SAHEL INTERNATIONAL JOURNAL OF ADMINISTRATION AND GOVERNANCE
Volume 1 | Issue 1 | January-June 2026

Electricity Outages, Adaptive Self-Generation and Firm Growth in Africa: Doubly Robust Evidence from Seven 2025 World Bank Enterprise Surveys

Adamu Jibrilla[1], Kwaji Ble Ngida[2] and Teri John[1]

[1] Department of Economics, Adamawa State University, Mubi, Nigeria
[2] Public Affairs and Public Policy Department, Nigerian Economic Summit Group (NESG), Nigeria
Corresponding author: adamjibril85@gmail.com | Other emails: kwajiblengida@gmail.com; kwaji.blengida@nesgroup.org; kwayateri@gmail.com

Abstract

Reliable electricity is a productive input, yet firms across much of Africa operate under recurrent outages and respond by installing costly self-generation. This article examines whether outage exposure and intensity are associated with firm growth and whether generator ownership moderates the relationship. We harmonize the 2025 World Bank Enterprise Surveys for Burundi, Comoros, Guinea, Guinea-Bissau, Liberia, Malawi and Nigeria, producing a pooled sample of 1,981 formal firms. The empirical design combines country-normalized sampling weights, country fixed effects, rich firm controls, heteroskedasticity-robust inference, country-clustered inference, continuous outage-intensity models and five-fold cross-fitted augmented inverse-probability weighting (AIPW). Approximately 83.1% of firms experienced an outage, 69.7% owned or shared a generator and 15.6% used solar power. In the weighted fixed-effects specification, outage exposure is associated with 1.20 percentage points lower annualized sales growth, although the estimate is imprecise. The doubly robust AIPW estimate is −1.85 percentage points ($p = 0.088$). A one-unit increase in log monthly outage-hours is associated with 0.50 percentage points lower sales growth; statistical significance is sensitive to the variance estimator. Employment effects are negative but imprecise. Generator ownership neither predicts faster growth nor significantly attenuates the outage penalty, suggesting that private backup is an incomplete and potentially costly substitute for reliable grid supply. The findings are best interpreted as robust conditional associations rather than definitive causal effects because outage exposure is non-random and the surveys are cross-sectional. Policy should prioritize reliability-enhancing grid investment while expanding cleaner, financeable resilience options for firms.

Keywords: *electricity outages; firm growth; self-generation; generators; Africa; Enterprise Surveys; AIPW*
JEL classification: D22; L25; L94; O12; O55

1. Introduction

Electricity reliability is a foundational condition for modern production. Interruptions halt machinery, disable digital systems, damage materials, disrupt delivery schedules and force firms to substitute toward expensive backup technologies. These mechanisms are especially consequential in low- and middle-income economies, where the grid is often less reliable and firms have thinner financial buffers. The contemporary policy relevance is substantial: the World Bank and African Development Bank's Mission 300 aims to connect 300 million people in Africa to electricity by 2030, but productive impact depends not only on connection rates but also on the quality, affordability and reliability of supply (IFC, 2025; World Bank et al., 2025).

A large empirical literature links electricity shortages to weaker firm performance. Evidence from India shows that shortages reduce plant revenue and producer surplus, even when firms adapt through self-generation (Allcott et al., 2016). African studies similarly identify sales, productivity and capacity-utilization losses (Cole et al., 2018; Abeberese et al., 2021; Osei-Gyebi and Dramani, 2023). Recent

cross-country work reports a negative relationship between power constraints and revenue-based total factor productivity (Apeti and Ly, 2024), while a 2025 study of African manufacturing emphasizes the joint role of outages and in-house generation in capacity utilization (Zhang et al., 2025). The central policy issue is therefore not whether electricity matters, but how much recent outage exposure constrains firm growth and whether private adaptation meaningfully protects firms.

