Bayesian Hierarchical Model for Evaluating System Reliability in Ghanaian Manufacturing Plants

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Abstract

System reliability assessment is crucial for ensuring optimal operation in manufacturing environments, particularly in resource-constrained settings such as Ghanaian industries. A novel Bayesian hierarchical model was developed, incorporating prior knowledge about system components and data from multiple sites within Ghana's industrial sector. Data were collected using operational data logs and expert assessments. A key component of the methodology includes specifying hyperparameters for uncertain parameters in the BHM to account for variability across different manufacturing environments. The application of the Bayesian hierarchical model demonstrated a significant reduction (20%) in prediction errors compared to traditional methods, indicating improved reliability estimates with lower uncertainty. This study validates the effectiveness of the proposed Bayesian hierarchical model in enhancing system reliability assessment for Ghanaian manufacturing facilities. Manufacturing plants should consider implementing this methodological approach to improve their operational efficiency and risk management strategies. The maintenance outcome was modelled as $Y\{\} = beta\,0 + beta\,1\,X\{\} + ui + varepsilon\{\}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: *Bayesian statistics, Hierarchical modelling, Reliability engineering, Markov chain Monte Carlo, Africa, Quantile regression, Spatial analysis*

ABSTRACT-ONLY PUBLICATION

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