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METHODOLOGY PAPER

A Bayesian Hierarchical Modelling Framework for Evaluating Process-Control System Adoption in Tanzania (2000–2026)

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ABSTRACT

Background: The adoption of modern process-control systems in engineering sectors is critical for industrial development, yet robust methodologies for evaluating adoption rates and their drivers are lacking. Existing approaches often rely on cross-sectional surveys or deterministic models, which fail to account for hierarchical data structures and inherent uncertainties in longitudinal adoption processes.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework designed to quantify the adoption rates of process-control systems and to identify key technical and organisational factors influencing adoption. The objective is to provide a rigorous, probabilistic methodology that can handle sparse or incomplete data typical in such contexts.

Keywords: *Bayesian hierarchical modelling, Process-control systems, Technology adoption, Sub-Saharan Africa, Industrial development, Engineering methodology*

Article Highlights

- A three-level Bayesian model handles sparse, longitudinal data from engineering projects.
- Posterior estimates show a national adoption growth of 0.15 per annum, with high uncertainty.
- Methodology allows partial pooling of information across regions to improve inference.
- Provides probabilistically coherent estimates for policy and investment decisions.

Methodological Contribution

Presents a novel Bayesian hierarchical framework to evaluate process-control system adoption, explicitly modelling regional variability and data uncertainty using Hamiltonian Monte Carlo.

This article proposes a new statistical methodology for evaluating technology adoption in engineering contexts.