Self-generation may preserve continuity, but it is not equivalent to reliable grid electricity. Generators require upfront capital, fuel, maintenance and managerial attention; small firms may be rationed out of this response, while adopters may operate generators only for critical loads. Earlier work documents substantial generator use under unreliable supply and warns that decentralized diesel generation is often more expensive than grid power (Steinbuks and Foster, 2010; Oseni and Pollitt, 2015). Recent evidence also suggests that adaptation technologies have heterogeneous effects across sectors and performance margins (Mounmemi, 2026). Accordingly, generator ownership could buffer outage losses, merely proxy for firms facing more severe outages, or even impose costs that offset its continuity benefit.

This study contributes in four ways. First, it uses seven newly available, common-year 2025 Enterprise Surveys—Burundi, Comoros, Guinea, Guinea-Bissau, Liberia, Malawi and Nigeria—thereby avoiding temporal mismatch across countries. Second, it distinguishes the extensive margin of outage exposure from a continuous measure of monthly outage-hours. Third, it evaluates generator ownership both directly and as a moderator of outage exposure. Fourth, it complements weighted fixed-effects regressions with cross-fitted AIPW. The latter combines an exposure model and outcome models and is consistent if either nuisance component is correctly specified, subject to overlap and conditional exchangeability (Robins et al., 1994; Chernozhukov et al., 2018).

The results reveal pervasive electricity insecurity: 83.1% of firms experienced outages and 69.7% owned or shared a generator. The weighted fixed-effects estimate for outage exposure is negative but not statistically precise. The AIPW estimate indicates a 1.85-percentage-point annualized sales-growth deficit among outage-exposed firms, significant only at the 10% level under country-clustered inference. Greater outage intensity is also negatively associated with sales growth, but inference is sensitive because only seven country clusters are available. Generator ownership does not significantly moderate the association. These findings support a reliability-first policy approach and caution against treating firm-level generators as a complete substitute for network reform.

2. Literature Review and Conceptual Framework

2.1 Electricity reliability and firm performance

In a production-function framework, effective electricity services enter alongside capital, labour and intermediate inputs. An outage lowers the utilization rate of installed capital and may destroy output already in process. If production stages are complementary, a short interruption can have a disproportionate effect because idle labour and machinery cannot be costlessly shifted across time. Firms can reschedule production, hold inventories, adjust shifts or generate electricity privately, but each response is costly. The resulting effect on measured sales depends on lost production, delayed delivery, quality deterioration, customer substitution and the firm’s ability to recover output later.

The empirical evidence broadly supports these mechanisms. Allcott et al. (2016) show that Indian manufacturers adjust their input mix and self-generate, yet shortages still reduce revenue and producer surplus. Fisher-Vanden et al. (2015) find that Chinese firms responded to shortages by outsourcing energy-intensive inputs, illustrating adjustment along supply chains rather than only through own generation. Using African firm data and an instrumental-variable strategy, Cole et al. (2018) report significant sales effects, while Abeberese et al. (2021) document productivity losses and firm responses in Ghana. Cissokho (2020) finds productivity costs among Senegalese manufacturers, and Osei-Gyebi and Dramani (2023) report adverse performance effects across sub-Saharan Africa.

Recent studies deepen the cross-country evidence. Xiao et al. (2022) connect electricity shortages to firm productivity in a broad Enterprise Survey sample. Apeti and Ly (2024) find that outage duration lowers revenue-based total factor productivity in developing countries and that effects vary with firms' technological and institutional environments. Zhang et al. (2025) focus on African manufacturing and find that outages and in-house generation jointly shape capacity utilization. Together, these studies motivate a design that considers exposure, intensity and adaptation rather than a single binary electricity variable.

2.2 Adaptation, generators and the resilience trade-off

Backup generation represents organizational redundancy: firms sacrifice static cost efficiency to maintain operations during a shock. Resilience theory predicts that such redundancy can reduce the immediate production discontinuity, but its net performance effect depends on acquisition cost, fuel price, utilization, scale economies and the fraction of load covered. Generator adoption is also endogenous. Productive, financially capable and electricity-intensive firms are more likely to purchase generators, while firms exposed to severe outages have stronger incentives to adopt. A naïve positive coefficient may therefore reflect firm capability; a negative coefficient may reflect adverse selection into adoption.

