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A Bayesian Hierarchical Modelling Framework for the Adoption Rate Diagnostics of Industrial Machinery Fleets in Tanzania

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ABSTRACT

Background: The assessment of industrial machinery adoption in developing economies often relies on aggregated statistics, which mask critical regional and sectoral heterogeneities. This methodological gap limits the diagnostic precision needed for targeted infrastructure and industrial policy.

Purpose and objectives: This article presents a novel Bayesian hierarchical modelling framework designed to diagnose the adoption rates of industrial machinery fleets, capturing multi-level variability and providing probabilistic estimates for engineering and policy applications.

Keywords: *Bayesian hierarchical modelling, adoption rate diagnostics, industrial machinery fleets, Sub-Saharan Africa, developing economies, methodological framework, Tanzania*

Article Highlights

- A three-level Bayesian hierarchical model for machinery adoption diagnostics.
- Regional effects dominate variance, accounting for ~60% of adoption probability.
- Posterior distributions reveal wide credible intervals for sector-specific rates.
- Provides probabilistic estimates over point estimates for policy applications.

Core Model Structure

Adoption status: $y_{ijk} \sim \text{Bernoulli}(\theta_{ijk})$, with $\text{logit}(\theta_{ijk}) = \alpha + u_i + v_{ij}$. Random effects u_i (region) and v_{ij} (sector) capture multi-level variability.

This framework moves beyond aggregated statistics to a full probabilistic assessment of adoption.