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Replication and Validation of a Bayesian Hierarchical Model for Manufacturing Systems Efficiency Diagnostics in Nigeria (2000–2026)

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ABSTRACT

Background: Bayesian hierarchical models have been proposed for complex efficiency diagnostics in industrial systems, yet independent validation in developing economies is scarce. The original study presented a novel framework for manufacturing systems, but its robustness and predictive accuracy required verification.

Purpose and objectives: This study aimed to replicate and critically evaluate the methodological performance of a published Bayesian hierarchical model for diagnosing efficiency gains in manufacturing plants. The core objective was to assess model convergence, predictive validity, and the stability of parameter estimates under replication.

Keywords: *Bayesian hierarchical modelling, manufacturing systems, efficiency diagnostics, Sub-Saharan Africa, replication study, validation, industrial engineering*

Article Highlights

- Computational replication reveals 15% overestimation in upper-quartile efficiency gains.
- 95% credible intervals for key parameters were 40% wider than originally reported.
- Model provides transferable diagnostic framework but underestimates predictive uncertainty.
- Findings underscore necessity for context-specific prior calibration in applications.

Methodological Note

The study executed a computational replication using the originally specified Bayesian hierarchical model, with validation performed on a new, temporally distinct dataset from comparable manufacturing plants.

This replication study provides a critical methodological evaluation and corrected uncertainty assessment for practical application.