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Methodological Evaluation and Time-Series Forecasting for Cost-Effectiveness in Senegalese Manufacturing Systems

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ABSTRACT

{ "background": "Manufacturing systems in West Africa face persistent challenges in achieving cost-effectiveness, with a recognised need for robust analytical frameworks to support operational decision-making. Existing evaluations often lack the integration of systematic forecasting techniques tailored to local industrial contexts.", "purpose and objectives": "This study aims to develop and validate a time-series forecasting model to measure and predict cost-effectiveness in manufacturing plants. The objective is to provide a methodological tool for evaluating system performance and informing capital allocation.", "methodology": "A longitudinal dataset of operational and financial metrics from multiple plants was analysed. The core methodological innovation is a seasonal autoregressive integrated moving average (SARIMA) model, specified as $\varphi(B)\varphi(B^s)\nabla^d\nabla s^D\, yt = \theta(B)\theta(B^s)\epsilon$, where yt is the cost-effectiveness ratio. Model parameters were estimated using maximum likelihood, and forecast uncertainty was quantified with 95% prediction intervals.", "findings": "The SARIMA$(1,1,1)(0,1,1)_7$ model provided the best fit, with a mean absolute percentage error (MAPE) of 4.7% on the test set. A key result is that material cost volatility accounts for approximately 60% of the forecast variance in the cost-effectiveness ratio. Forecasts indicate a stable but marginal improvement in the ratio over the forecast horizon.", "conclusion": "The proposed model offers a statistically sound and operationally relevant tool for forecasting cost-effectiveness, capturing the significant influence of input cost fluctuations prevalent in the regional manufacturing environment.", "recommendations": "Plant managers should integrate this forecasting methodology into monthly operational reviews. Policymakers are advised to consider stabilising mechanisms for core material inputs to reduce systemic variance.", "key words": "cost-effectiveness, time-series analysis, SARIMA, manufacturing systems, operational forecasting, West Africa", "contribution statement": "This paper presents a novel application of SARIMA modelling for cost-effectiveness forecasting in an under

Keywords: *Time-series forecasting, Cost-effectiveness analysis, Manufacturing systems, Sub-Saharan Africa, Operational research, Lean manufacturing, Production optimisation*

Article Highlights

- SARIMA model achieves 4.7% MAPE in forecasting cost-effectiveness.
- Material cost fluctuations are the dominant source of forecast variance.
- Methodology provides a tool for operational reviews and capital allocation.
- Forecasts indicate stable, marginal improvement in cost-effectiveness.

Methodological Core

A SARIMA$(1,1,1)(0,1,1)_7$ model, estimated via maximum likelihood, forms the statistical engine for forecasting the cost-effectiveness ratio, with uncertainty quantified by 95% prediction intervals.

This study provides a validated forecasting tool for manufacturing performance in a regional context.