If pre-existing poles were disproportionately wood poles then this could explain part of the discrepancy.

Figure 8: Costs versus benefits of different contracting approaches



Notes: 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 20-year time horizon and an annual discount rate of 5%. The horizontal axis represents the gains from households benefiting sooner. The vertical axis represents improved 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 80 new household connections per site at all sites. Panel B reflects our count of household connections on the ground, which average 72 at African Development Bank-funded sites and 58 at World Bank-funded sites. Figure A12 explores additional assumptions.

sents increased present-discounted benefits due to fewer delays in construction at AfDB-funded sites (corresponding to an increase in welfare gains in Equation 1).

To illustrate the uncertainty in these estimates, the red box marks a range of 8 to 16 months faster construction and between 5 to 15 years of additional service life for poles, consistent with the data and with Muthike and Ali (2021). Using plausible estimates of the gains in construction speed and in quality of poles, the overall net benefits of either set of procurement policies are ambiguous, ranging anywhere from WB procedures having a net benefit worth 4% of total project costs to AfDB procedures having a net benefit worth 7% of project costs. (Figure A12 displays qualitatively similar results under a range of alternative assumptions.)

Under a shorter time horizon, or if the value of a connection to households were larger, the relative benefits of AfDB contracting would be more pronounced, up to 16% of the total. Under a lower discount rate the relative benefits of WB contracting would be more pronounced, up to 5% of the total. However, it appears unlikely that WB procurement procedures would have generated the 30% improvement required to make up for the increased costs per connection.[26]

Section 7 showed that the additional audits improved some household installation outcomes at AfDB-funded sites. The audits were conducted at an average cost of approximately $500 per site

[26]This result holds across a fairly broad range of assumptions. 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.

(around 1.2% of the average LMCP cost per site). While the audit treatment did not increase the number of drop-down cables (Table 5), electricity actually flowed through those connections for approximately 8% more households, and the audit treatment increased the fraction of households with a working meter by 11% (Table 7, detailed in Table A11). Valuing each additional working connection conservatively at $147, the implied added value of $1,029 far exceeds the cost of the audit treatment. This is despite the fact that the audit treatment activity was more involved and thus more expensive than would be needed in other contexts as they also included household and firm surveys, which are not part of the standard inspection reports (IRs) conducted at WB-funded sites. These results are consistent with the framework presented in Section 4: bundled contracts with high levels of monitoring may successfully incentivize higher effort (and the selection of high quality firms), with fewer delays and administrative costs as compared with unbundled contracts.

These results come with important caveats. The cost calculations do not consider the additional staff time incurred by Kenya Power, the WB, and other government agencies due to increased paperwork and processing necessary to implement WB contracting procedures. The benefit calculations also do not consider spillovers such as increased knowledge of oversight mechanisms among Kenyan government agencies, which could positively affect other programs. We also do not consider possible degradation of electricity service quality and reliability over time due to lower quality construction. Perhaps most importantly, we do not directly observe the leakage of funds. It is possible that WB contracting requirements meaningfully reduced leakage, which was recently observed to be substantial for WB lending (e.g. Andersen et al. 2022). However, to the extent that WB procedures increased the availability of funds for intended construction by reducing leakage, this does not appear to have increased the number of household connections.

8.3 Policy discussion

We next complement the empirical results with qualitative data gathered during interviews with officials at Kenya Power, the WB, and the AfDB over several years, to better understand key processes.[27] This work found that Kenya Power's administrative burden under unbundling was significantly higher than under bundled contracting. The greater absolute number of contracts and the substantial heterogeneity in legal details across different types of contracts required more Kenya Power staff time to write, issue, review, and award bids. Contracting between the principal and the designers and suppliers was significantly more involved (requiring official tender and bid review processes) than the subcontracting processes used by AfDB installers for those same goods and services. Despite these substantial differences in staffing demands across the two donors, total Kenya Power staff time availability for these administrative tasks was equal across the WB and AfDB components (one full-time staff member each), and 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). It is possible that increasing Kenya Power staff time for the unbundled WB

[27] Appendix E provides an anonymized list of individuals with different project roles and responsibilities that the research team interviewed for this research.

contracts might have moderated some of the delay caused by unbundling, though at the expense of incurring additional administrative costs.

