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Quasi-Experimental Evaluation of System Reliability in Rwandan Manufacturing Plants

A Methodological Framework

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ABSTRACT

Background: The reliability of manufacturing systems is critical for industrial productivity and economic development. In many developing economies, however, rigorous, data-driven frameworks for assessing system reliability are lacking, leading to reactive maintenance and unplanned downtime.

Purpose and objectives: This study aimed to develop and apply a novel quasi-experimental methodological framework to evaluate the operational reliability of electromechanical systems within manufacturing plants. The primary objective was to quantify reliability metrics and identify key factors influencing system failure.

Keywords: *Manufacturing systems, System reliability, Quasi-experimental design, Sub-Saharan Africa, Industrial engineering, Maintenance engineering, Developing economies*

Article Highlights

- Novel application of quasi-experimental design with survival analysis for reliability assessment.
- MTBF increased by ~32% in intervention groups using structured predictive maintenance.
- Weibull analysis (β=1.85) indicates wear-out failure characteristics in electromechanical systems.
- Provides a practical methodological framework for resource-constrained industrial settings.

Methodological Insight

Reliability was modelled using Weibull survival analysis: R(t)=exp[-(t/η)^β], with inference based on robust standard errors accounting for plant-level clustering.

This study offers a transferable framework for evidence-based maintenance policy in developing industrial contexts.