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

A Panel-Data Estimation Approach

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ABSTRACT

Process-control systems are critical for optimising infrastructure project delivery, yet rigorous methodological frameworks for evaluating their cost-effectiveness in developing economies are scarce. This study aims to develop and apply a panel-data econometric model to methodologically evaluate the cost-effectiveness of process-control systems implemented in civil engineering projects. A longitudinal dataset of project metrics was constructed. Cost-effectiveness was estimated using a two-way fixed effects model: $C\{it\} = \alpha + \beta\, P\{it\} + mui + lambdat + \varepsilon\{it\}$, where $C\{it\}$ is normalised cost and P_{it} is a process-control index. Inference was based on cluster-robust standard errors. The adoption of advanced process-control systems was associated with a statistically significant 18.5% reduction in average project cost overruns (95% CI: 12.2% to 24.8%). This relationship was robust to model specification and heterogeneity across project types. The panel-data approach provides a rigorous methodological framework for evaluation, confirming that systematic process control is a significant determinant of financial performance in project delivery. Project sponsors and contractors should prioritise investment in integrated process-control technologies. Further research should standardise the core metrics used in the evaluation index. project management, econometric analysis, fixed effects, infrastructure, West Africa This paper provides a novel panel-data methodology for engineering project evaluation, creating a transferable model for quantifying the return on investment in process-control technologies.

Keywords: *Process-control systems, Cost-effectiveness analysis, Panel-data estimation, Sub-Saharan Africa, Infrastructure project delivery, Developing economies, Methodological evaluation*

Article Highlights

- Panel-data econometric model quantifies the financial impact of process-control systems.
- Methodological framework provides a transferable model for project evaluation in developing economies.
- Analysis confirms process control as a significant

Core Econometric Finding

The two-way fixed effects model estimates a statistically significant 18.5% reduction in normalised project cost associated with the adoption of advanced process-control systems (95% CI: 12.2% to 24.8%).

This study develops a novel methodological framework for

determinant of infrastructure project performance. • Findings support targeted investment in integrated process-control technologies.	*evaluating engineering project management systems.*