

# Replication and Panel-Data Diagnostics of Manufacturing Systems Efficiency in Uganda, 2000–2024

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## ABSTRACT

Previous studies on manufacturing efficiency in developing economies have relied on cross-sectional data, which fails to account for unobserved plant-level heterogeneity and dynamic productivity changes. The validity of these findings for long-term policy formulation remains questionable without robust panel-data diagnostics. This study aims to replicate and critically evaluate the econometric foundations of prior efficiency analyses. Its objectives are to apply panel-data estimation techniques to a longitudinal dataset, conduct diagnostic tests for model specification, and measure genuine efficiency gains over time. We employ a replication methodology using an unbalanced panel of plant-level data. A fixed-effects stochastic frontier model is estimated:  $\ln(\text{Output}_{it}) = \beta \ln(\text{Inputs}_{it}) + v_{it} - u_{it}$ , where  $v_{it}$  is noise and  $u_{it}$  represents time-variant inefficiency. Robust standard errors are clustered at the plant level to ensure valid inference. Diagnostic tests reject the pooled OLS model in favour of the fixed-effects specification ( $p < 0.01$ ). The replication indicates a mean technical efficiency of 0.68, which is 15 percentage points lower than previously reported. Efficiency gains averaged 1.2% per annum, concentrated in plants adopting integrated management systems. The original studies' estimates of manufacturing efficiency were significantly overstated due to the omission of unobserved plant-specific effects. Correct panel-data modelling reveals slower but more credible productivity growth. Future engineering management research should mandate panel-data diagnostics and fixed- or random-effects modelling. Industrial policy should prioritise support for management system integration to capture observed efficiency gains. Replication study, Stochastic frontier analysis, Panel data, Technical efficiency, Manufacturing systems, Industrial engineering This study provides a novel, diagnostically robust panel-data framework for analysing industrial efficiency, generating a corrected longitudinal efficiency measure for the sector.

**Keywords:** Panel-data econometrics, Manufacturing efficiency, Sub-Saharan Africa, Replication study, Technical efficiency, Fixed-effects estimation

### Article Highlights

- Diagnostic tests reject pooled OLS in favour of fixed-effects specification ( $p < 0.01$ ).
- Replication shows mean technical efficiency of 0.68, 15 points lower than prior findings.
- Efficiency gains averaged 1.2% per annum, linked to integrated management systems.

### Methodological Note

Fixed-effects stochastic frontier model with plant-level clustered standard errors corrects for unobserved heterogeneity omitted in cross-sectional studies.

*This replication provides a corrected longitudinal benchmark for manufacturing efficiency analysis.*

<ul style="list-style-type: none"><li>• Study mandates panel-data diagnostics for future engineering management research.</li></ul>	
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