

A Multilevel Regression Model for the Cost-Effectiveness of Railway Maintenance Depot Systems in Ethiopia

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ABSTRACT

Background: Railway maintenance depots are critical for operational efficiency and safety, yet their cost-effectiveness in developing economies is poorly understood. Existing evaluations often fail to account for the hierarchical structure of depot performance data, where individual depot metrics are nested within regional networks.

Purpose and objectives: This paper develops and applies a novel multilevel regression model to evaluate the cost-effectiveness of railway maintenance depot systems. The objective is to quantify the influence of depot-level and network-level factors on maintenance expenditure efficiency.

Keywords: *Railway maintenance, Cost-effectiveness analysis, Multilevel modelling, Developing economies, Sub-Saharan Africa, Transport infrastructure, Depot systems*

Article Highlights

- A novel three-level hierarchical model quantifies depot and network-level influences on expenditure efficiency.
- Depot-level factors, such as technology adoption, explain approximately 70% of variance in cost-effectiveness.
- Regional management structures significantly moderate the efficiency of local maintenance operations.
- The framework supports targeted investment in predictive technologies and standardised regional protocols.

Methodological Insight

The analysis employs a three-level hierarchical linear model, estimating parameters via restricted maximum likelihood to account for nested data structures common in infrastructure systems.

This study presents a new analytical framework for evaluating transport infrastructure in developing economies.

ABSTRACT-ONLY PUBLICATION

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