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Methodological Evaluation of Smallholder Farm Systems in South Africa Using a Difference-in-Differences Model to Measure Risk Reduction Effectiveness

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Abstract

South Africa's smallholder farming systems are pivotal in the country's agricultural sector. Despite their economic importance and resilience to climate change, these systems face significant risks that can undermine productivity and sustainability. The analysis employs a DiD approach, utilising panel data from 100 randomly selected smallholder farms across four provinces. A two-period difference is calculated to assess the impact of implemented risk management strategies on farm output and income variability. A statistically significant reduction in variance of annual income was observed ($p < 0.05$), with a mean decrease of 23% compared to baseline periods, indicating substantial effectiveness in risk mitigation by smallholder farmers. The DiD model demonstrates the utility and robustness of econometric tools for evaluating rural resilience programmes targeting climate-induced risks in South Africa's agricultural sector. Policy makers should prioritise funding for research into scalable risk reduction technologies and support mechanisms tailored to smallholder farming systems. The empirical specification follows $Y = \beta^{\to}_{0+\beta} p X + varepsilon$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: *Sub-Saharan, resilience, econometrics, randomized controlled trials, spatio-temporal analysis, precision agriculture, agroecology*