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A Bayesian Hierarchical Model for the Adoption Rate of Industrial Machinery Fleet Systems in South Africa

A Methodological Case Study

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ABSTRACT

Background: The adoption of advanced industrial machinery fleet systems, which integrate telematics and predictive maintenance, is critical for improving productivity and safety in heavy industries. However, quantifying and understanding the drivers of adoption rates in emerging economies remains methodologically challenging, with existing approaches often lacking the flexibility to model complex, multi-level industrial data.

Purpose and objectives: This case study presents and evaluates a novel Bayesian hierarchical modelling framework designed to estimate and analyse the adoption rate of such systems within the South African industrial sector. The objective is to provide a robust methodological tool that accounts for heterogeneity across different industrial sub-sectors and company sizes.

Keywords: *Bayesian hierarchical modelling, industrial machinery fleets, technology adoption, Southern Africa, predictive maintenance, telematics, methodological case study*

Article Highlights

- Bayesian hierarchical model quantifies adoption heterogeneity across industrial sectors
- Firm asset value shows >0.98 posterior probability of positive effect on adoption
- Methodology captures multi-level uncertainty through posterior credible intervals
- Framework enables targeted policy and industry strategy development

Methodological Contribution

Presents a Bayesian hierarchical logistic model with sector-level random effects and firm-level covariates, using Hamiltonian Monte Carlo for inference on industrial technology adoption.

This case study provides a methodological framework applicable to technology adoption analysis in emerging industrial economies.