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A Multilevel Regression Analysis of Power-Distribution System Efficiency Gains in Uganda

A Methodological Case Study (2000–2026)

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ABSTRACT

Background: Power-distribution systems in many developing nations face chronic inefficiencies, leading to substantial technical and commercial losses. Evaluating the impact of equipment upgrades and interventions is complex due to hierarchical data structures and confounding regional factors.

Purpose and objectives: This case study presents a methodological framework for quantifying efficiency gains in power-distribution networks. It aims to demonstrate the application of multilevel regression modelling to isolate the effect of equipment modernisation from other operational variables.

Keywords: Power-distribution systems, Sub-Saharan Africa, Multilevel modelling, Technical losses, Network efficiency, Uganda, Infrastructure upgrade

Article Highlights

- Multilevel modelling isolates equipment effects from regional operational variables
- Framework provides robust analytical tool for infrastructure investment appraisal
- Hierarchical approach accounts for clustered data in utility performance analysis
- Methodology enables nuanced evaluation of intervention efficacy in power networks

Core Statistical Model

Three-level mixed-effects model: $y_{ij} = \beta_0 + \beta_1 X_{ij} + u_j + v_k + \epsilon_{ij}$, where y_{ij} is system efficiency for feeder i in region j , X_{ij} denotes intervention status, and u_j , v_k are random intercepts for region and year.

This methodological framework demonstrates rigorous evaluation of infrastructure upgrades in developing power systems.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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