Methodological Evaluation of Bayesian Hierarchical Models for Measuring Adoption Rates in Process-Control Systems in Ghana

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Abstract

Recent advancements in Bayesian hierarchical models have been applied to study adoption rates of process-control systems (PCSs), particularly in non-Western contexts like Ghana. These models offer a nuanced approach to understanding how PCSs are adopted across different settings, considering the variability and complexity inherent in such implementations. We employed a Bayesian hierarchical linear regression model to estimate adoption rates across various sectors in Ghana. Data were collected through surveys and administrative records, with an emphasis on capturing temporal trends and sector-specific differences. Model uncertainty was quantified using posterior predictive checks and credible intervals. The analysis revealed significant variability in PCS adoption rates between industries, with manufacturing showing higher rates compared to agriculture and services (direction: significantly higher in manufacturing). Posterior predictive checks indicated that the model adequately captured data patterns (proportion: 95% confidence interval for all sectors combined was within expected range). The Bayesian hierarchical models provided a robust framework for measuring adoption rates, highlighting sector-specific differences and offering insights into factors influencing PCS uptake in Ghanaian contexts. These findings can inform targeted interventions to accelerate adoption. Future research should consider incorporating additional explanatory variables and exploring the impact of technological infrastructure on PCS adoption. Practitioners are encouraged to use these models for strategic planning and policy development aimed at improving PCS utilization. Bayesian hierarchical model, process-control systems, adoption rates, Ghanaian industries The maintenance outcome was modelled as $Y\{\} = beta\,0 + beta\,1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *Geographic, Hierarchical, Bayesian, Adoption, Evaluation, Quantitative, Analysis*

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