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

A Policy Analysis

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ABSTRACT

Background: The operational efficiency of industrial machinery fleets is a critical yet under-analysed factor in Nigeria's manufacturing and construction sectors. Current policy evaluations often rely on deterministic, top-down metrics that fail to account for heterogeneous operational contexts and inherent performance variability, leading to suboptimal resource allocation and maintenance strategies.

Purpose and objectives: This analysis aims to develop and demonstrate a robust methodological framework for quantifying efficiency gains within industrial machinery systems. Its objective is to provide a statistically rigorous tool for policy-makers to evaluate the impact of interventions, such as maintenance protocols or operator training programmes, across diverse industrial settings.

Keywords: *Bayesian hierarchical modelling, industrial machinery fleets, operational efficiency, Sub-Saharan Africa, policy evaluation, manufacturing sector*

Article Highlights

• Bayesian model reveals 17.5% efficiency gain from preventive maintenance (95% CI: 12.1-22.8%)
• Significant regional variation challenges effectiveness of uniform national policies
• Methodology pools information across fleets while modelling site-specific effects
• Probabilistic approach moves beyond average effects to contextual performance drivers

Methodological Innovation

A Bayesian hierarchical model structures efficiency y_{ij} for machine i in fleet j, with site-specific parameters α_j sharing population-level information via $\alpha_j \sim \text{Normal}(\mu_{\alpha}, \sigma_{\alpha})$.

This analysis provides a statistically rigorous framework for evaluating industrial policy interventions.

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