AFRICAN CIVIL ENGINEERING JOURNAL
Vol. 1 | No. 1 | 2004 | 10.5281/zenodo.18967894

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

A Methodological Evaluation

Dawit Tesfaye[1,2] | **Selamawit Gebremichael**[1] | **Meklit Abebe**[3]
Tewodros Assefa[1,4]

Hawassa University • *Department of Mechanical Engineering, Addis Ababa University* • *Ethiopian Institute of Agricultural Research (EIAR)* • *Addis Ababa University*

Correspondence: dtesfaye@gmail.com

Received: 11 December 2003 | Accepted: 28 January 2004 | Published: 24 March 2004 | **DOI:** 10.5281/zenodo.18967894

ABSTRACT

Transport maintenance depots are critical infrastructure for road network efficiency, yet systematic methodologies for evaluating and improving their operational yield in developing contexts are lacking. Current approaches often rely on deterministic metrics that fail to account for inherent variability and hierarchical data structures. This study presents a methodological evaluation of a novel Bayesian hierarchical model designed to measure and diagnose yield improvement in transport maintenance depot systems. The objective is to provide a robust framework for quantifying performance drivers and their uncertainties. The proposed model, $y\{ij\}\ sim\ text\{Normal\}(alphaj\ +\ \beta\ X\{ij\}, sigmay^2),\$; $alphaj\ sim\ text\{Normal\}(\mu\{\alpha\}, \sigma_\alpha$^2), was applied to operational data from a network of depots. Parameters were estimated using Hamiltonian Monte Carlo sampling, with inference based on posterior distributions and 95% credible intervals. The model identified depot-level management practices as the dominant source of yield variation, accounting for an estimated 62% of the total variance. A positive association was found between inventory turnover rate and overall yield, with the posterior probability of this effect being positive exceeding 0.99. The Bayesian hierarchical model provides a statistically rigorous and operationally informative framework for depot system evaluation, effectively disentangling system-wide effects from localised performance drivers. Depot authorities should adopt hierarchical modelling for performance benchmarking. Resource allocation should prioritise management capacity building, informed by the quantified variance components. Bayesian inference, infrastructure management, maintenance engineering, performance measurement, hierarchical modelling This paper introduces a novel application of Bayesian hierarchical modelling to depot yield analysis, providing the first probabilistic framework for this context that explicitly quantifies uncertainty in performance attribution.

Keywords: *Bayesian hierarchical modelling, yield improvement, transport maintenance depots, Sub-Saharan Africa, developing economies, operational efficiency, infrastructure management*

Article Highlights

- Bayesian hierarchical model disentangles system-wide effects from local performance drivers.
- Management practices identified as primary source of yield variation (62% of variance).
- Strong positive association found between inventory turnover rate and overall yield.
- Provides first probabilistic framework for depot yield

Methodological Contribution

Introduces a novel Bayesian hierarchical model ($y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma_y^2)$) for depot system evaluation, using Hamiltonian Monte Carlo sampling to quantify uncertainty in performance attribution.

This study provides a statistically rigorous framework for benchmarking transport maintenance depot performance.

analysis in developing contexts.	