Methodological Evaluation and Panel-Data Estimation of System Reliability in Senegalese Manufacturing Plants

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ABSTRACT

Background: Reliability engineering in manufacturing contexts of developing economies is under-researched, with a paucity of longitudinal studies that account for operational and environmental variability. Existing assessments often rely on cross-sectional data, which fails to capture the dynamic nature of system performance and maintenance effects.

Purpose and objectives: This study aims to methodologically evaluate system reliability within manufacturing plants and to develop a robust panel-data estimation framework for quantifying reliability metrics. The objective is to identify key operational determinants of system failure and to provide a validated model for predictive maintenance planning.

Keywords: *reliability engineering, panel-data analysis, manufacturing systems, Sub-Saharan Africa, system failure modelling, developing economies, industrial maintenance*

Article Highlights

• Panel-data analysis reveals unobserved plant heterogeneity is critical for accurate reliability modelling.

• Preventive maintenance adherence shows a significant negative effect on system failure probability.

• Ambient humidity and power fluctuation severity are statistically significant operational covariates.

• The study provides a validated GLMM framework for predictive maintenance planning in similar contexts.

Core Methodological Specification

System reliability was modelled using a generalised linear mixed model (GLMM) with a logit link for failure events: $\text{logit}(p\_it) = \beta_0 + \beta_1 X\_it + \mu\_i + \varepsilon\_it$.

This study offers a longitudinal framework for reliability assessment in manufacturing contexts with limited historical data.

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