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Innovations for Managing Basis Risk under Index Insurance for Small Farm Agriculture

Michael R. Carter

Michael R. Carter is researcher at the Department of Agricultural & Resource Economics of the University of California. He is also professor of agricultural and applied economics at the University of Wisconsin. His research focuses on the nature of growth and transformation in low income economies, poverty dynamics, rural credit and insurance markets, agricultural development and income distribution.

Decades of research and observation have demonstrated that risk is economically costly in low-income agricultural economies, prompting protective self-insurance strategies that keep small farmers poor as they eschew remunerative, but risky opportunities. Making matters worse, self- and community-based insurance strategies are at best only partially effective, leaving small farm households to costly ex post coping strategies when correlated shocks hit, affecting everyone in the community. These problems are further compounded because risk itself stunts the development of rural financial markets, making it that much harder for small farmers to capitalize and move forward with new technologies and market opportunities.

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• • • / • • • Recent advances in the design of index insurance contracts—such as technological advances in remote sensing—raise the hope that this vicious circle of risk and small farm economic underperformance can be broken[1]. While promising, index insurance faces its own challenges, and in practice demand for index insurance contracts has sometimes been surprisingly low. While there are a number of possible explanations of low demand by small farmers for index insurance contracts (such as lack off understanding or trust), this brief note focuses on the quality of the contract itself and the reliability of the protection that it offers small farmers. While there are a number of innovative ideas under development to improve the insurance value of index contracts, it important to take a holistic approach to the contract design problem.

Index Insurance and the Sources of Basis Risk

We first define an index insurance zone z as the geographic space that is covered by a single insurance index. For illustrative purposes, assume that there are H farm households in this zone (say 2000 households) and we will denote a single representative household with the subscript h. Let y_{hzt} denote the agricultural yield of household h in zone z in year t, and let $\bar{y}_{zt}$ denote the average yields of all households in the zone in year t. Similarly, let μ_{hz} denote the long-term average yields of household h, and let μ_z denote long-term average yields for farm households located in district z. Using these terms, we can decompose fluctuations in household yields in year t as:

1. Unlike conventional insurance that measures and indemnifies contract holders based on their individual losses, index insurance offers payments based on easily observable index (e.g., average crop yields in a community) that is correlated with, but not identical to individual losses. Index insurance minimizes concerns about moral hazard and adverse selection, and because it obviates the need for the costly measurement of individual losses, it is in principal feasible to implement with a small farm population.

$$[y_{hzt} - \mu_{hz}] = \beta[\bar{y}_{zt} - \mu_z] + [\varepsilon_{hzt}]$$

where the parameter β indicates how closely yield fluctuations for household h track the average fluctuations for its neighbors. Note that if $\beta = 0$, then the household's yields do not track average neighbor yields at all. In contrast, if $\beta = 1$, then h's yields closely follow those of neighbors in the zone. By definition, the average value of β must equal 1. To keep matters simple, we will focus on this typical household and set $\beta = 1$ in the discussion that follows.

Finally, the term ε_{hzt} measures the idiosyncratic factors that further drive h's yields above or below its long-term average. This idiosyncratic factor reflects things like localized animal or bird damage to crops suffered by household h, but not suffered by most households in the zone.

To keep simplify the notation, define

$$y^*_{hzt} = y_{hzt} - \mu_{hz} \text{ and } \bar{y}^*_{zt} = y_{zt} - \mu_z.$$

Using this notation and the assumption that $\beta = 1$, the yield decomposition above can be written as:

$$y^*_{hzt} = \bar{y}^*_{zt} + \varepsilon_{hzt}$$

This expression captures the two sources of yield variation faced by households, the common or correlated sources of variation across households in the zone ($\bar{y}^*_{zt}$) and the idiosyncratic sources of variation (ε_{hzt}). Complete insurance for the household would cover both of these sources of variation. However, as a myriad of experience shows, trying to insure all sources of variation in agricultural outcomes for small farmers is beset by a host of problems rooted in the costs of obtaining information on small farm outcomes that renders such insurance infeasible [add citations]. Index insurance is an explicitly second best attempt to create an insurance that is both feasible and provides insurance value to the smallholder.

Figure 1 illustrates this basic risk decomposition. The total width of the diagram (A+B+C) represents the total risk (variance in yield) faced by the farmer. The width of the diagram is set by agro-climatic variation and the sensitivity of the crop technology to these variations. The division of this total variation between idiosyncratic (A) and correlated risk (B+C) is set by these two factors plus the geographic scale of the insurance zone, z. Note that as the scale of the insurance zone increases, the proportion of total variation that is idiosyncratic cannot decrease and will likely increase[2].

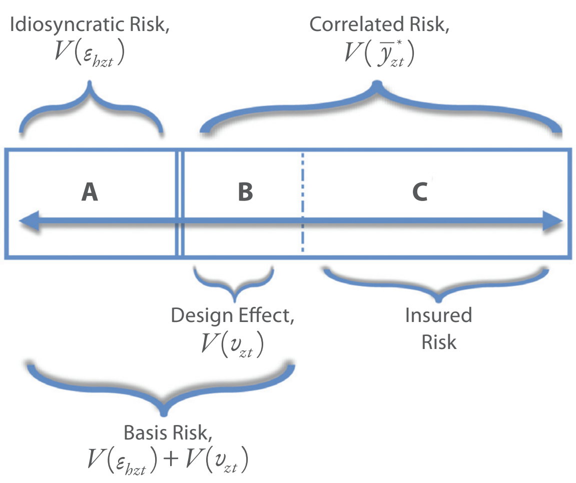

Figure 1 Risk Decomposition

As a first step toward understanding the quality and design of index insurance, we need to further take apart average outcomes, $\bar{y}_{zt}$, in the insurance zone. Let S_{zt} denote the insurance index signal that is correlated with yields in the zone and can statistically explain some fraction of average outcomes in the insurance zone. Examples of S_{zt} include rainfall, remotely sensed measures of vegetative cover, or direct measures of average zone yields. We can then write average zone yields as:

$$\bar{y}^*_{zt} = f(S_{zt}) + v_{zt}$$

where is a yield loss predictor function that maps the index signal into average zone outcomes and v_{zt} is the prediction or design error. If the signal predicts average outcomes well, then the design error will tend to be small. If the signal is a poor predictor, then this design error becomes large.