Unbundled contracting also created coordination frictions, exacerbating administrative costs and delays. The lack of coordination between the design and installation contracts meant that designs were sometimes out of date by the time construction began, requiring costly adjustments to the designs or the procurement of additional materials. Similarly, a lack of coordination between materials and installation contracts meant that materials were often physically transported into Kenya Power custody before installers were ready for them, accruing expensive storage fees. These coordination frictions were substantially lower for bundled contracts, where installers could more easily adjust designs or acquire additional supplies at their discretion.

In interviews, we learned that one of the WB's internal reasons for choosing unbundled contracting was the belief that having coordinated nationwide contracts for major materials purchases would enable them to secure lower prices through auction. This turns out to have been true on paper: the cost per wooden (concrete) pole was 38% (17%) lower in the WB contracts when compared with the AfDB contracts. However, as noted in Subsection 8.1 above, the aggregate costs per site and per successful connection are in fact substantially higher at WB-funded sites.

8.4 Broader policy lessons

The cost-benefit calculations above illustrate the trade-offs that influence the relative benefits of different procurement contracting approaches for large-scale infrastructure projects more generally, even beyond our case of rural residential electrification in Kenya. If the planner discounts future costs and benefits more severely, if benefits are larger such that delays are more undesirable, or if unbundling is expected to produce especially large delays then bundling contracts may be more attractive. For example, when building emergency shelters for disaster relief or clinics in response to a health emergency, the longevity of construction may be relatively unimportant while delays are particularly harmful.

Conversely, if bundling is expected to cause a greater decline in quality—perhaps because there are many low quality local firms bidding for projects—or if future costs of remedying low quality construction are especially important, then unbundled contracting may yield higher net benefits. For example, building a bridge or a dam may have long-term regional benefits, while the future costs of addressing structural issues associated with low quality construction can be substantial. In some settings, a combination of bundled contracting with enhanced monitoring may generate quality improvements with less delay or administrative cost than unbundling.

9 Conclusion

Outsourcing public goods provision creates a standard misaligned incentives problem: how can a principal identify good contractors and incentivize them to provide high quality projects? Public procurement regulations can thus have important implications for the costs, timeliness, and quality

of infrastructure construction, a major spending category for governments and aid donors. One key decision the principal faces is whether to unbundle the various components of a project across contracts auctioned to private firms, or whether to award a single bundled contract that includes multiple components. This decision is ubiquitous in public contracting, but causal inference on this topic has been hampered by the infrequency, endogeneity, and complexity of infrastructure projects.

We present a stylized framework to provide intuition for this problem: unbundling can improve outcomes by enforcing more stringent eligibility criteria on subcontractors, but may introduce additional delays and inefficiencies. Furthermore, combining bundled contracting with high monitoring can achieve similar quality standards but with significantly fewer administrative costs and delays, because it leverages bundled contractors' private information about potential subcontractors while still exploiting the synergies inherent in contract bundling.

We then use natural policy and experimental variation to study these questions 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. To disentangle the impacts of contract unbundling and enhanced monitoring we implement an additional randomized audit treatment at a subset of sites.

We find that WB-funded sites experience significant delays in project implementation, with households receiving electricity on average 16 months later than households in AfDB-funded sites. Yet there is a stark trade-off: we estimate a 0.6 standard deviation improvement in construction quality at WB-funded sites, driven by increased presence of pole caps, stays, and struts, which were key components examined during the additional inspection round required under WB procedures. While we find no immediate impacts on reliability and voltage quality, these quality improvements could have long-term impacts on the longevity of the local infrastructure network.

The audits generate a 0.2 standard deviation improvement in household installation quality and a 0.3 standard deviation improvement in electricity usage at AfDB-funded sites, while causing significantly shorter delays than those caused by unbundled contracting sites. The enhanced monitoring has no impact at WB-funded sites, most likely due to the substitutability of monitoring and unbundling, or because additional monitoring has a decreasing marginal effect.

Comparing the procurement processes in this context may generate insights for a trade-off relevant to a wider range of infrastructure projects. The policymaker may need to weigh the short-term benefits of achieving earlier project completion (the AfDB-funded approach in this context) versus the longer-term benefits arising from improved project quality (under the WB-funded approach), according to their time preferences. We evaluate this trade-off under a plausible range of assumptions and find that neither approach definitively dominates the other in this context: the results imply anything from a net benefit of 7% of project value in favor of the AfDB approach to a net benefit of 4% of project value in favor of the WB approach.