African evidence shows that self-generation is widespread but expensive. Steinbuks and Foster (2010) demonstrate that unreliable public supply induces own generation, especially among larger and more electricity-intensive firms. Oseni and Pollitt (2015) quantify high costs of backup generation in Africa. More recent work emphasizes that backup generators may improve turnover while reducing net income because operating costs absorb the continuity benefit (Mounmemi, 2026). Solar and storage could provide cleaner resilience, but adoption remains constrained by finance, system sizing and technical capability. This suggests a "partial insurance" hypothesis: generators may protect selected activities without eliminating the growth penalty from unreliable grid supply.

2.3 Research gap and hypotheses

Three gaps motivate the present analysis. Many cross-country studies combine surveys conducted in different years, making common shocks and technological trends difficult to separate from country differences. Generator studies often model adoption or average performance but do not test whether ownership changes the outage–growth relationship. Finally, conventional regressions can be sensitive to functional-form assumptions when outage exposure is strongly selected. A harmonized common-year sample and a doubly robust estimator help address these limitations, although they cannot remove bias from unobserved confounding.

The analysis evaluates three hypotheses. H1: outage exposure and greater outage intensity are associated with slower firm sales and employment growth. H2: generator ownership is associated with improved firm growth after conditioning on observable characteristics. H3: generator ownership attenuates the negative association between outage exposure and growth. Given the cost of backup power, H2 and H3 are empirical rather than directional certainties.

3. Data and Methodology

3.1 Data source and sample

The study uses the 2025 World Bank Enterprise Surveys for seven African economies. The surveys interview owners and senior managers of formal, privately owned establishments with at least five workers. They use stratified random sampling by firm size, sector and geographic region, and supply sampling weights to recover population-relevant estimates (World Bank Enterprise Surveys, 2025a). The standardized instrument makes core electricity, sales, employment, ownership, finance, innovation and digital-use variables comparable across countries.

The pooled raw sample contains 1,981 firms: Burundi (161), Comoros (153), Guinea (160), Guinea-Bissau (153), Liberia (158), Malawi (153) and Nigeria (1,043). Negative survey codes indicating “do not know,” “not applicable” or refusal are treated as missing. Outcome-specific estimation samples are smaller because current and lagged performance measures and covariates must be observed. To prevent the Nigerian sample from mechanically dominating the pooled analysis, the median survey weight is divided by its country-specific mean. This preserves within-country sampling structure while giving each country an approximately comparable aggregate contribution.

3.2 Variables

Construct	Operational definition	Survey item(s)
Sales growth	Annualized log change in nominal sales over three years; winsorized at pooled 1st/99th percentiles	d2, n3
Employment growth	Annualized log change in permanent full-time employment over three years; winsorized	l1, l2
Outage exposure	1 if the establishment experienced an electrical outage in the last fiscal year	c6
Outage intensity	ln(1 + frequency × average duration in hours) per typical month; zero for non-exposed firms	c7, c8a, c8b
Generator	1 if the firm owned or shared a generator	c10
Solar adoption	1 if the firm used solar power	c43
Controls	Age, manager experience, foreign share, exporter, loan, innovation, website, female ownership, sector, size and country effects	b5, b7, b2b, d3b/d3c, k82a, h1, c22b, b4, a4a, a6a

Notes: Sales and employment growth are expressed in percentage points per year: 100[ln(Yt) − ln(Yt−3)]/3. Nominal sales growth is not deflated within country because a consistent firm-level price deflator is unavailable; country fixed effects absorb common national inflation but not firm-specific price changes.

