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ORIGINAL RESEARCH

A Bayesian Hierarchical Model for Cost-Effectiveness Analysis of Manufacturing Systems in Rwanda

A Methodological Evaluation

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ABSTRACT

Background: Cost-effectiveness analysis in manufacturing systems within developing economies is often hampered by sparse, heterogeneous data and the need to integrate multi-level operational uncertainties. Traditional deterministic models fail to adequately quantify these uncertainties, limiting robust decision-making for plant investment and policy.

Purpose and objectives: This study presents a methodological evaluation of a novel Bayesian hierarchical model designed for cost-effectiveness analysis of manufacturing systems. The objective is to provide a robust framework that quantifies uncertainty and borrows strength across related manufacturing units to improve inference where data are limited.

Keywords: *Bayesian hierarchical modelling, cost-effectiveness analysis, manufacturing systems, Sub-Saharan Africa, developing economies, operational uncertainty*

Article Highlights

- Superior uncertainty quantification compared to frequentist alternatives.
- 95% credible intervals for cost-effectiveness ratios achieved nominal coverage.
- Framework synthesises information across manufacturing systems.
- Provides full probabilistic inference on key economic parameters.

Methodological Core

A hierarchical model with plant-level random effects, evaluated via MCMC sampling on simulated and case study data from Rwandan agro-processing.

This study presents a statistically rigorous framework for techno-economic evaluation under uncertainty.