In this context, enhanced monitoring appears to be an effective and lower-cost substitute for contract unbundling, achieving significant improvements in construction quality without the de-

lays. Furthermore, unbundling contracts greatly increases the principal's administrative burden, which—in contexts where staff time and human capital are constrained—can generate substantial delays. Taken together, these results suggest that combining bundled contracting with more rigorous monitoring could reduce delays while maintaining construction quality standards.

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

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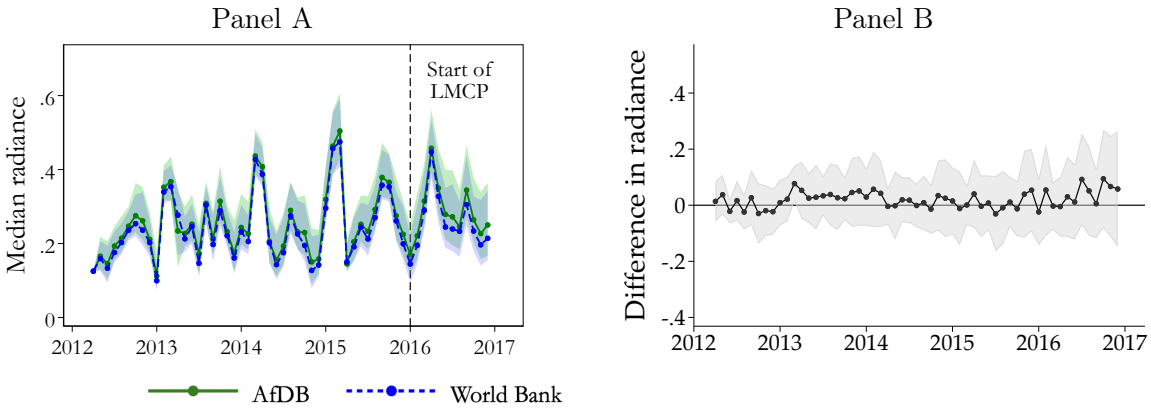
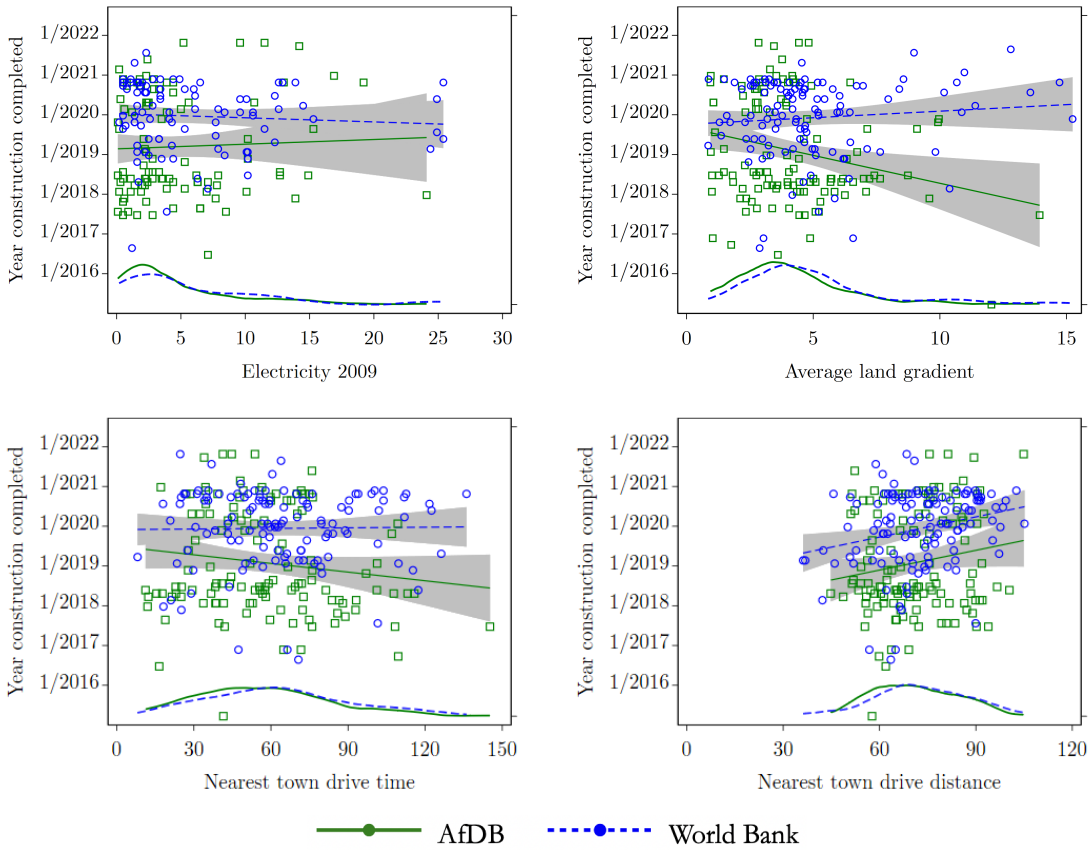
Additional tables and figures