3.3 Econometric strategy

The baseline weighted least-squares model is:

$$g_i c = \alpha + \beta\ Outage_i c + X_i c'\gamma + \mu c + \varepsilon_i c, \quad (1)$$

where g is annualized sales or employment growth, X is the vector of firm controls and μc denotes country fixed effects. Equation (1) compares observationally similar firms within the pooled country structure. A second model replaces the binary exposure with log monthly outage-hours. A third adds generator ownership, and a moderation model includes Outage × Generator:

$$g_i c = \alpha + \beta_1 Outage_i c + \beta_2 Generator_i c + \beta_3 (Outage_i c \times Generator_i c) + X_i c'\gamma + \mu c + \varepsilon_i c. \quad (2)$$

The buffering hypothesis requires $\beta_3 > 0$. We report HC3 heteroskedasticity-robust standard errors and country-clustered CR1 standard errors. Neither is perfect: HC3 does not model within-country correlation, while only seven clusters make conventional cluster inference fragile. Conclusions therefore emphasize sign, magnitude and consistency across estimators rather than a mechanical significance threshold (Cameron and Miller, 2015).

To reduce dependence on a single parametric outcome equation, the study estimates the average treatment effect of outage exposure using five-fold cross-fitted AIPW. In each training fold, a weighted logistic model estimates the propensity to experience an outage and separate weighted linear models estimate potential outcomes for exposed and unexposed firms. Predictions are generated only for held-out observations. Propensities are trimmed to [0.05, 0.95], and the AIPW score is:

$$\psi_i = \hat{m}_1(X_i) - \hat{m}_0(X_i) + A_i[Y_i - \hat{m}_1(X_i)]/\hat{e}(X_i) - (1-A_i)[Y_i - \hat{m}_0(X_i)]/[1-\hat{e}(X_i)]. \quad (3)$$

AIPW is doubly robust in the sense that, under conditional exchangeability, positivity and consistency, the estimator is consistent if either the propensity model or the outcome model is correctly specified (Robins et al., 1994). Cross-fitting reduces overfitting bias and permits flexible nuisance estimation (Chernozhukov et al., 2018). In this application, “treatment” is observed exposure rather than an assigned intervention. Thus, AIPW improves observable-confounding adjustment but does not justify an unconditional causal interpretation.

4. Results

4.1 Descriptive evidence

Electricity disruption is widespread but heterogeneous. In the country-normalized weighted sample, 83.1% of firms report an outage, 69.7% own or share a generator, 15.6% use solar power, and 47.1% rate electricity as a major or very severe obstacle. Exposure ranges from 64.5% in Liberia to 93.9% in Burundi. Generator ownership ranges from 31.2% in Burundi to 90.5% in Liberia. The contrast is substantively important: Liberia combines the lowest measured outage prevalence with the highest generator penetration, plausibly reflecting adaptation, selection into grid use or differences in reporting and supply arrangements.

Country	N	Outage %	Generator %	Solar %	Major/ severe obstacle %	Median outages/month	Median duration (h)
Burundi	161	93.9	31.2	8.2	44.1	6	1.0
Comoros	153	91.7	58.1	18.0	84.8	40	4.0
Guinea-Bissau	153	72.2	42.5	9.7	14.0	4	0.5
Guinea	160	91.1	49.9	0.6	5.9	3	2.0
Liberia	158	64.5	90.5	3.0	78.1	10	4.5
Malawi	153	89.1	35.3	12.7	26.4	10	3.0
Nigeria	1043	82.5	86.3	22.0	51.6	10	5.0
Pooled	1981	83.1	69.7	15.6	47.1	—	—

Notes: Percentages use country-normalized median sampling weights. Medians are calculated among observations with nonnegative reported values and, for frequency/duration, principally describe outage-exposed firms.

