AFRICAN CIVIL ENGINEERING JOURNAL

ISSN: XXXX-XXXX | Peer-Reviewed | Open Access

A Bayesian Hierarchical Model for Cost-Effectiveness in Uganda's Industrial Machinery Fleet Management

A Policy Analysis for 2000–2026

DOI: 10.5281/zenodo.18968196 | **Received:** 08 April 2007 | **Accepted:** 25 May 2007 | **Published:** 13 June 2007

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ABSTRACT

Background: The cost-effectiveness of industrial machinery fleets is a critical yet under-researched factor in national infrastructure development and industrial policy. In many developing economies, poor fleet management leads to substantial capital waste and project delays, but robust analytical frameworks for policy evaluation are lacking.

Purpose and objectives: This policy analysis develops and applies a novel Bayesian hierarchical model to evaluate the cost-effectiveness of industrial machinery fleet management systems. It aims to quantify the impact of different policy interventions on lifecycle costs and operational availability.

Keywords: *Bayesian hierarchical modelling, cost-effectiveness analysis, industrial machinery, Sub-Saharan Africa, fleet management, policy analysis, developing economies*

Article Highlights

- Performance-based contracting shows 18–27% potential improvement in cost-effectiveness.
- Maintenance strategy outweighs machine age or initial capital cost as key factor.
- Bayesian hierarchical model provides robust framework for policy evaluation.
- Integrated data systems are essential for evidence-based fleet management.

Methodological Note

The model employs a Bayesian hierarchical structure: $y_{ij} \sim \text{Normal}(\alpha_j + \beta X_{ij}, \sigma^2)$, $\alpha_j \sim \text{Normal}(\mu_\alpha, \tau^2)$, with inference based on 95% credible intervals from MCMC sampling.

This analysis provides a statistically robust framework for engineering asset management policy in developing economies.