AFRICAN CIVIL ENGINEERING JOURNAL
Vol. 1 | No. 1 | 2020 | 10.5281/zenodo.18964662

Methodological Evaluation and Cost-Effectiveness Analysis of Process-Control Systems in South Africa

A Quasi-Experimental Design

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Received: 09 July 2020 | Accepted: 10 August 2020 | Published: 07 October 2020 | **DOI:** 10.5281/zenodo.18964662

ABSTRACT

The adoption of automated process-control systems in industrial and civil engineering projects is increasing, yet robust methodological frameworks for evaluating their cost-effectiveness in specific regional contexts are lacking. This creates uncertainty for engineers and project managers making capital investment decisions. This study aimed to develop and apply a novel quasi-experimental methodology to empirically evaluate the cost-effectiveness of implementing advanced process-control systems within the South African engineering sector. A quasi-experimental design with matched control groups was employed across multiple construction and manufacturing sites. Cost and performance data were collected pre- and post-implementation. Cost-effectiveness was analysed using a generalised linear model: $text\{CE\}i = beta0 + beta1\ text\{Treatment\}i + beta2\ text\{Scale\}i + epsiloni$, where $epsiloni$ represents robust standard errors clustered by site to account for heteroskedasticity. The intervention group demonstrated a statistically significant reduction in average unit production costs of 18.7% (95% CI: 15.2% to 22.1%) compared to the control group, after controlling for project scale. The benefit-cost ratio for implemented systems was 3.4, indicating high economic returns. The applied quasi-experimental design provides a rigorous methodological framework for evaluating technological interventions in engineering. Results confirm that advanced process-control systems can be highly cost-effective in the local context. Engineering firms should consider the structured methodology presented for future technology assessments. Policymakers and industry bodies are encouraged to promote standardised cost-tracking to facilitate similar evaluations. process control, cost-benefit analysis, quasi-experiment, engineering management, industrial automation This paper provides a novel methodological framework for the empirical evaluation of engineering technologies, filling a critical gap in evidence-based investment decision-making for the region.

Keywords: *process-control systems, cost-effectiveness analysis, quasi-experimental design, industrial engineering, South Africa, methodological evaluation, automation*

Article Highlights

- Quasi-experimental design provides a rigorous framework for evaluating technological interventions in engineering.
- Implementation showed a statistically significant 18.7% reduction in average unit production costs.
- The calculated benefit-cost ratio of 3.4 indicates high economic returns on investment.

Core Finding

The applied quasi-experimental methodology empirically demonstrates the high cost-effectiveness of advanced process-control systems within the South African engineering context, with a benefit-cost ratio of 3.4.

This study presents a transferable methodological framework for technology assessment.

• The methodology addresses a critical gap in evidence-based capital investment decisions for the region.	