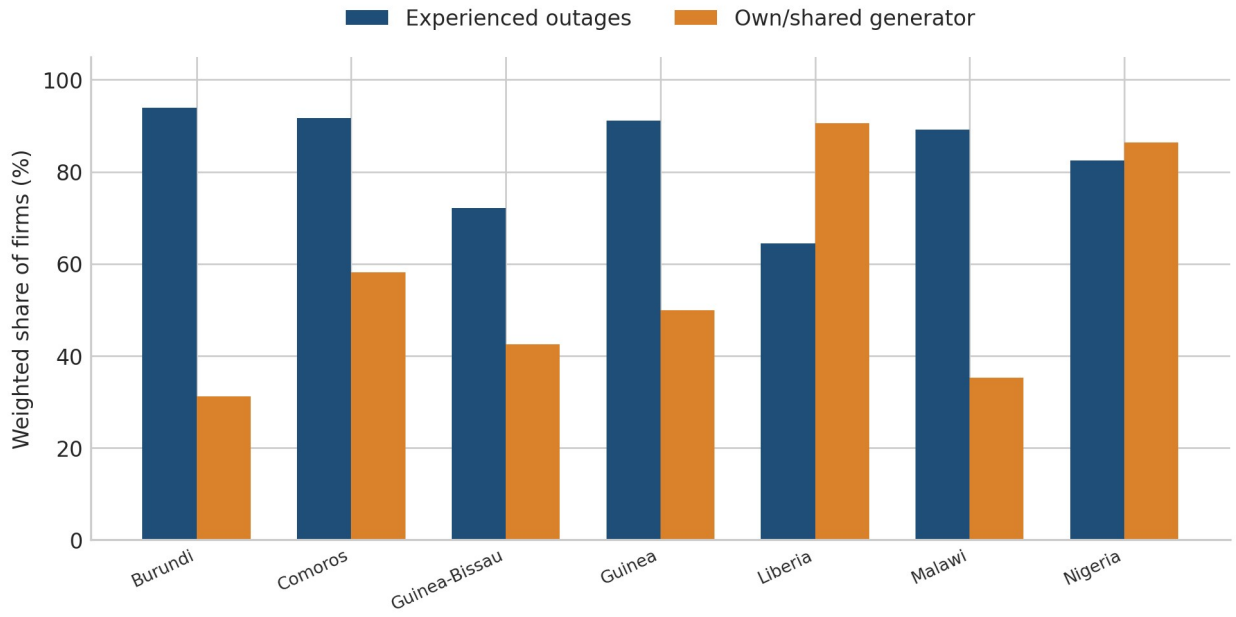


Figure 1. Electricity outage exposure and generator ownership by country

4.2 Baseline, intensity and doubly robust estimates

Table 2 reports the principal estimates. In the weighted fixed-effects model, outage exposure is associated with 1.20 percentage points lower annualized sales growth (country-clustered p = 0.159) and 0.74 percentage points lower employment growth (p = 0.309). These estimates have the expected sign but are not conventionally significant. The continuous intensity model is more informative: a one-unit increase in log monthly outage-hours is associated with 0.50 percentage points slower annualized sales growth. Country-clustered inference produces p = 0.009, whereas HC3 inference produces p = 0.106. The discrepancy reinforces the need for caution with seven clusters.

The cross-fitted AIPW estimate is −1.85 percentage points for annual sales growth (p = 0.088) and −2.20 percentage points for employment growth (p = 0.124). Estimated propensities retain usable overlap after trimming, ranging from 0.15 to 0.95 in the sales sample and 0.12 to 0.95 in the employment sample. The AIPW magnitudes are larger than the regression-adjusted estimates, suggesting that observed characteristics of outage-exposed firms partly mask the underlying negative association.

Outcome / estimator	Exposure measure	Estimate	HC3 SE	HC3 p	Country-cluster SE	Cluster p	N
Sales growth: WLS	Outage indicator	−1.200	1.429	0.401	0.747	0.159	1,777
Employment growth: WLS	Outage indicator	−0.743	0.910	0.414	0.670	0.309	1,837
Sales growth: WLS	ln(1 + outage-hours)	−0.500	0.310	0.106	0.131	0.009	1,715
Employment growth: WLS	ln(1 + outage-hours)	−0.103	0.216	0.633	0.181	0.588	1,761
Sales growth: AIPW	Outage indicator	−1.852	—	—	0.909	0.088	1,777
Employment growth: AIPW	Outage indicator	−2.204	—	—	1.234	0.124	1,837

Notes: Outcomes are annualized percentage-point log growth rates, winsorized at the pooled 1st and 99th percentiles. WLS models include age, manager experience, foreign ownership, exporter, loan, innovation, website, female ownership, sector, size and country effects. AIPW uses five-fold cross-fitting and the same adjustment set. Cluster p-values use a t distribution with six degrees of freedom. "—" denotes not applicable.

