

A Bayesian Hierarchical Model for the Cost-Effectiveness Evaluation of Power-Distribution Equipment in Ghana

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ABSTRACT

Background: Evaluating the cost-effectiveness of power-distribution equipment in developing grids is complex, requiring the integration of sparse, heterogeneous data on costs, failure rates, and local operational conditions. Traditional deterministic models often fail to adequately quantify uncertainty, which is critical for robust infrastructure investment planning.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework designed to quantify the cost-effectiveness of distribution equipment, such as transformers and switchgear, while formally incorporating parameter uncertainty and variability across different operational districts.

Keywords: *Bayesian hierarchical modelling, cost-effectiveness analysis, power-distribution networks, sub-Saharan Africa, reliability engineering, developing electricity grids*

Article Highlights

- Bayesian hierarchical model quantifies uncertainty in cost-effectiveness ratios.
- Application to Ghanaian data shows considerable variance in equipment performance.
- Framework integrates sparse, heterogeneous reliability and cost data.
- Provides statistically rigorous alternative to deterministic point estimates.

Methodological Insight

The core model uses a Gamma likelihood with hierarchical priors on parameters, estimated via Hamiltonian Monte Carlo to yield full posterior distributions for inference.

This analysis provides a template for probabilistic investment planning in data-scarce environments.

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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