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A Comparative Methodological Evaluation of Industrial Machinery Fleet Reliability in South Africa

A Bayesian Hierarchical Modelling Approach

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ABSTRACT

Background: The reliability assessment of industrial machinery fleets is critical for operational efficiency and cost management in heavy industries. Traditional reliability models often fail to account for heterogeneity across different machine types and operational sites, leading to imprecise maintenance strategies.

Purpose and objectives: This study conducts a comparative methodological evaluation of approaches for modelling fleet reliability. Its primary objective is to demonstrate the superiority of a Bayesian hierarchical framework over conventional pooled and separate models in handling multi-level data from heterogeneous fleets.

Keywords: *Bayesian hierarchical modelling, reliability engineering, industrial machinery fleets, comparative methodology, Sub-Saharan Africa*

Article Highlights

- Bayesian hierarchical Weibull model outperforms conventional pooled and separate analyses
- Applied to novel dataset of 15,000+ failure events from mining and construction fleets
- Reduces uncertainty in mean-time-failure estimates by approximately 40%
- Provides rigorous framework for multi-level reliability data structures

Methodological Advantage

The hierarchical approach pools information across fleets while accounting for inherent differences, yielding more precise and robust inferences than standard methods.

This study presents a comparative framework for reliability modelling of heterogeneous industrial fleets.