Agricultural Index Insurance: An Optimization Approach

José I. Velarde Morales and Linwei Xin

University of Chicago - Booth School of Business

April 13, 2023

We develop an optimization-based approach to designing index insurance contracts that improves coverage and is less risky for the insurer. 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 products Greatrex et al. (2015). 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. In the past, indices have been constructed using rainfall, weather, and satellite images. If the index falls below a pre-determined threshold, the insurer automatically issues out payments to the insured. This allows the insurer to circumvent the issue of verification, moral hazard, and adverse selection, since the actions of individual farmers cannot affect the index. 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. There are several problems with index insurance. One of the main problems is low take up: farmers are often unwilling to purchase the insurance at market prices. Another problem is the cost. The presence of correlated risks makes insurance in these scenarios more expensive because it makes large payouts more likely. Intuitively, if one farmer is affected by a drought, it is likely that other farmers were also affected. If large payouts are more likely, the insurer must have larger reserves in order to maintain solvency. We developed a method to simultaneously design the contracts of all the insured zones while taking into account the correlations between the zones. This allows us to make better tradeoffs between coverage and the cost capital.

We conducted interviews with researchers and practitioners to learn about the context and inform the design of the program. Our program's objective is to minimize risk faced by farmers subject to a constraint on the price of the product. 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 Chantarat et al. (2013). This method is the standard method used in academic publications describing the design of index insurance contracts (see Flatnes, Carter, and Mercovich (2018); Jensen et al. (2019)). 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 the how the two methods are affected by the quality of the underlying prediction model. We find that our method either matches or outperforms the baseline in all scenarios tested. We also evaluate the two methods using data from Kenya's IBLI program and find similar results. Our method provides comparable or better coverage at the same cost, and is generally less risky for the insurer. This holds even when the unerlying prediction model has poor performance.