4.3 Generator moderation and robustness

Generator ownership is not associated with faster sales growth after adjustment. In the model without an interaction, its coefficient is 0.22 percentage points (p = 0.589). In the interaction model, the outage coefficient is −0.55, the generator coefficient is 1.08 and the interaction is −1.10; all are imprecisely estimated. The negative interaction does not support the proposition that ownership systematically buffers the growth effect of outages. This is plausible if generators cover only selected processes or if their fuel and maintenance costs offset continuity benefits.

Term	Coefficient	Country-cluster SE	p-value
Outage exposure	−0.553	1.990	0.794
Generator ownership	1.082	1.506	0.495
Outage × generator	−1.099	2.195	0.635

Notes: Dependent variable is annualized sales growth. The model contains the full control set, country fixed effects and country-normalized sampling weights; N = 1,775; weighted R^2 = 0.095.

As a sector-specific check, the manufacturing-only sample provides no evidence that outage exposure or intensity is associated with contemporaneous capacity utilization: the binary-outage coefficient is 1.16 percentage points (p = 0.697; N = 357), and the intensity coefficient is 0.04 (p = 0.968; N = 349). The null result may reflect small samples, adaptation, measurement noise, or the fact that reported capacity utilization captures a different time window from retrospective growth. It also demonstrates that the negative sales-growth pattern should not be generalized mechanically to every operational outcome.

5. Discussion

The descriptive results establish that electricity insecurity is a near-systemic business condition in the seven economies. Four out of five firms report outages, while roughly seven out of ten own or share a generator. The coexistence of high outage and generator rates is consistent with an equilibrium in which firms privately insure against unreliable public supply. However, generator adoption is highly uneven, creating a likely resilience gap between firms that can finance redundant capacity and those that cannot.

The econometric results are consistent with H1 for sales growth but less conclusive for employment. Binary exposure estimates are negative but imprecise; outage intensity and AIPW produce larger or more precise negative sales estimates. This pattern is economically plausible because a binary indicator treats one short interruption and chronic downtime alike. Intensity captures the accumulated disruption to production, sales and customer service. The employment response may be slower because labour adjustment is costly, firms retain trained employees during temporary disruptions, or outages lower hours and productivity before headcount.

H2 and H3 are not supported. Generator ownership does not predict significantly faster sales growth and does not attenuate the outage association. This aligns with the distinction between operational continuity and profitability. A generator can keep essential equipment running while raising average energy costs. It may also be undersized, intermittently used, or unavailable during fuel shortages. Hence, ownership alone is a crude measure of effective resilience; generator capacity, fuel expenditure, runtime and the share of electricity self-generated would better capture protection.

The findings broadly agree with studies documenting performance losses from unreliable electricity (Allcott et al., 2016; Cole et al., 2018; Abeberese et al., 2021; Apeti and Ly, 2024). They also complement Zhang et al. (2025) by showing that, in a common-year multi-country sample, generator ownership does not automatically translate into a measurable growth buffer. The results differ from a simple technology-adoption narrative in which backup generation fully solves the constraint. Instead, they support a cost-sensitive resilience framework: adaptation reduces some physical disruption but can preserve a wedge between private and socially efficient electricity provision.

6. Policy Implications

First, electricity policy should target reliability alongside access. New connections generate limited productive value if voltage instability and recurrent outages prevent firms from using machinery and digital services. Reliability metrics—interruption frequency, duration, restoration time and voltage quality—should be embedded in utility performance contracts and regulatory reporting. Mission 300's emphasis on reliable and affordable electricity provides an appropriate umbrella, but firm-level service quality should be an explicit outcome rather than an assumed consequence of connection (IFC, 2025).

