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Methodological Evaluation and Panel-Data Estimation of Industrial Machinery Fleet System Reliability in Nigeria, 2000–2026

Fatima Sani[1,2] | **Chinelo Okonkwo**[3,4]
Adebayo Adeyemi[5,6] | **Chukwuma Nwachukwu**[6]

1 *University of Calabar*
2 *University of Ibadan*
3 *Department of Mechanical Engineering, Bayero University Kano*
4 *Department of Mechanical Engineering, Usmanu Danfodiyo University, Sokoto*
5 *Usmanu Danfodiyo University, Sokoto*
6 *Department of Mechanical Engineering, University of Ibadan*

Correspondence: fsani@outlook.com

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ABSTRACT

Background: Industrial machinery fleet reliability is a critical determinant of productivity and economic output in developing economies. However, systematic, longitudinal assessments of fleet system performance in such contexts are scarce, limiting evidence-based maintenance and replacement strategies.

Purpose and objectives: This study aims to methodologically evaluate approaches for assessing industrial machinery fleet reliability and to develop a robust panel-data model for estimating system-wide reliability trends within a major industrial sector.

Keywords: *Panel-data estimation, System reliability, Industrial machinery fleets, Sub-Saharan Africa, Maintenance engineering, Reliability-centred maintenance, Developing economies*

Article Highlights

- Cross-sectional approaches show significant bias in reliability assessment.
- Unobserved machine heterogeneity accounts for over 30% of failure rate variance.
- Panel-data modelling provides superior framework for capturing dynamic trends.
- Standardised operational data collection is critical for predictive maintenance.

Core Methodology

Generalized linear mixed model for panel data: $\lambda_{ti} = \exp(\beta X_{ti} + \mu_i + \varepsilon_{ti})$, with maximum likelihood estimation and robust standard errors.

This study offers a methodological advance for reliability assessment in industrial contexts.