Figure 9: Site-level nighttime radiance by funding source, study sites



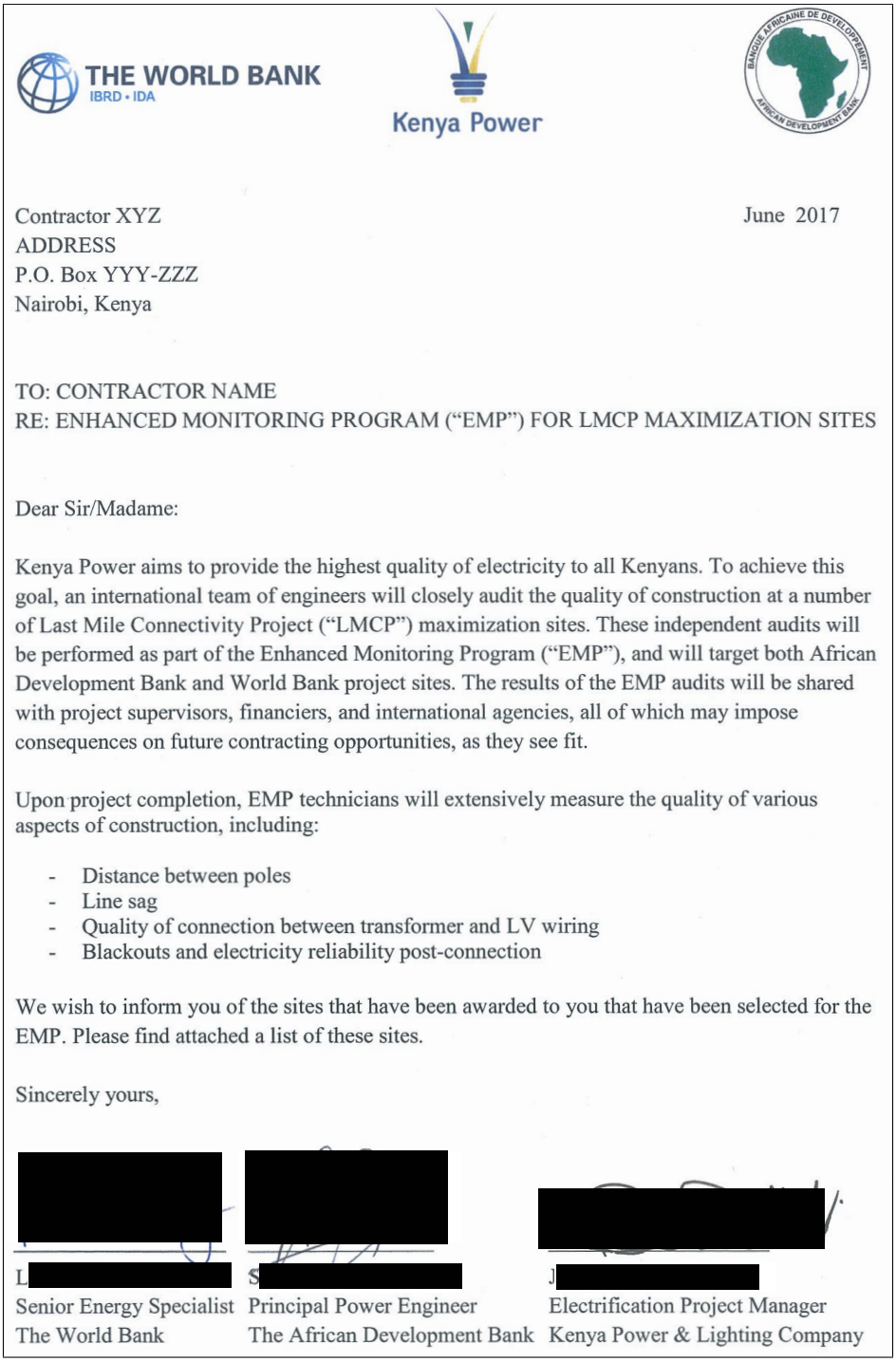
Notes: Panel A presents median monthly nighttime radiance (VIIRS), with bands showing the 25th to 75th percentile across sites, before and after the start of the LMCP. Panel B confirms that radiance is statistically indistinguishable across sites (estimates include constituency FE). Table A1 confirms baseline balance using a pooled regression of these data. Figure A2 performs the same analysis on the national sample of phase 1 transformers.

