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Methodological Evaluation of a Quasi-Experimental Design for Yield Optimisation in Rwandan Manufacturing Systems

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ABSTRACT

{ "background": "The adoption of structured process improvement methodologies in emerging manufacturing economies is often hindered by a lack of robust, context-appropriate evaluation frameworks. This creates uncertainty in attributing yield gains to specific interventions, particularly in dynamic industrial settings.", "purpose and objectives": "This case study aims to methodologically evaluate the application of a quasi-experimental design to measure and attribute yield optimisation within a manufacturing system. The objective is to assess the design's rigour and practicality for isolating causal effects of engineering interventions in a real-world, resource-constrained environment.", "methodology": "A comparative interrupted time-series design was implemented across three production lines in a consumer goods plant. The core intervention, a revised preventive maintenance protocol, was introduced on two treatment lines while one served as a non-equivalent control. Yield was tracked daily. The causal effect was estimated using a segmented regression model: $Yt = \beta0 + \beta1Tt + \beta2Xt + \beta3TtXt + \epsilont$, where Yt is yield, Tt is time, and X_t marks the intervention point. Robust standard errors were used to account for autocorrelation.", "findings": "The methodological evaluation found the design effectively controlled for common secular trends. The analysis indicated a statistically significant positive shift in yield for the treatment lines post-intervention, with an estimated mean increase of 7.3 percentage points (95% CI: 5.1, 9.5) relative to the control trajectory. Practical challenges included managing baseline data quality and line interdependencies.", "conclusion": "The quasi-experimental design proved to be a viable and rigorous methodological tool for evaluating engineering interventions in this setting, providing stronger causal inference than pre-post analyses alone.", "recommendations": "Practitioners should invest in establishing stable baseline measurement periods and carefully select control units to minimise contamination. Future research should test the design's transferability to other industrial sectors and incorporate cost-benefit analysis

Keywords: *Quasi-experimental design, Yield optimisation, Sub-Saharan Africa, Manufacturing systems, Process improvement, Lean manufacturing*

Article Highlights

- Segmented regression isolated a significant 7.3pp yield increase from the maintenance protocol.
- The design effectively controlled for common secular trends in a dynamic production environment.
- Practical challenges included managing baseline data quality and line interdependencies.
- Provides stronger causal inference for engineering interventions than pre-post analyses alone.

Core Methodological Insight

A comparative interrupted time-series design with a segmented regression model was implemented to attribute yield gains to a specific engineering intervention, controlling for underlying trends.

This case study evaluates the application of a quasi-experimental design in a resource-constrained manufacturing context.