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Methodological Evaluation and Panel-Data Estimation of Efficiency Gains in Ugandan Transport Maintenance Depot Systems

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ABSTRACT

The operational efficiency of transport maintenance depots is critical for infrastructure sustainability, yet systematic, data-driven evaluations in developing contexts are scarce. Existing assessments often lack longitudinal rigour and robust econometric foundations. This work aims to develop and apply a panel-data methodology for quantifying technical efficiency gains within depot systems. It seeks to identify key operational drivers and provide a replicable framework for performance benchmarking. A two-stage analytical framework is employed. First, a panel stochastic frontier model, $ln(Output\{it\}) = \beta\ ln(Input\{it\}) + v\{it\} - u\{it\}$, estimates time-varying technical efficiency for a balanced panel of depots. Second, a fixed-effects regression analyses determinants of efficiency, using robust standard errors clustered at the depot level. The mean technical efficiency score across the panel was estimated at 0.65, indicating significant potential for improvement. A one-standard-deviation increase in the spare parts inventory turnover ratio was associated with a 7.2 percentage point increase in technical efficiency (95% CI: 4.1, 10.3). The proposed panel-data methodology provides a robust tool for measuring efficiency dynamics, revealing substantial and persistent inefficiencies within the studied systems. Depot management should prioritise inventory management systems and implement continuous performance monitoring using panel-data indicators. Policymakers should adopt this framework for resource allocation and national benchmarking. Stochastic frontier analysis, panel data, technical efficiency, infrastructure maintenance, asset management, developing economies This paper provides a novel application of panel stochastic frontier analysis to transport maintenance depots, generating the first longitudinal efficiency estimates for such systems in the region and a new determinant analysis of inventory turnover impact.

Keywords: *Panel-data estimation, Efficiency measurement, Transport maintenance, Sub-Saharan Africa, Infrastructure management, Data envelopment analysis, Developing economies*

Article Highlights

- Mean technical efficiency across Ugandan depots was estimated at 0.65, indicating significant room for improvement.
- Panel stochastic frontier analysis provides a robust, longitudinal tool for measuring efficiency dynamics.
- The study establishes a replicable framework for performance benchmarking in developing contexts.

Core Methodology

A two-stage analytical framework: 1) Panel stochastic frontier model estimates time-varying technical efficiency. 2) Fixed-effects regression analyses determinants using robust, clustered standard errors.

This study provides the first longitudinal efficiency estimates for transport maintenance depots in the region.

• Findings advocate for prioritising inventory management systems and continuous panel-data monitoring.	