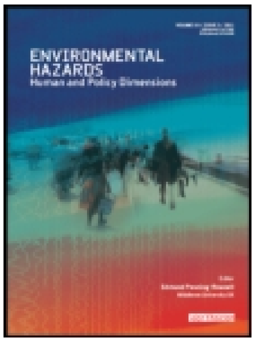

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Papers

Innovation in risk transfer for natural hazards impacting agriculture ☆

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Abstract

Agricultural income from growing crops is susceptible to a variety of risks—the price of output and the actual amount of output are generally the largest risk variables. This article focuses on yield risk rather than price risk by reviewing innovation in risk transfer for natural hazard risk in agriculture. While many higher-income countries have long-standing crop insurance programs, these programs are not appropriate for lower-income countries. Lower-income countries can ill-afford the subsidies that are used in most multiple peril crop insurance programs throughout the world. Still, lower-income countries have large numbers of small farms increasing the need for agricultural insurance to protect against common problems that create disastrous losses for many individual farm households.

Keywords: Agriculture risk management

1. Introduction

The article begins by briefly reviewing agricultural risk management strategies used by farm households. Next, agricultural insurance is introduced to acquaint the reader with some of the unique problems associated with this type of insurance. From this vantage point, the experience of North America is highlighted to make the case for why such approaches cannot work in lower-income countries. The article then introduces innovations that use index-based insurance products. While these products hold promise for lower-income countries with large numbers of small farm households, the article reviews both the advantages and disadvantages of these products—carefully pointing to situations where index insurance products are not appropriate. The article is meant as an overview of the topic only. The reader is referred to Skees et al. (2005) for a more comprehensive review of this topic.

2. Agriculture risk management

The strategies farmers use to address the financial consequences of risk generally can be categorized as risk mitigation, risk transfer, risk diversification, and management of retained risk. Risk mitigation refers to actions such as irrigation and pest management that reduce either or both the probability of a loss occurring and the severity resulting from a loss event. Risk transfer shifts a portion of a producer's risk exposure, at some cost, to another entity willing and more able to diversify the risk. Futures and insurance markets are the most common risk transfer mechanisms. These choices are quite limited in lower-income countries.

Risk diversification involves mixing several production activities be they multiple farm enterprises of adding off-farm income into the household production function. In lower-income countries diversification is also likely to involve selection of low-risk, low-returns strategies that slow economic growth. Even more troublesome, the very diversification strategies that are used such as ownership of livestock can expose farm households to even more risk

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during major droughts as forced sales of livestock creates a major price decline. Dercon (2002) examines risk management strategies for the rural poor demonstrating that many of the diversification strategies fail to smooth income for rural households. For example, the common strategy of using both farm and off-farm income can also fail during a drought as off-farm employment is tied to farm income.

Even if they utilize available risk mitigation and/or risk-transfer mechanisms, farmers still retain some degree of risk exposure and must use additional strategies for smoothing consumption across time—cutting back and drawing from savings when times are rough and contributing to savings when times are good. Savings and borrowing can occur using both formal (e.g., banks) and informal mechanisms (e.g., use of money lenders). While these mechanisms may work well for low-magnitude losses, even if they are frequent, they often prove to be inadequate for retained risk that is rare but severe. Weather risk is wholly retained in situations where existing crop-yield insurance is either not purchased or unavailable by location or crop. Yet in cases where crop-yield insurance is utilized, the loss deductible is retained.

It is highly likely that risk management strategies also vary over time as a function of farm household experience, the regulatory environment and changing risk attitudes among other factors. While this discussion casts risk management strategies as complementary, there may also be instances when risk mitigation and coping mechanisms for retained risk substitute for risk transfer, as seen in the US crop insurance experience (Glauber, 2004). There are likely several explanations, but in the absence of risk transfer, risk mitigation and risk coping strategies may potentially be overwhelmed by catastrophic loss events. Building systems whereby insurance transfers highly correlated and catastrophic losses out of the community, and banks and non-banking institutions facilitate savings and borrowing to assist in coping with more frequent and less severe events, is at the core of designing effective systems for agricultural output risk.

