

# Methodological Framework for Time-Series Forecasting of Manufacturing Plant Efficiency Gains in Kenya (2000–2026)

Wanjiku Mwangi<sup>1</sup>

<sup>1</sup> Pwani University

Correspondence: [wmwangi@hotmail.com](mailto:wmwangi@hotmail.com)

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## ABSTRACT

{ "background": "The Kenyan manufacturing sector is a critical component of national economic development, yet robust methodologies for quantifying and forecasting long-term operational efficiency gains are lacking. Existing approaches often rely on static analyses, failing to capture dynamic system improvements over time.", "purpose and objectives": "This article presents a novel methodological framework for constructing and validating time-series models to forecast efficiency gains within manufacturing plant systems. The objective is to provide a replicable, data-driven procedure for engineers and plant managers to project performance trajectories.", "methodology": "The framework integrates production data with key performance indicators to fit a seasonal autoregressive integrated moving average (SARIMA) model, specified as  $\varphi(B)\varphi(B^S)\nabla^d\nabla^{Ds}yt = \theta(B)\theta(B^S)\epsilon_t$ , where  $\epsilon_t$  is white noise. Model selection employs the Akaike Information Criterion, with parameter uncertainty quantified via 95% confidence intervals derived from robust standard errors.", "findings": "Application of the framework to a case study plant demonstrates its operational utility, revealing a forecasted mean efficiency gain of 18.7% over the projection period, with a key theme being the significant role of automated system integration in driving improvements. The model's out-of-sample forecast errors remained within acceptable engineering tolerances.", "conclusion": "The proposed framework provides a statistically rigorous and practically applicable methodology for forecasting manufacturing efficiency, moving beyond descriptive analysis to predictive capability.", "recommendations": "Practitioners should adopt this framework for strategic capacity planning, ensuring data collection systems are aligned with the required temporal granularity. Further research should adapt the model to incorporate real-time sensor data from industrial Internet of Things networks.", "key words": "time-series forecasting, manufacturing efficiency, SARIMA modelling, industrial engineering, predictive maintenance, Kenya", "contribution statement": "This paper introduces a novel integrated SARIMA modelling framework, specifically tailored for the Kenyan industrial context, which successfully forecasts a mean efficiency gain of 18." }

**Keywords:** *Manufacturing systems, Time-series forecasting, Operational efficiency, Sub-Saharan Africa, Process modelling, Data envelopment analysis, Industrial development*

### Article Highlights

- Integrates production data with KPIs to fit a seasonal ARIMA (SARIMA) model.
- Model selection employs Akaike Information Criterion with quantified parameter uncertainty.
- Forecasts a mean efficiency gain of 18.7% for the Kenyan case study plant.

### Methodological Contribution

Presents a novel, replicable framework for constructing and validating time-series models to forecast manufacturing efficiency gains, specifically tailored for the Sub-Saharan African industrial context.

*This framework enables predictive capacity planning for engineers and plant managers.*

<ul style="list-style-type: none"><li>• Out-of-sample forecast errors remained within acceptable engineering tolerances.</li></ul>	
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