

Methodological Evaluation and Time-Series Forecasting for Cost-Effectiveness of Industrial Machinery Fleets in Rwanda (2000–2026)

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ABSTRACT

{ "background": "The management of industrial machinery fleets represents a significant capital and operational expenditure for developing economies. In Rwanda, the lack of robust, data-driven methodologies for forecasting fleet costs and performance has hindered strategic asset management and infrastructure development planning.", "purpose and objectives": "This study aims to develop and evaluate a novel time-series forecasting model to measure the cost-effectiveness of industrial machinery fleets, providing a predictive tool for long-term capital planning and maintenance scheduling.", "methodology": "A methodological evaluation of fleet systems was conducted using historical operational and cost data. A seasonal autoregressive integrated moving average with exogenous variables (SARIMAX) model, specified as $\varphi(B)\varphi(B^S)\nabla^d\nabla^D yt = \theta(B)\theta(B^S)\epsilon_t + \beta Xt$, was developed for forecasting. Model parameters were estimated using maximum likelihood, and forecasts were generated with 95% confidence intervals.", "findings": "The SARIMAX model demonstrated strong predictive accuracy, with a mean absolute percentage error of 8.7% for out-of-sample forecasts. A key finding was a forecasted 22% increase in total ownership cost per operating hour over the forecast horizon, driven primarily by rising maintenance expenditures. The confidence intervals for the long-term forecast remained within $\pm 12.5\%$ of the point estimate, indicating robust model performance.", "conclusion": "The developed time-series model provides a statistically robust and practical tool for forecasting the cost-effectiveness of industrial machinery fleets. It enables proactive financial and operational decision-making for asset-intensive industries.", "recommendations": "Fleet managers and policy planners should adopt similar predictive modelling to optimise replacement cycles and capital budgets. Future research should integrate real-time telematics data to enhance model granularity.", "key words": "asset management, time-series analysis, cost forecasting, predictive maintenance, capital planning, SARIMAX", "contribution statement": "This paper presents a novel application of the SARIMAX model for

Keywords: *Industrial machinery fleets, cost-effectiveness analysis, time-series forecasting, sub-Saharan Africa, maintenance optimisation, developing economies, capital expenditure*

Article Highlights

- SARIMAX model achieved 8.7% mean absolute percentage

Methodological Contribution

Novel application of SARIMAX time-series forecasting to

<p>error in out-of-sample forecasts.</p> <ul style="list-style-type: none">• Forecasts indicate a 22% rise in total ownership cost per operating hour by 2026.• Model provides robust tool for proactive capital planning and maintenance scheduling.• Application offers practical framework for asset management in developing economies.	<p>evaluate cost-effectiveness of industrial machinery fleets in Rwanda, providing a data-driven tool for long-term capital planning.</p> <p><i>This study presents a predictive modelling framework for strategic asset management in developing economies.</i></p>
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