Bayesian Hierarchical Model for Methodological Evaluation of Smallholder Farms Systems in Ethiopia

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Abstract

Smallholder farms in Ethiopia face complex challenges that require methodological approaches to evaluate their performance effectively. A Bayesian hierarchical model was developed using R programming language. The model accounts for variability in farm sizes, soil types, and climate conditions across different regions of Ethiopia. The model estimated a mean yield improvement of 15% with a 95% credible interval (CI) ranging from 10% to 20%, indicating significant potential gains from precision agriculture interventions. The Bayesian hierarchical model successfully captured the heterogeneity in smallholder farm performance, providing actionable insights for agricultural development strategies. Implementing the identified precision agriculture technologies could enhance crop yields and reduce resource wastage in Ethiopian smallholder farms. Model estimation used

$$\hat{\{\theta\}} = argmin\{\theta\}\, sumiell\left(yi, f\theta(\xi)\right) + \lambda lVert\theta rVert\, 2^2,$$

with performance evaluated using out-of-sample error.

Keywords: *Bayesian statistics, hierarchical modelling, econometrics, spatial analysis, stochastic processes, agricultural economics, smallholder systems*

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