

A Multilevel Regression Framework for Efficiency Diagnostics in Ghanaian Industrial Machinery Fleets

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ABSTRACT

Background: The operational efficiency of industrial machinery fleets is a critical determinant of productivity and economic output in developing industrial sectors. Current diagnostic approaches often rely on aggregate metrics or single-level analyses, which fail to account for the hierarchical structure of fleet data and contextual operational factors, leading to imprecise efficiency estimates.

Purpose and objectives: This article presents a novel multilevel regression framework designed to provide robust efficiency diagnostics for industrial machinery fleets. The primary objective is to delineate a methodology that partitions variance in machinery performance across different organisational levels, thereby isolating controllable efficiency drivers from systemic or contextual factors.

Keywords: *Multilevel modelling, Efficiency diagnostics, Industrial machinery fleets, Sub-Saharan Africa, Regression analysis, Maintenance optimisation, Developing economies*

Article Highlights

- Proposes a three-level linear mixed model for machinery fleet diagnostics.
- Partitions performance variance across operational cycles, machines, and sites.
- Case study shows site-level factors account for majority of efficiency variance.
- Provides statistically rigorous confidence intervals for variance components.

Methodological Core

The model employs restricted maximum likelihood estimation to isolate controllable efficiency drivers from systemic contextual factors across hierarchical data levels.

This framework shifts diagnostics from descriptive averages to quantified sources of variation.

ABSTRACT-ONLY PUBLICATION

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