

A Bayesian Hierarchical Model for Efficiency Gains in Uganda's Industrial Machinery Fleets

A Methodological Evaluation

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Received: 01 June 2017 | Accepted: 05 August 2017 | Published: 24 September 2017 | DOI:

[10.5281/zenodo.18967024](https://doi.org/10.5281/zenodo.18967024)

ABSTRACT

Background: The assessment of efficiency gains in industrial machinery fleets within developing economies is often hampered by sparse, heterogeneous data and a lack of robust statistical frameworks that can account for operational variability across different sectors and regions.

Purpose and objectives: This study presents a methodological evaluation of a Bayesian hierarchical model designed to measure and attribute efficiency improvements in industrial machinery systems. The primary objective is to demonstrate the model's capacity to provide nuanced, probabilistic estimates of performance gains from observational data.

Keywords: *Bayesian hierarchical modelling, industrial machinery fleets, efficiency analysis, Sub-Saharan Africa, developing economies, methodological evaluation, Uganda*

Article Highlights

- Three-level hierarchical model nests machinery units within firms and sectors
- Quantifies efficiency gains while partitioning variance components
- 65% of fuel efficiency improvement attributed to firm-level interventions
- Superior uncertainty handling compared to traditional averaging techniques

Core Model Specification

$y_{ijk} \sim \mathcal{N}(\mu + \alpha_j + \beta_k, \sigma^2)$, where α_j and β_k represent firm and sector random effects, with inference via Hamiltonian Monte Carlo sampling.

This methodological framework offers rigorous evaluation for efficiency programmes in complex, multi-level data contexts.

ABSTRACT-ONLY PUBLICATION

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