3. Agriculture insurance

Insurance is a commonly used risk-transfer mechanism for property damage throughout the developed world, and in many lower-income countries. Personal liability risk is also commonly transferred, as is the risk of illness or injury and loss of life. When purchasing these insurance policies, individuals choose to accept a relatively small, consistent stream of losses (the insurance premiums) rather than face the risk of a large loss that has a low probability of occurrence. Developed countries have many different insurance products available. Again, this is not true for lower-income countries. If insurance for property damage is available at all, it is likely that it is only available in the urban areas and largely absent in the rural areas. The transaction cost of delivering insurance products to economically small rural households is simply too great.

When considering the potential functionality of any risk-transfer instrument, a major consideration is the degree of correlation in financial losses caused by the risk, and building a diversified portfolio of insureds. Aggregating uncorrelated risks into a single insurance pool reduces the variance of loss as the mean of the individual variances is always greater than the variance around the mean loss of the pool, a result that follows from the statistical property known as the "law of large numbers." Society benefits from insurance markets that pool uncorrelated risks, since the volatility of the risk faced by the pool is less than the pre-aggregated sum of individual risks (Priest, 1996).

Agricultural production losses, especially due to weather events, tend to be characterized by some degree of positive spatial correlation, since weather patterns are generally similar over large geographic areas. Thus, the degree of positive correlation is often inversely related to the size of the region under consideration: relatively small (large) countries are likely characterized by more (less) positively correlated agricultural losses. Positive spatial correlation of losses limits the risk reduction that can be obtained by pooling risks from different geographical areas and increases the variance in indemnities paid by insurers. As a result, it also increases the cost of maintaining adequate reserves or reinsurance to fund potentially large indemnities caused by systemic loss events. In general, when losses are more positively correlated, insurance is less efficient as a risk-transfer mechanism.

Other risk-transfer markets may be better suited to highly positively correlated risks. For example, futures exchange markets exist to transfer risks associated with commodity prices and interest rates where the underlying values are generally highly correlated. In recent years, various capital market instruments have developed for transferring highly correlated weather risks or risks associated with natural disasters (Doherty, 2000; Skees, 1999). While growing in significance these markets are generally small when compared to conventional reinsurance markets.

In general, agricultural production losses are typically neither uncorrelated nor highly positively correlated. They are what have been referred to as "in-between" risks (Skees and Barnett, 1999). This implies that, if used exclusively, neither insurance nor capital market instruments are well suited for transferring agricultural production risks. However, a careful blending of these instruments can foster further development of agricultural risk-transfer opportunities, and weather index insurance contracts lend themselves to facilitating that blending.

Besides the lack of statistical independence, agricultural insurance is often plagued by high administrative costs, due, in part, to the risk classification and monitoring systems that insurers must put in place to forestall the asymmetric information problems associated with moral hazard and adverse selection. Moral hazard occurs when the insured changes behavior after the purchase of the insurance. The changed behavior makes the insured more risky than they were prior to purchasing the insurance. Adverse selection occurs when those who are more risky are attracted to purchase the insurance and those who are less risky chose not to purchase. Obtaining more information either prior to the sale of insurance or after the sale of insurance can mitigate moral hazard and adverse selection. It is costly to obtain more information. Other costs include acquiring the data needed to establish accurate premium rates and conducting claims adjustments. As a percentage of the premium, the smaller the policy, typically, the larger the administrative costs.

