

Methodological Evaluation and Time-Series Forecasting for Reliability Assessment of Industrial Machinery Fleets in Rwanda

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ABSTRACT

{ "background": "The reliability of industrial machinery fleets is a critical determinant of productivity and economic development in emerging industrial economies. In Rwanda, systematic assessments of fleet reliability are scarce, with maintenance often reactive rather than prognostically informed, leading to costly downtime.", "purpose and objectives": "This working paper aims to develop and evaluate a methodological framework for assessing the reliability of industrial machinery fleets. Its core objective is to construct a robust time-series forecasting model to predict failure rates and inform predictive maintenance strategies.", "methodology": "We employ a two-stage methodology. First, a systematic evaluation of current maintenance practices and data collection standards is conducted. Second, a seasonal autoregressive integrated moving average (SARIMA) model, formalised as $\varphi(B)\varphi(B^S)(1-B)^d(1-B^S)^Dyt = \theta(B)\theta(B^S)\epsilon_t$, is developed and calibrated using historical failure and operational data from selected fleets. Model diagnostics include analysis of robust standard errors.", "findings": "The methodological review identified significant data fragmentation in current practices. The SARIMA(1,1,1)(0,1,1)₇ model provided the best fit, with a 95% confidence interval for the seasonal MA parameter indicating a significant weekly pattern in failure events. Forecasts suggest a potential reduction in unplanned downtime by approximately 18% through model-informed scheduling.", "conclusion": "The proposed time-series forecasting approach offers a viable, data-driven pathway for enhancing the reliability assessment of industrial machinery. It demonstrates that existing operational data, when systematically modelled, can yield actionable insights for maintenance planning.", "recommendations": "Implement standardised data logging protocols across fleets to improve model inputs. Pilot the forecasting model in a single industrial sector before broader rollout. Invest in capacity building for local engineers in predictive maintenance analytics.", "key words": "Predictive maintenance, reliability engineering, SARIMA modelling, fleet management, industrial development", "contribution statement": "

Keywords: *Industrial machinery reliability, Time-series forecasting, Sub-Saharan Africa, Condition-based maintenance, Fleet management, Prognostics and health management, Developing economies*

Article Highlights

- Systematic review reveals significant data fragmentation in current maintenance practices across Rwandan industrial fleets.
- SARIMA modelling of historical failure data identifies a statistically significant weekly pattern in machinery reliability.

Methodological Contribution

Presents a two-stage framework combining evaluation of maintenance practices with development of a seasonal ARIMA model for failure rate forecasting in an emerging industrial context.

This working paper proposes a practical forecasting model

- Forecasting approach demonstrates a viable, data-driven pathway for enhancing predictive maintenance strategies.
- Implementation requires standardised data logging protocols and capacity building in predictive analytics.

grounded in analysis of Rwandan fleet operational data.

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