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A Quasi-Experimental Evaluation of Risk Reduction in Uganda's Power Distribution Network

A Methodological Framework for Asset Diagnostics

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ABSTRACT

Power distribution networks in developing nations face significant reliability challenges due to ageing infrastructure and constrained maintenance resources. There is a pressing need for robust methodological frameworks to evaluate the efficacy of asset diagnostic interventions in mitigating operational risks. This study aimed to develop and apply a quasi-experimental methodological framework to quantitatively evaluate the risk reduction achieved through a systematic asset diagnostics programme within a national power distribution network. A quasi-experimental design compared treated and control groups of medium-voltage distribution equipment. The core risk reduction was estimated using a difference-in-differences model: $\delta\ Risk\{it\} = beta0 + beta1\,(Treati \times Postt) + \gamma\, X\{it\} + \varepsilon\{it\}$, where robust standard errors were clustered at the feeder level. Field data on fault frequency and severity were collected before and after the diagnostic intervention. The application of the framework demonstrated a statistically significant reduction in aggregate technical risk. The estimated coefficient $beta1$ indicated a 22.5% reduction in the composite risk index for the treated asset group relative to the control, with the 95% confidence interval excluding zero. The proposed quasi-experimental framework provides a rigorous, evidence-based method for quantifying the impact of asset health interventions on network risk, moving beyond descriptive diagnostics. Utilities should adopt quasi-experimental evaluation designs for capital investment programmes. Future work should integrate this framework with predictive failure models to optimise intervention scheduling. asset management, difference-in-differences, distribution network, power infrastructure, quasi-experiment, risk reduction This paper presents a novel application of quasi-experimental design to the field of power asset management, providing a validated methodological framework for causal inference on engineering interventions.

Keywords: *Power distribution networks, Asset diagnostics, Quasi-experimental design, Sub-Saharan Africa, Risk reduction, Condition monitoring, Uganda*

Article Highlights

- A novel quasi-experimental framework quantifies the causal impact of asset diagnostics on network risk.
- Difference-in-differences analysis revealed a statistically significant 22.5% reduction in technical risk.
- The methodology moves beyond descriptive diagnostics to rigorous, evidence-based evaluation.
- Provides a validated model for utilities to assess capital investment programmes in constrained environments.

Methodological Contribution

This study formalises a quasi-experimental design with a difference-in-differences model, establishing a causal link between systematic asset diagnostics and measurable risk reduction in a real-world utility network.

This paper offers a rigorous evaluation framework for engineering asset managers.

ABSTRACT-ONLY PUBLICATION

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