

Agricultural Index Insurance: An Optimization Approach

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Research Problem. We study the problem of contract design for agricultural index insurance and develop a method to make it more cost efficient. Index insurance is a popular way of providing agricultural insurance in developing countries. Index insurance programs have been implemented in a variety of countries (e.g. India, Mexico, Tanzania) and it is estimated that tens of millions of farmers worldwide are covered by such programs [4]. In index insurance, an index (or statistic) is created using easily observable quantities, and it is used to determine whether the insured party suffered an adverse event. Even though index insurance has proved to be a less costly way of providing insurance for small farmers, it has been difficult to scale up. Two of the biggest problems with index insurance are low take up and high cost. Farmers are often unwilling to purchase the insurance at market prices. Providing insurance in these contexts is often more costly due to the presence of correlated risks. We develop a method to simultaneously design the contracts of all insured zones while taking into account the correlations between the zones.

Literature Review There are many studies that evaluate how access to index insurance affects the behavior of farmers (see [3]; [2]; [5]). Overall, there is evidence that index insurance reduces reliance on detrimental risk-coping strategies, increases investment, and leads to riskier, but more profitable production decisions. However, there has been relatively little research done on the design of index insurance. In [1], the authors describe the design of an index insurance program for pastoralists in Northern Kenya. Most subsequent academic research on the topic follows the same core method ([6]; [7]). To the extent of our knowledge, we are the first to use an optimization based approach to this problem.

Methodology We conducted interviews with researchers and practitioners to learn more about the context and inform our approach. Based on these interviews, we developed an optimization program to simultaneously design the insurance contracts for all insured zones. This allows us to make better tradeoffs between coverage and the cost of holding capital. Our program’s objective is to minimize risk faced by farmers subject to a budget constraint. We use the Conditional Value at Risk ($CVaR$) as our measure of risk, and derive a convex approximation to the problem. We evaluate our method by comparing its performance with the method developed by [1]. This method is the standard method used in academic publications describing the design of index insurance programs (see [6]; [7]). It is also what was used to design Kenya’s Index Based Livestock Insurance (IBLI) program.

We first compare the two methods using synthetic data. We compare the performance of the two methods under different scenarios with varying degrees of correlation between the insured zones. We also compare how the two methods are affected by the quality of the underlying prediction model. Finally, we compare the two methods using a detailed dataset of livestock losses for Kenyan pastoralists between 2009 and 2013.

Main results. We find that the insurance contracts designed by our method are significantly more cost efficient than the baseline in all scenarios tested using synthetic data. The contracts designed by our method offer comparable coverage at a lower cost, or better coverage at the same cost. Our method is able to outperform the baseline because it changes its payout strategy based on the correlation between the insured zones. This allows it to make better tradeoffs between coverage and costs associated with risk. Our method also takes into account the quality of the prediction model when designing contracts. Our method also outperforms the baseline when evaluated using real data from Kenya’s index insurance program. In this evaluation, we find that our method is more robust to the misspecification of the underlying prediction model. This allows our method to provide comparable coverage at a significantly lower cost for the insurer.

References

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