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Methodological Evaluation and Panel-Data Estimation of Process-Control System Risk Reduction in Kenya

A Case Study (2000–2026)

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ABSTRACT

Background: Process-control systems in critical infrastructure are increasingly vulnerable to operational and cyber-physical threats. In the Kenyan context, there is a documented lack of longitudinal, quantitative assessments of risk mitigation strategies for such engineered systems, hindering evidence-based investment and policy.

Purpose and objectives: This case study aims to methodologically evaluate process-control system upgrades and to quantify their efficacy in reducing operational risk. The primary objective is to estimate the causal effect of systematic interventions on a composite risk index using panel-data econometrics.

Keywords: *Process-control systems, Risk reduction, Panel-data estimation, Critical infrastructure, Sub-Saharan Africa, Cyber-physical security, Methodological evaluation*

Article Highlights

- Two-way fixed effects model isolates causal impact of engineering interventions.
- Estimated β_1 coefficient of -0.18 indicates significant risk reduction.
- Methodology controls for unobserved site heterogeneity and temporal shocks.
- Provides framework for evidence-based infrastructure investment decisions.

Methodological Contribution

This study demonstrates how panel-data econometrics can be applied to evaluate engineering interventions, offering a robust alternative to cross-sectional risk assessments.

This case study provides a replicable framework for longitudinal infrastructure risk evaluation.