Spatially correlated risk, moral hazard, adverse selection, and high administrative costs are all important reasons why agricultural insurance markets may fail. Furthermore, insurers must generally load premiums to reflect the possibility of ruin in the early years as the variance of insuring a correlated risk is higher than the variance of insuring an uncorrelated risk. If global reinsurance markets are efficient, what is correlated risk within a single country can be placed into a well-diversified portfolio of risk globally and reduce the need for this type of loading. Still the transaction costs of performing due diligence for small volumes of premium in lower-income countries make it highly unlikely that reinsurance will be available in these countries. Finally, cognitive failure among potential insurance purchasers and ambiguity loading on the part of insurance suppliers are other possible causes of agricultural insurance market failure.[1]

If consumers fail to recognize and plan for low-frequency, high-consequence events, the likelihood that an insurance market will emerge diminishes. When considering an insurance purchase, the consumer may have difficulty determining the value of the contract or, more specifically, the probability and magnitude of loss relative to the premium (Kunreuther and Pauly, 2001). Many decision makers tend to underestimate their exposure to low-frequency, high-consequence losses. Thus, they are unwilling to pay the full costs of an insurance product that protects against these losses. Low-frequency events, even when severe, are frequently discounted or ignored altogether by producers trying to determine the value of an insurance contract. The evaluation of probability assessments regarding future events is complex and often entails high search costs. Many people resort to various simplifying heuristics, but probability estimates based on these heuristics may differ greatly from the true probability distribution (Schade et al., 2002; Morgan and Henrion, 1990). The general finding regarding subjective crop-yield distributions is that agricultural producers forget extreme low-yield events and tend to overestimate the mean yield and underestimate the variance (Buzby et al., 1994; Pease et al., 1993; Dismukes et al., 1989).

On the other hand, insurers will typically load premium rates heavily for low-frequency, high-consequence events where considerable ambiguity surrounds the actual likelihood of the event (Schade et al., 2002; Kunreuther et al., 1995). Ambiguity is especially serious when considering highly skewed probability distributions with long tails, as is typical of crop yields. Uncertainty is further compounded when the historical data used to estimate probability distributions are incomplete or of poor quality, a very common problem in lower-income countries. Small sample size creates large measurement error, especially when the underlying probability distribution is heavily skewed. Kunreuther et al. (1993) demonstrate via experimental economics that when risk estimates are ambiguous, loads on insurance premiums can be 1.8 times higher than when insuring events with well specified probability and loss estimates.

Together, these effects create a wedge between the prices that farmers are willing to pay for catastrophic agricultural insurance and the prices that insurers are willing to accept. Thus, functioning private-sector markets may fail to materialize or, if they do materialize, they may cover only a small portion of the overall risk exposure (Pomareda, 1986).

4. Approaches to agriculture insurance in developed countries

To better understand agricultural risk management markets and government policies to facilitate access to risk management instruments, it is worthwhile to analyze critically the experiences of some developed countries. The United States and Canada have long established a quite sophisticated multiple peril crop insurance programs. In both countries, the programs have undergone significant changes in the past 20–30 years. In both countries, heavy government subsidies are used (e.g., in the US farmers pay only about 30 percent of the total costs of the agricultural insurance). These subsidies mask many of the underwriting problems that are inherent in offering individual multiple peril crop insurance. If farmer premiums are subsidized, it makes the premiums more attractive to those farmers who represent better risk than the pool of farmers who would purchase without the subsidies. Thus, given premium subsidies with little attention to individual underwriting, the higher risk farmers will still end up with more transfers.

Two major differences between the US and Canadian crop insurance programs involve the delivery systems and the role of provinces in designing alternative products in Canada. The US uses the private sector to deliver crop insurance. The Canadians deliver crop insurance via provincial government entities. In the US there is one Risk Management Agency (RMA) in the United States Department of Agriculture that is responsible for maintenance of existing products and the development of new products. The RMA also sets premium rates. Unlike the US, in Canada provinces have a degree of autonomy to tailor design products that fit their region. Provinces have a relationship with Federal government in Canada to

[1]See Skees et al. (2005) background paper for more discussion of "cognitive failure" and "ambiguity loading."

provide some of the subsidy and reinsurance capacity under the broader umbrella of Canadian agricultural safety net policy.

