AFRICAN STRUCTURAL ENGINEERING

ORIGINAL RESEARCH

Methodological Evaluation and Panel-Data Estimation of Process-Control System Reliability in Rwanda, 2000–2026

Jean de Dieu Uwimana[1,2] | **Pacifique Niyonsenga**[3]
Marie Claire Mukamana[4]

1 *Department of Mechanical Engineering, University of Rwanda*
2 *African Leadership University (ALU), Kigali*
3 *Department of Electrical Engineering, African Leadership University (ALU), Kigali*
4 *Department of Electrical Engineering, Rwanda Environment Management Authority (REMA)*

Correspondence: juwimana@aol.com

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ABSTRACT

Background: Process-control systems are critical for industrial and infrastructure performance, yet their long-term reliability in developing economies is under-researched. There is a lack of robust methodological frameworks for assessing these systems' degradation and failure modes over extended periods in such contexts.

Purpose and objectives: This study aims to develop and apply a novel panel-data econometric methodology to evaluate the reliability of industrial process-control systems. The objective is to quantify the impact of operational stressors and maintenance regimes on system failure rates.

Keywords: *Process-control systems, Panel-data estimation, System reliability, Sub-Saharan Africa, Developing economies, Methodological evaluation, Industrial automation*

Article Highlights

- Panel-data methodology quantifies reliability drivers in industrial automation.
- Inadequate calibration intervals significantly predict control-loop failure.
- Environmental factors like dust ingress strongly correlate with reduced reliability.
- Findings advocate for condition-based protocols over fixed maintenance schedules.

Methodological Contribution

Introduces a panel-data econometric framework using Generalised Estimating Equations (GEE) to model the reliability of process-control systems over time in a developing economy context.

This study provides a rigorous diagnostic tool for engineers and policymakers focused on industrial system longevity.