Figure 10: Construction Delays and Geographic Features



Notes: Differences in construction delays between WB and AfDB are approximately constant across the distribution of baseline electricity access, land gradient, and distance to nearest town. Baseline electricity data from Kenya National Bureau of Statistics (2006; 2009). Average land gradient is calculated for each site over the 600 meter radius around its transformer using the 90-meter Shuttle Radar Topography Mission Global Digital Elevation Model. Towns from WRI (2007); distances calculated using HERE (2022).

Figure 11: 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

Notes: This figure displays the monitoring intervention sent to contractors. All letters were signed by relevant representatives from Kenya Power, the World Bank, and the African Development Bank, with their names and positions listed below. Each letter specified the contractor's name and contact information. The letters were then hand-delivered to management at the relevant contractors by members of our research team to ensure receipt, together with the list of treatment sites referenced in the letter.

Table 9: Construction timing

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 3: Construction timing index	0.00	-0.90***	-0.07	-0.29*	250
	[1.00]	(0.17)	(0.16)	(0.17)	
LMCP construction start date (months since Jan 2015)	37.22	10.18***	1.66	4.00**	250
	[11.38]	(1.90)	(1.72)	(1.93)	
Pole erection completion date (months since Jan 2015)	45.20	9.90***	1.85	3.52	249
	[15.17]	(2.67)	(2.49)	(2.59)	
Stringing completion date (months since Jan 2015)	46.91	9.47***	1.33	2.70	247
	[15.48]	(2.76)	(2.52)	(2.56)	
Metering completion date (months since Jan 2015)	47.73	15.67***	-1.23	4.71*	226
	[14.56]	(2.48)	(2.17)	(2.65)	
months between construction start and pole erection complete	7.83	-0.06	0.18	-0.32	249
	[10.19]	(1.81)	(1.63)	(1.52)	
months between pole erection complete and stringing complete	1.90	-0.73	-0.48	-0.53	246
	[4.41]	(0.80)	(0.64)	(0.68)	
months between stringing complete and metering complete	0.95	6.25***	-2.01*	0.37	224
	[8.04]	(1.53)	(1.20)	(1.47)	

Notes: 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 6).* ≤ 0.10,** ≤ .05,*** ≤ .01.

Table 10: 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	0.13	250
	(0.21)	(0.18)	(0.28)	
Outcome 2: Network size and configuration index	-0.04	-0.08	0.27	244
	(0.16)	(0.18)	(0.24)	
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)	

Notes: Outcome variables are indices constructed from groups of variables standardized to have mean 0 and standard deviation 1. Each column presents results when the treatment variable is either: (1) WB funding source, or (2) the randomized audit treatment. In rows 1–3, observations are transformer sites; standard errors are shown in parentheses. In rows 4–8, observations are individual respondents. Table 7 presents a version with separate treatment effects. All regressions control for site land gradient and public facility type. Standard errors are clustered by transformer site and shown in parentheses. * ≤ 0.10,** ≤ .05,*** ≤ .01.