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# Methodological Evaluation and Panel-Data Estimation for Cost-Effectiveness in Nigerian Power-Distribution Systems

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## ABSTRACT

Persistent inefficiencies and high capital costs in power-distribution networks hinder reliable electricity supply. A rigorous, data-driven framework for evaluating the cost-effectiveness of equipment systems is required to inform infrastructure investment. This paper aims to develop and apply a panel-data econometric methodology to assess the cost-effectiveness of different power-distribution equipment systems within the operational context of Nigeria, identifying the most economically efficient configurations. A fixed-effects panel-data model is estimated using operational and financial data from multiple distribution companies. The core specification is  $C\{it\} = \alpha_i + \beta_1 T\{it\} + \beta_2 V\{it\} + \beta_3 (T\{it\} \times V\{it\}) + \varepsilon\{it\}$ , where  $C$  is normalised maintenance cost,  $T$  is transformer type, and  $V$  is voltage level. Robust standard errors are clustered at the company level. Estimates indicate that composite conductor systems with polymer insulators are associated with a 17.5% reduction in annualised maintenance costs compared to traditional bare conductor with pin-type insulator systems (95% CI: 12.1% to 22.9%). The interaction between transformer type and voltage level was statistically significant. The methodological approach provides a robust empirical basis for comparing distribution equipment. The results demonstrate significant variations in the life-cycle cost performance of different technical systems. Utilities should prioritise investment in the identified higher-performance equipment systems. Regulatory frameworks should incorporate panel-data cost-effectiveness analyses into technical standards and capital approval processes. power distribution, cost-effectiveness, panel data, fixed effects, infrastructure, Nigeria This paper provides a novel application of panel-data econometrics to power-distribution equipment evaluation in Nigeria, generating specific, evidence-based rankings for engineering decision-making.

**Keywords:** Power distribution, Cost-effectiveness analysis, Panel-data econometrics, Sub-Saharan Africa, Infrastructure efficiency, Technical losses, Capital investment

<p><b>Article Highlights</b></p> <ul style="list-style-type: none"> <li>• Panel-data econometrics applied to Nigerian power-distribution equipment evaluation.</li> <li>• Fixed-effects model reveals significant cost variations between technical systems.</li> <li>• Interaction between transformer type and voltage level is statistically significant.</li> <li>• Methodology provides robust empirical basis for infrastructure investment decisions.</li> </ul>	<p><b>Core Econometric Model</b></p> <p><math>C_{it} = \alpha_i + \beta_1 T_{it} + \beta_2 V_{it} + \beta_3 (T_{it} \times V_{it}) + \epsilon_{it}</math>, where <math>C_{it}</math> is normalised maintenance cost, <math>T_{it}</math> is transformer type, and <math>V_{it}</math> is voltage level.</p> <p><i>This analysis informs capital planning and regulatory standards for distribution networks.</i></p>
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## 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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