Bayesian Hierarchical Model for Cost-Effectiveness Evaluation of Industrial Machinery Fleets in South Africa: A Methodological Study

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Abstract

Industrial machinery fleets play a crucial role in South Africa's manufacturing sector, influencing productivity and operational costs. The study employs a Bayesian hierarchical model to analyse data from multiple industrial machinery fleets across South Africa. This approach accounts for variability in operational costs and productivity within different sectors. A key finding is that the proportion of fleets achieving cost savings through targeted maintenance interventions exceeded 60%, highlighting the effectiveness of predictive analytics in fleet management. The Bayesian hierarchical model successfully quantifies the impact of various fleet management strategies on overall costs and efficiency, providing actionable insights for policymakers and industry leaders. Implementing preventive maintenance programmes is recommended to further enhance fleet cost-effectiveness. Future research should explore scalability issues in implementing these models across diverse industries. Bayesian hierarchical model, industrial machinery fleets, cost-effectiveness, predictive analytics, South Africa The maintenance outcome was modelled as $Y\{\} = beta\,0 + beta\,1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *African geography, Bayesian inference, Hierarchical modelling, Cost-effectiveness analysis, Industrial systems, Methodology, Quantitative methods*