There are several common elements among the North American crop insurance programs. Each of the programs:

1. Mixing both social and market-based goals.
2. Core products that involve insurance at the farm level for multiple perils.
3. Government subsidies that are linked to premiums on a percentage basis.
4. Government subsidies or government agencies for the administrative cost of the program.
5. A major role for government in pooling and holding some of the most catastrophic risk.

A fundamental challenge for any country rethinking current approaches to agricultural insurance programs or attempting to design new instruments, including indexed weather insurance, is to critically assess key features that are common to existing government-facilitated agricultural insurance programs.

5. Why the experience of developed countries is not a good model for lower-income countries

For various reasons, lower-income countries should avoid adopting approaches to risk management similar to those adopted in developed countries because the opportunity cost of their more limited fiscal resources may be significantly greater than in a developed country. Thus, it is critical for a developing country to consider carefully how much risk management support is appropriate and how to leverage limited government dollars to spur insurance markets. Governments in lower-income countries cannot afford to facilitate income transfers, given the large segments of the population often engaged in farming. Nonetheless, since a larger percentage of the population in lower-income countries is typically involved in agricultural production or related industries, catastrophic agricultural losses will have a much greater impact on GDP than may occur in developed countries.

Policymakers should also carefully consider the varying structural characteristics of agriculture in different countries. For traditional crop insurance products, the typically smaller farms in lower-income countries imply higher administrative costs as a percentage of total premiums due to marketing and servicing (loss adjustment) insurance policies, lack of farm-level data, and lack of cost effective mechanisms for controlling moral hazard.

Lower-income countries also have far less access to global crop reinsurance markets than do developed countries. Reinsurance contracts typically involve high transaction costs related to due diligence. Reinsurers must understand every aspect of the specific insurance products being reinsured (for example, underwriting, contract design, rate making, and adverse selection and moral hazard controls). Some minimum volume of business, or the prospect for strong future business, must be present to rationalize incurring these largely fixed transaction costs, and the enabling environment must foster confidence in contract enforcement and institutional regulations. These components are largely missing in lower-income countries. Setting rules assuring that premiums will be collected and that indemnities will be paid is not a trivial undertaking.

6. Innovation in managing production risk: index insurance

Index insurance products offer some potential new solutions to help mitigate several aspects of the problems outlined above (Skees et al., 1999). These contingent claims contracts are less susceptible to some of the problems that plague multiple-peril farm-level crop insurance products. Unlike traditional crop insurance that attempts to measure individual farm yields or revenues, index insurance makes use of variables exogenous to the individual policyholder—such as area-level yield or some objective weather event or measure such as temperature or rainfall—but have a strong correlation to farm-level losses.

For most insurance products, a precondition for insurability is that the loss for each exposure unit be uncorrelated (Rejda, 2001). For index insurance, a precondition is that risk be spatially correlated. When yield losses are spatially correlated, index insurance contracts can be an effective alternative to traditional farm-level crop insurance.

Index products also facilitate risk transfer into financial markets where investors acquire index contracts as another investment in a diversified portfolio. In fact, index contracts may offer significant diversification benefits to investors, since the returns generally should be uncorrelated with returns from traditional debt and equity markets.

7. Basic characteristics of an index

The underlying index used for index insurance products must be correlated with yield or revenue outcomes for farms across a relatively large geographic area. In addition, the index must satisfy a number of additional properties affecting the degree of confidence or trust that market participants have that the index is believable, reliable, and void of human manipulation; that is, the measurement risk for the index must be low (Ruck, 1999). A suitable index requires that the random variables measured meet the following criteria:

- Observable and easily measured;
- Objective;
- Transparent;
- Independently verifiable;
- Reportable in a timely manner (Turvey, 2002; Ramamurtie, 1999); and
- Stable and sustainable over time.

