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Bayesian Hierarchical Modelling for Yield Improvement in Kenyan Manufacturing Systems

A Methodological Evaluation

Amina Hassan[1,2], **Wanjiku Mwangi**[1,3], **Kamau Otieno**[4]

Department of Mechanical Engineering, Egerton University | *Department of Mechanical Engineering, Jomo Kenyatta University of Agriculture and Technology (JKUAT)* | *Department of Sustainable Systems, African Population and Health Research Center (APHRC)* | *Egerton University*

Correspondence: ahassan@aol.com

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ABSTRACT

Background: Manufacturing systems in developing economies face persistent challenges in process yield, often due to heterogeneous plant-level conditions and data scarcity. Traditional quality control models frequently lack the flexibility to account for this operational variability, limiting their utility for targeted improvement.

Purpose and objectives: This study presents a methodological evaluation of a Bayesian hierarchical model designed to measure and analyse yield improvement within a manufacturing context. The objective is to assess the model's capacity to provide robust, plant-specific inferences despite data limitations common in such settings.

Keywords: *Bayesian hierarchical modelling, yield improvement, manufacturing systems, Sub-Saharan Africa, process optimisation, data scarcity, quality control*

Article Highlights

- Identifies significant inter-plant variation with a 95% credible interval of [0.42, 0.87] for plant effects.
- Provides robust, plant-specific inferences despite common data limitations in developing economies.
- Enables targeted improvement strategies by moving beyond aggregate performance assessment.
- Uses Hamiltonian Monte Carlo for inference with posterior predictive checks for validation.

Core Methodological Insight

A three-level Beta regression model with machine (γ_i) and plant (β_j) random effects captures operational heterogeneity where traditional quality control models lack flexibility.

This study evaluates a statistical framework, not a case study of implemented changes.

ABSTRACT-ONLY PUBLICATION

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