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A Bayesian Hierarchical Model for Evaluating Manufacturing Systems Adoption in Senegal

A Methodological Assessment, 2000–2026

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ABSTRACT

Background: The adoption of advanced manufacturing systems in developing economies is a critical driver of industrialisation, yet robust methodological frameworks for evaluating its progress are lacking. Existing assessments often rely on aggregate indicators that mask regional and sectoral heterogeneity.

Purpose and objectives: This paper develops and assesses a novel Bayesian hierarchical modelling framework to evaluate the adoption rates of manufacturing plant systems. The objective is to provide a methodologically rigorous tool for capturing spatial and temporal variations in technological uptake.

Methodology: A Bayesian hierarchical model is constructed, integrating plant-level survey data with regional economic covariates. The core adoption rate for plant i in region j is modelled as $\text{logit}(p_{ij}) = \alpha_j + \beta X_{ij}$, with $\alpha_j \sim \text{Normal}(\mu_\alpha, \sigma^2_\alpha)$. Inference uses Markov chain Monte Carlo simulation, with posterior distributions summarising parameter uncertainty.

Keywords: *Bayesian hierarchical modelling, manufacturing systems adoption, Sub-Saharan Africa, industrialisation, developing economies, methodological assessment*

Article Highlights

- Bayesian hierarchical model quantifies regional adoption disparities in manufacturing systems.
- Posterior estimates show industrial corridor uptake 2.3 times higher than other regions.
- Framework captures unobserved heterogeneity through region-specific parameters.
- Probabilistic outputs provide transparent uncertainty for policy targeting.

Core Methodological Contribution

A novel Bayesian hierarchical model, integrating plant-level data with regional covariates, provides probabilistic estimates of manufacturing systems adoption while quantifying spatial heterogeneity and uncertainty.

This paper presents a methodological framework, not a comprehensive empirical analysis of adoption drivers.