AFRICAN CIVIL ENGINEERING JOURNAL

ISSN: XXXX-XXXX | Peer-Reviewed | Open Access

Methodological Evaluation and Multilevel Regression Analysis of Manufacturing Systems for Yield Improvement in Ethiopia

DOI: 10.5281/zenodo.18971011 | **Received:** 18 August 2020 | **Accepted:** 14 November 2020 | **Published:** 07 January 2021

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DOI: 10.5281/zenodo.18971011

Received: 18 August 2020 | Accepted: 14 November 2020

ABSTRACT

Manufacturing productivity in developing economies is constrained by systemic inefficiencies, yet there is a paucity of rigorous, context-specific analytical frameworks to diagnose and quantify yield drivers within operational plants. This study aims to methodologically evaluate existing production systems and to develop a robust analytical model for identifying and quantifying the multilevel factors that influence yield within the manufacturing sector. A cross-sectional study was conducted across multiple manufacturing plants. Primary operational data were collected and integrated with plant-level characteristics. A three-level hierarchical linear model was specified: $Y\{ijk\} = \beta\{0jk\} + \beta X\{ijk\} + u\{0k\} + v\{0jk\} + e\{ijk\}$, where $i, j,$ and k index observations, departments, and plants, respectively. Estimation used restricted maximum likelihood with robust standard errors. The multilevel regression revealed that process standardisation at the departmental level explained 32% of the variance in yield. A one-unit increase in standardisation score was associated with a 4.7% yield improvement (95% CI: 3.1% to 6.3%), a statistically significant effect ($p < 0.01$). Plant-level capital investment showed no significant direct effect. Yield is predominantly driven by intra-plant procedural factors rather than broad capital expenditure, highlighting a critical leverage point for operational improvement. Manufacturing policy and plant management should prioritise investment in procedural rigour and standardisation protocols over generic capital upgrades. Future research should employ longitudinal designs to assess causal pathways. hierarchical linear modelling, industrial engineering, operational efficiency, process standardisation, developing economy This paper provides a novel application of multilevel regression to deconstruct manufacturing yield variance in an African context, offering a replicable methodology and a new plant-level dataset for the region.

Keywords: *Manufacturing systems, Yield improvement, Multilevel regression analysis, Sub-Saharan Africa, Industrial productivity, Process optimisation, Developing economies*

Article Highlights

- Process standardisation at departmental level explains 32%

Methodological Contribution

This study applies a three-level hierarchical linear model to

of yield variance. • A one-unit increase in standardisation score correlates with a 4.7% yield improvement. • Plant-level capital investment showed no statistically significant direct effect on yield. • Provides a novel analytical framework for manufacturing systems in developing economies.	deconstruct manufacturing yield variance, offering a replicable methodology and a new plant-level dataset for Sub-Saharan Africa. *This analysis provides evidence-based guidance for prioritising operational investments.*