

# Comparative Methodological Evaluation of Industrial Machinery Fleets

*A Multilevel Regression Analysis for Cost-Effectiveness in South Africa (2000–2026)*

**Thandiwe Nkosi<sup>1,2</sup>, Kagiso Naidoo<sup>1,3</sup>, Pieter van der Merwe<sup>4</sup>**

University of the Free State | SA Medical Research Council (SAMRC) | Department of Sustainable Systems,  
University of the Witwatersrand | University of the Witwatersrand

Correspondence: [tnkosi@yahoo.com](mailto:tnkosi@yahoo.com)

Received: 06 March 2014 | Accepted: 19 May 2014 | Published: 05 July 2014 | DOI: [10.5281/zenodo.18968993](https://doi.org/10.5281/zenodo.18968993)

## ABSTRACT

**Background:** The management of industrial machinery fleets represents a significant capital and operational expenditure for engineering firms. In South Africa, the selection and evaluation of fleet management methodologies have historically relied on deterministic cost models, which inadequately capture the hierarchical and temporal variability inherent in operational data.

**Purpose and objectives:** This study conducts a comparative methodological evaluation to determine the most robust analytical framework for measuring the long-term cost-effectiveness of different fleet management systems. It aims to quantify the predictive performance of multilevel regression against traditional pooled and fixed-effects models.

**Keywords:** *Industrial machinery fleets, cost-effectiveness analysis, multilevel regression modelling, South Africa, comparative methodology, fleet management*

### Article Highlights

- Multilevel regression outperformed traditional pooled and fixed-effects models in predictive accuracy.
- Fleet-type variance accounted for 35% of unexplained cost variance, a key insight for management.
- Superior model fit was validated using WAIC and out-of-sample predictive performance.
- Provides a rigorous framework for long-term, data-driven fleet investment appraisals.

### Core Analytical Advance

The study specifies a three-level linear mixed model to capture hierarchical variance across fleet types and individual assets, moving beyond deterministic cost models.

*This analysis offers a statistically robust framework for evaluating machinery fleet cost-effectiveness in engineering contexts.*

## **ABSTRACT-ONLY PUBLICATION**

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

## **REQUEST FULL PAPER**

 **Email:** [info@parj.africa](mailto:info@parj.africa)

Request your copy of the full paper today!

## **SUBMIT YOUR RESEARCH**

**Are you a researcher in Africa? We  
welcome your submissions!**

Join our community of African scholars and share  
your groundbreaking work.

 **Submit at:** [app.parj.africa](http://app.parj.africa)



Scan to visit [app.parj.africa](http://app.parj.africa)

### **Open Access Scholarship from PARJ**

Empowering African Research | Advancing Global  
Knowledge