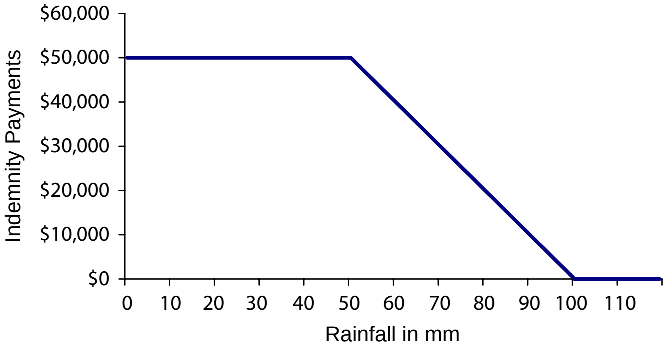

Fig. 1. Payout structure for a hypothetical rainfall contract. *Source*: Skees (2003).

Publicly available measures of weather variables generally satisfy these properties.[2]

For weather indexes, the units of measurement should convey meaningful information about the state of the weather variable during the contract period, and they are often shaped by the needs and conventions of market participants. Indexes are frequently cumulative measures of precipitation or temperature during a specified time. In some applications, average precipitation or temperature measures are used instead of cumulative measures.

Innovations in technology, including the availability of low-cost weather monitoring stations that can be placed in many locations and sophisticated satellite imagery, will expand the number of areas in which weather variables can be measured as well as of the types of measurable variables. Measurement redundancy and automated instrument calibration further increase the credibility of an index.

The terminology used to describe features of index insurance contracts resembles that used for futures and options contracts rather than for other insurance contracts. Rather than referring to the point at which payments begin as a trigger, for example, index contracts typically refer to it as a strike. They also pay in increments called ticks.

Consider a contract being written to protect against deficient cumulative rainfall during a cropping season. Fig. 1 maps the payout structure for a hypothetical $50,000 rainfall contract with a strike of 100 mm and a limit of 50 mm.

The writer of the contract may choose to make a fixed payment for every 1 mm of rainfall below the strike. If an individual purchases a contract where the strike is 100 mm of rain and the limit is 50 mm, the amount of payment for each tick would be a function of how much liability is purchased. There are 50 ticks between the 100 mm strike and 50 mm limit. Thus, if $50,000 of liability were purchased, the payment for each 1 mm below 100 mm would be equal to $50,000/(100−50), or $1000. Once the tick and the payment for each tick are known, the indemnity payments are easy to calculate. A realized rainfall of 90 mm, for example, results in ten payment ticks of $1000 each, for an indemnity payment of $10,000.

In developed countries, index contracts that protect against unfavorable weather events are now sufficiently well developed that some standardized contracts are traded in exchange markets. These exchange-traded contracts are used primarily by firms in the energy sector, although the range of weather phenomena that might potentially be insured using index contracts appears to be limited only by imagination and the ability to parameterize the event. A few examples include excess or deficient precipitation during different times of the year, insufficient or damaging wind, tropical weather events such as typhoons, various measures of air temperature, measures of sea surface temperature, the El Niño southern oscillation (ENSO) tied to El Niño and La Niña, and even celestial weather events such as disruptive geomagnetic radiation from solar flare activity. Contracts are also designed for combinations of weather events, such as snow and temperature (Dischel, 2001; Ruck, 1999). The potential for the use of index insurance products in agriculture is significant (Skees, 2001). In the US, weather derivatives witnessed a dramatic 4-fold growth from 2004–2005 to 2005–2006 of roughly $10 billion to a forecast in excess of $40 billion of notional risk (Weather Risk Management Association).

A major challenge in designing an index insurance product is minimizing basis risk. Since index-insurance indemnities are triggered by exogenous random variables, such as area yields or weather events, an index-insurance policyholder can experience a yield or revenue loss and not receive an indemnity or may experience no yield or revenue loss and receive an indemnity. The effectiveness of index insurance as a risk management tool depends on how positively correlated farm yield losses are with the underlying index. In general, the more homogeneous the area, the lower the basis risk and the more effective area-yield insurance will be as a farm-level risk management tool. