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CASE STUDY

A Bayesian Hierarchical Model for Yield Improvement in Ghanaian Transport Maintenance Depot Systems

A Methodological Evaluation

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ABSTRACT

Background: Transport maintenance depots in Ghana face systemic inefficiencies, leading to suboptimal asset availability and high operational costs. Traditional performance measurement frameworks often fail to account for the complex, multi-level variability inherent in depot operations and supply chains, resulting in unreliable yield estimates.

Purpose and objectives: This case study aims to methodologically evaluate the application of a Bayesian hierarchical model for quantifying and improving yield within these depot systems. The objective is to assess the model's capacity to provide robust, actionable insights by formally incorporating operational uncertainty and hierarchical data structures.

Keywords: *Bayesian hierarchical modelling, Yield improvement, Transport maintenance depots, Sub-Saharan Africa, Systems engineering, Methodological evaluation, Asset availability*

Article Highlights

- Identifies significant inter-depot performance variation through hierarchical parameters
- Provides probabilistic performance ranking for root-cause diagnosis in depot networks
- Formally incorporates operational uncertainty into yield estimates for robust insights
- Demonstrates applicability in data-scarce, high-variability operational environments

Core Statistical Model

Bayesian hierarchical linear model: $y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2)$, $\alpha_j \sim \text{Normal}(\mu_{\alpha}, \tau^2)$, where α_j represents depot-specific intercepts capturing performance variation.

This methodological evaluation demonstrates a statistically rigorous framework for transport depot performance analysis.