Second, governments should avoid making diesel self-generation the de facto industrial policy. Generator tax relief may offer temporary support during acute crises, yet generalized subsidies risk locking firms into high-cost, polluting private generation. Better instruments include competitively

procured embedded generation, industrial mini-grids, rooftop solar-plus-storage finance, energy-service contracts and credit guarantees that are accessible to smaller firms. These measures should complement—not replace—transmission, distribution and utility-governance reform.

Third, resilience policy should be differentiated by firm capability. Large firms may self-finance generators or renewable systems, whereas small firms face collateral and scale constraints. Cluster-based solutions in markets and industrial zones can pool demand and lower unit costs. Regulators can also streamline interconnection, net-metering and captive-power rules while enforcing technical and environmental standards. Finally, future Enterprise Surveys should retain detailed questions on solar, storage, generator capacity, runtime, energy costs and outage timing to distinguish ownership from actual protection.

7. Limitations and Future Research

The analysis has five principal limitations. First, the data are cross-sectional; retrospective sales and employment measures do not create a true firm panel, and reverse causality or omitted variables may remain. Second, outages and performance are self-reported and may contain recall error. Third, nominal sales growth is affected by inflation and firm-specific price changes; country fixed effects absorb national averages but not heterogeneous price movements. Fourth, seven country clusters are too few for fully reliable conventional cluster asymptotics, which is why both HC3 and cluster results are shown. Fifth, generator ownership does not measure capacity, reliability, operating cost or actual generation share.

Future work should link repeated Enterprise Survey waves into panels, combine firm reports with feeder-level outage records and exploit plausibly exogenous changes in grid supply or infrastructure. Wild-cluster bootstrap inference, randomization-based designs and causal forests could refine uncertainty and heterogeneity. More detailed cost data would permit welfare analysis comparing grid-reliability investment, generators, solar-plus-storage and shared mini-grids. Such work would move from documenting resilience gaps to identifying the least-cost policy portfolio for closing them.

8. Conclusion

Using 1,981 firms from seven 2025 African Enterprise Surveys, this article finds that electricity outages are widespread and are consistently associated with weaker firm growth, particularly when exposure is measured by intensity or adjusted with cross-fitted AIPW. The doubly robust estimate implies an approximately 1.85-percentage-point annual sales-growth deficit for outage-exposed firms, though evidence is only suggestive under few-cluster inference. Employment estimates are negative but imprecise. Generator ownership is common, yet it neither predicts stronger growth nor demonstrably buffers the outage penalty.

The main conclusion is not that private adaptation is useless, but that ownership of backup equipment is an incomplete proxy for resilience and an imperfect substitute for reliable public supply. Policy should therefore combine utility reliability reform with cleaner, financeable distributed-energy options, especially for smaller firms. Because the design remains observational, the numerical estimates should guide hypothesis formation and policy prioritization rather than be read as definitive causal effects.

Declarations

Funding: No external funding was received for this study.

Conflict of interest: The authors declare no conflict of interest.

Ethics statement: The study uses anonymized secondary firm-level survey data and involves no direct human-subject interaction by the authors.

Data availability: The underlying World Bank Enterprise Survey microdata and documentation are available through the Enterprise Surveys data portal subject to its terms of use. The harmonization and estimation logic are described in the article.

