

# A Multilevel Regression Analysis of Manufacturing Systems for Risk Reduction in Nigeria

A Policy Evaluation, 2000–2026

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## ABSTRACT

Manufacturing systems in Nigeria face persistent operational and safety risks, undermining industrial productivity and economic development. Existing policy evaluations often lack the methodological rigour to account for the hierarchical structure of plant-level data, where observations within firms are correlated. This policy analysis evaluates the efficacy of national industrial safety and risk reduction policies by applying a multilevel modelling approach to measure their impact on manufacturing system performance. A longitudinal, plant-level dataset was analysed using a three-level hierarchical linear model. The core equation is  $y_{ijt} = \beta_0 + \beta_1 X_{ijt} + u_j + v_t + \varepsilon_{ijt}$ , where  $i$ ,  $j$ , and  $t$  index plants, firms, and time, respectively. Robust standard errors were used for inference. The analysis indicates that policies emphasising systemic process integration were associated with a 15–20% greater reduction in critical failure rates compared to prescriptive equipment standards. The random effects for firms ( $u_j$ ) were statistically significant, confirming the necessity of the multilevel approach. Policy effectiveness is contingent on addressing the nested structure of manufacturing systems. Interventions that enhance integrated process controls are more potent for systemic risk reduction than isolated technical mandates. Policy formulation should mandate multilevel impact assessments. Regulatory frameworks must shift from compliance-based equipment checks towards incentivising firm-level investment in integrated safety management systems. multilevel regression, manufacturing systems, risk reduction, policy evaluation, hierarchical linear model, industrial safety This study provides a novel methodological framework for policy evaluation in engineering by demonstrating the application of multilevel regression to disentangle firm-specific and policy-driven effects on manufacturing system risk.

**Keywords:** Manufacturing systems, Risk reduction, Multilevel regression analysis, Policy evaluation, Sub-Saharan Africa

### Article Highlights

- Multilevel modelling confirms firm-specific effects are statistically significant in policy outcomes.
- Integrated process controls outperform isolated technical mandates for systemic risk reduction.
- Study provides a novel framework for disentangling firm-specific and policy-driven effects.
- Regulatory frameworks should incentivize firm-level

### Methodological Insight

The analysis employs a three-level hierarchical linear model to account for the nested structure of plant-level data within firms and over time, a necessity confirmed by significant random effects.

*This analysis shifts the policy evaluation paradigm from compliance checks to systemic integration.*

investment in integrated safety systems.	
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