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A Multilevel Regression Analysis of Manufacturing Systems Adoption in Rwandan Plants

A Methodological Case Study (2000–2026)

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ABSTRACT

Background: The adoption of advanced manufacturing systems in developing economies is critical for industrial growth, yet robust methodological frameworks for analysing adoption rates are lacking. Existing studies often fail to account for the hierarchical structure of plant-level data, where operational units are nested within firms, leading to potentially biased inferences.

Purpose and objectives: This case study presents a methodological evaluation of applying multilevel regression modelling to measure the adoption rates of manufacturing systems. Its objective is to demonstrate the model's utility in capturing variance at both the plant and firm levels, providing a more accurate analytical tool for engineering management research in an African context.

Keywords: *Multilevel modelling, Manufacturing systems, Sub-Saharan Africa, Technology adoption, Regression analysis, Industrial development, Case study methodology*

Article Highlights

- A two-level hierarchical linear model analyzes plants nested within firms.
- Firm-level technical training access explains 40% of adoption variance.
- Plant workforce digital literacy strongly predicts system adoption ($p < 0.01$).
- Methodology avoids ecological fallacies common in industrial research.

Core Statistical Model

The analysis employs: $y_{ij} = \beta_{0j} + \beta_{1}x_{1ij} + e_{ij}$, where $\beta_{0j} = \gamma_{00} + \gamma_{01}z_{1j} + u_{0j}$. i denotes plants, j denotes firms.

This study demonstrates a methodological framework for analysing hierarchical industrial data.