References

Abeberese, A. B., Ackah, C. G., & Asuming, P. O. (2021). Productivity losses and firm responses to electricity shortages: Evidence from Ghana. The World Bank Economic Review, 35(1), 1–18. https://doi.org/10.1093/wber/lhz027

Allcott, H., Collard-Wexler, A., & O'Connell, S. D. (2016). How do electricity shortages affect industry? Evidence from India. American Economic Review, 106(3), 587–624. https://doi.org/10.1257/aer.20140389

Apeti, A. E., & Ly, A. (2024). Power constraints and firm-level total factor productivity in developing countries. Energy, 309, 132871. https://doi.org/10.1016/j.energy.2024.132871

Cameron, A. C., & Miller, D. L. (2015). A practitioner's guide to cluster-robust inference. Journal of Human Resources, 50(2), 317–372. https://doi.org/10.3368/jhr.50.2.317

Chernozhukov, V., Chetverikov, D., Demirer, M., Duflo, E., Hansen, C., Newey, W., & Robins, J. (2018). Double/debiased machine learning for treatment and structural parameters. The Econometrics Journal, 21(1), C1–C68. https://doi.org/10.1111/ectj.12097

Cissokho, L. (2020). The productivity cost of power outages for manufacturing small and medium enterprises in Senegal. AERC Research Paper 393. African Economic Research Consortium.

Cole, M. A., Elliott, R. J. R., Occhiali, G., & Strobl, E. (2018). Power outages and firm performance in Sub-Saharan Africa. Journal of Development Economics, 134, 150–159. https://doi.org/10.1016/j.jdeveco.2018.05.003

Fisher-Vanden, K., Mansur, E. T., & Wang, Q. J. (2015). Electricity shortages and firm productivity: Evidence from China's industrial firms. Journal of Development Economics, 114, 172–188. https://doi.org/10.1016/j.jdeveco.2015.01.002

IFC. (2025). Mission 300: Powering progress in Africa. International Finance Corporation. https://www.ifc.org/en/what-we-do/sector-expertise/infrastructure/energy/mission-300

International Energy Agency. (2024). Electricity 2024: Analysis and forecast to 2026. IEA. https://www.iea.org/reports/electricity-2024

Mounmemi, M. (2026). Impact of adaptation strategies to power outages on business in Sub-Saharan Africa: Does energy management measure make a difference? Managerial and Decision Economics, 47(2), 263–285. https://doi.org/10.1002/mde.70040

Osei-Gyebi, S., & Dramani, J. B. (2023). Firm performance in sub-Saharan Africa: What role do electricity shortages play? Cogent Economics & Finance, 11(2), 2251822. https://doi.org/10.1080/23322039.2023.2251822

Oseni, M. O., & Pollitt, M. G. (2015). A firm-level analysis of outage loss differentials and self-generation: Evidence from African business enterprises. Energy Economics, 52, 277–286. https://doi.org/10.1016/j.eneco.2015.11.008

Robins, J. M., Rotnitzky, A., & Zhao, L. P. (1994). Estimation of regression coefficients when some regressors are not always observed. Journal of the American Statistical Association, 89(427), 846–866. https://doi.org/10.1080/01621459.1994.10476818

Steinbuks, J., & Foster, V. (2010). When do firms generate? Evidence on in-house electricity supply in Africa. Energy Economics, 32(3), 505–514. https://doi.org/10.1016/j.eneco.2009.10.012

World Bank Enterprise Surveys. (2025a). Methodology. World Bank Group. https://www.enterprisesurveys.org/en/methodology

World Bank Enterprise Surveys. (2025b). Infrastructure: Electricity indicators. World Bank Group. https://www.enterprisesurveys.org/en/data/exploretopics/infrastructure

World Bank, IEA, IRENA, UNSD, & WHO. (2025). Tracking SDG 7: The Energy Progress Report 2025. World Bank. https://trackingsdg7.esmap.org/

Xiao, Z., Gao, J., Wang, Z., Yin, Z., & Xiang, L. (2022). Power shortage and firm productivity: Evidence from the World Bank Enterprise Survey. Energy, 247, 123479. https://doi.org/10.1016/j.energy.2022.123479

Zhang, D., Durmaz, N., & Kagochi, J. M. (2025). Energy outages, in-house power generators, and capacity utilization: The case of African manufacturing. Energy Economics, 147, 108614. https://doi.org/10.1016/j.eneco.2025.108614