



# Bayesian Hierarchical Model for Efficiency Gains in Smallholder Farm Systems of Rwanda: A Methodological Evaluation

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## Abstract

Efficiency gains in smallholder farm systems are crucial for agricultural development in Rwanda. Bayesian hierarchical models offer a flexible framework to analyse and quantify these gains. A Bayesian hierarchical linear regression model was developed to estimate efficiency scores across different farm characteristics. The model accounts for spatial and temporal variations using prior distributions informed by existing data. The model demonstrated a significant improvement in capturing heterogeneity among smallholder farms, with estimated coefficients indicating substantial gains in productivity. The Bayesian hierarchical model provided more nuanced insights into efficiency dynamics compared to traditional methods, enhancing the reliability of efficiency assessments. Further research should explore the scalability and generalizability of this approach across other African contexts. Bayesian Hierarchical Model, Smallholder Farms, Efficiency Gains, Rwanda Model estimation used  $\hat{\theta} = \operatorname{argmin}\{\theta\} \operatorname{sumiell}(y_i, f\theta(\xi)) + \lambda \operatorname{Vert}\theta \operatorname{Vert}^2$ , with performance evaluated using out-of-sample error.

**Keywords:** *Bayesian statistics, hierarchical modelling, econometrics, smallholder agriculture, Rwanda, agricultural development, spatial analysis*

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