

# Methodological Evaluation and Reliability Assessment of Process-Control Systems in Nigeria

*A Difference-in-Differences Approach*

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## ABSTRACT

Process-control systems are critical for industrial efficiency and safety, yet their methodological evaluation in developing economies remains understudied. In Nigeria, a lack of robust empirical frameworks has hindered the systematic assessment of these systems' operational reliability. This study aims to develop and apply a rigorous methodological framework for evaluating the reliability of process-control systems. The primary objective is to quantify the causal impact of system upgrades on reliability metrics. A quasi-experimental difference-in-differences (DiD) model was employed. Data were collected from 42 industrial sites. The core econometric specification is  $Y_{it} = \alpha + \beta (Treat_i \times Post_t) + \gamma_i + \delta_t + \varepsilon_{it}$ , where robust standard errors were clustered at the site level. System reliability was measured via mean time between failures (MTBF). The intervention group, following system upgrades, exhibited a statistically significant 18.7% increase in MTBF compared to the control group ( $p < 0.01$ , 95% CI: 12.3% to 25.1%). This improvement was robust to multiple model specifications. The applied DiD model provides a valid and powerful methodological framework for reliability assessment. The results confirm that targeted upgrades substantially enhance the operational reliability of process-control systems in the studied context. Industry practitioners should adopt quasi-experimental evaluation methods for capital investment decisions. Regulatory bodies should consider incorporating such methodological standards into technical audit guidelines. process control, reliability engineering, difference-in-differences, quasi-experimental design, industrial systems, Nigeria This paper provides a novel application of the difference-in-differences econometric model to the field of engineering system reliability, establishing a causal methodology absent from prior regional literature.

**Keywords:** *Process-control systems, Reliability assessment, Difference-in-differences, Industrial automation, Sub-Saharan Africa, Systems engineering, Nigeria*

### Article Highlights

- Applies a quasi-experimental DiD model to engineering reliability, a novel methodological contribution for the region.
- Finds a robust 18.7% increase in MTBF for upgraded systems versus control group.
- Data from 42 industrial sites provides empirical grounding for causal inference.
- Proposes the adoption of such frameworks for technical audits and investment decisions.

### Core Finding

The intervention group showed an 18.7% increase in Mean Time Between Failures (95% CI: 12.3% to 25.1%) after system upgrades, quantified using a difference-in-differences model.

*This study establishes a causal methodology for evaluating industrial system performance.*

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