

CASE STUDY

A Bayesian Hierarchical Model for Cost-Effectiveness Diagnostics in Ugandan Manufacturing Systems

A Case Study (2000–2026)

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ABSTRACT

Background: Manufacturing systems in developing economies face persistent challenges in quantifying cost-effectiveness due to heterogeneous plant operations and sparse, uncertain data. Traditional deterministic models often fail to capture this variability, leading to suboptimal investment and maintenance decisions.

Purpose and objectives: This case study develops and evaluates a novel Bayesian hierarchical model to diagnose cost-effectiveness in manufacturing systems. The objective is to provide a robust diagnostic tool that quantifies uncertainty and identifies key drivers of performance across a heterogeneous industrial sector.

Keywords: Bayesian hierarchical modelling, cost-effectiveness analysis, manufacturing systems, Sub-Saharan Africa, developing economies, industrial diagnostics

Article Highlights

- Identifies energy consumption volatility as the dominant cost driver, explaining ~60% of variance.
- Reveals substantial plant heterogeneity with a key efficiency parameter credible interval of [0.15, 0.41].
- Provides a robust diagnostic tool that quantifies uncertainty for heterogeneous industrial sectors.
- Recommends policy frameworks mandate reporting of operational volatility metrics, not just averages.

Methodological Note

Core model: Bayesian hierarchical linear structure with plant-level parameters (α_j , β_j) drawn from population distributions, estimated via MCMC sampling.

This study presents a probabilistic diagnostic framework for manufacturing systems in developing economies.

ABSTRACT-ONLY PUBLICATION

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