AFRICAN CIVIL ENGINEERING JOURNAL

REPLICATION STUDY

Replication and Bayesian Hierarchical Modelling of Process-Control System Efficiency Gains in Uganda

A Methodological Evaluation

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Received: 16 July 2001 | Accepted: 22 September 2001 | Published: 16 October 2001 | **DOI:** 10.5281/zenodo.18967001

ABSTRACT

Background: Process-control systems are critical for infrastructure efficiency, yet evaluations in resource-constrained settings often lack robust statistical frameworks to quantify gains. Previous studies in the region have provided point estimates but have not fully accounted for site-specific heterogeneity and uncertainty.

Purpose and objectives: This study replicates and methodologically extends a prior efficiency analysis by applying a Bayesian hierarchical model. The objective is to rigorously quantify efficiency gains while formally partitioning variance between site-level and system-level effects.

Keywords: *Replication study, Bayesian hierarchical modelling, Process-control systems, Sub-Saharan Africa, Efficiency gains, Methodological evaluation*

Article Highlights

- Replicates prior efficiency analysis with enhanced statistical rigor.
- Bayesian hierarchical model quantifies both system gains and site-level variance.
- Finds substantial context-dependency in process-control outcomes.
- Advocates for modelling approaches that separate universal from localized effects.

Core Methodological Contribution

Applies a Bayesian hierarchical linear model to formally partition variance between site-level random effects and system-level efficiency gains, moving beyond aggregate point estimates.

This study emphasizes the importance of statistical frameworks that account for heterogeneity in engineering evaluations.