AFRICAN STRUCTURAL ENGINEERING
Vol. 1 | No. 1 | 2013 | 10.5281/zenodo.18972487

A Bayesian Hierarchical Modelling Framework for Evaluating Transport Depot Maintenance System Adoption in Nigeria

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Received: 22 September 2012 | Accepted: 05 January 2013 | Published: 01 February 2013 | **DOI:** 10.5281/zenodo.18972487

ABSTRACT

Background: The adoption of modern maintenance systems in transport depots is critical for infrastructure integrity and operational safety. Current evaluation methods often rely on aggregated metrics, failing to account for the hierarchical nature of data and regional heterogeneity, which limits the precision of adoption rate estimates and the identification of influential factors.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework designed to rigorously evaluate the adoption rates of depot maintenance systems. Its objectives are to provide a robust method for quantifying adoption, to identify key technical and organisational drivers, and to produce region-specific estimates that inform targeted interventions.

Keywords: *Bayesian hierarchical modelling, transport depot maintenance, Sub-Saharan Africa, infrastructure evaluation, adoption rates, maintenance management systems, developing economies*

Article Highlights

- A three-level Bayesian hierarchical logistic model for rigorous adoption evaluation.
- Depot size and technician certification identified as strongest adoption predictors.
- Posterior probability for certified technician effect exceeded 0.98.
- Framework quantifies regional heterogeneity for targeted interventions.

Core Model Specification

$\text{logit}(p_{ij}) = \beta_0 + \beta X_{ij} + u_j + v_k$, with regional random effects $u_j \sim N(0, \sigma_u^2)$ and sector offsets v_k. Inference via Hamiltonian Monte Carlo.

Presents a statistically rigorous framework for infrastructure evaluation in developing economies.