The width of area B in Figure 1 represents the magnitude of the "design effect," meaning the variation created by the imperfect ability of the insurance index to perfectly predict the average outcomes in the insurance zone. If the insurance index is an area yield index, then this design error will be small, say 2-3% of average yields. If the index is based on rainfall, then this design error may be as much as 50% of the total correlated risk. As illustrated in Figure 1, the total basis or uninsured risk under a standard index insurance contract will be the sum of the idiosyncratic risk plus the design effect (A+B). The insured risk is that represented by the width of area C.

Improving the Value of Index Insurance to Small Scale Farmers

A possible reason for the sometimes-tepid uptake of index insurance is that the risk covered by the contracts themselves (area C in Figure 1) is modest relative to the cost of the insurance[3].

2. While a more localized contract might thus seem unambiguously desirable, a too localized scale (e.g., a area contract based on village level yields rather than district level area yields) makes it likely that moral hazard problems will increase as such a small number of farmer might easily coordinate to generate the poor yields that would generate an insurance payout.

3. While standard economic analysis based on expected utility theory implies that risk averse agents will purchase even partial insurance—like index insurance—at actuarially fair prices (in which the premium equals the expected payout), real world index insurance contracts are typically priced at levels that are 20% or more above actuarially fair prices. At these higher price levels, even an expected utility maximizing agent will only purchase index insurance if the insured risk is a sufficiently high fraction of total risk.

There are at least four approaches to improving the desirability of index insurance from the small farmer's perspective:

1. Minimizing design effects through choice of index

Designing the insurance index in order to minimize the design effect [$V(v_{zt})$] is perhaps the most obvious way to improve the value of the insurance contract. A number of recent projects have begun to design indexes through a ground-truthing procedure (see Carter, 2011). As will be discussed below, careful choice of index also has a role to play in supporting the other approaches, especially the "gap insurance" discussed below.

2. Multi-scale/multi-trigger contracts

As discussed above, moral hazard limits the ability to downscale an insurance index to a more local level where idiosyncratic risk will be less. One novel approach to solving this problem is being pursued in Mali where a multi-scale, double trigger contract is being employed. As detailed in Guirkinger (2011), the primary index is a village level area yield index that *conditionally* triggers payments when village yields fall below 750 kg/hectare. While a village level index would normally raise the specter of morally hazardous behavior, payments are only made if average yield at a higher scale (a conglomeration of 10 villages) also fall below 900 kg/hectare. This second trigger is meant to discipline moral hazard. Statistical analysis shows that this double trigger structure radically reduces the magnitude of idiosyncratic risk (A in Figure 1). In addition, because it is an area yield index, the design effect (B in Figure 1) is also small, implying that overall basis risk is minimal.

3. Interlinking insurance with credit and opportunity expansion

Another approach to improving the value of index insurance to small farms is to interlink insurance (variance reduction) with opportunity expansion (increase in expected returns). This logic is detailed in Carter *et al.* (2011) and is practical to implement in environments where *correlated risk* and other problems have led to poorly developed credit markets. Shukri et al. (2011) details one effort to exploit this logic in the case of small farmers in Ethiopia. This project creates a credit-insurance package that is designed to allow farmers to improve their mean returns while reducing variance with an index contract.

4. Provision of localized 'gap insurance' that covers risks not covered by the insurance index

A fourth innovative approach to improving the quality of index insurance for small farmers is to use secondary insurance mechanisms to cover some of the risks (the 'coverage gaps') that are not covered by an index contract (see Dercon et al., 2011). The logic behind this approach is that a local community should be able to form an insurance pool against the idiosyncratic component of risk (A in Figure 1). In practice, this idea could be implemented if insured parties pay an additional premium into a locally administered idiosyncratic risk pool. Assuming reasonably that information is readily available at the local level to distinguish real losses from morally hazardous behavior, then this idea would seem quite promising. However, as Figure 1 makes clear, part of the uncovered risk under any index insurance contract is the design effect (B in Figure 2), which is a fraction of the correlated risk. A local pool cannot self-insure against correlated risk. It is thus vital that the underlying index contract not be saddled with too much of a design effect. From this perspective, gap insurance could work much better with an area yield index (perhaps of the dual-trigger variety) than with a weather index.

In summary, it is important to match the pace of innovation of new kinds of index insurance contracts (e.g., those based on satellite images or automated weather stations) with innovations to manage basis risk under these contracts and insure that the contracts are 'demand-worthy' and achieve their development goals of improved small farm productivity and well-being. While there are a number of innovative efforts to solve this problem, it is necessary to take a holistic look at the overall risk structure and not overlook the complementarities between these mechanisms. Failure to do so could result in an incomplete or even damaging 'solution' to the problem of basis risk under small farm index insurance contracts.

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www.ferdi.fr
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+33 (0)4 73 17 75 30

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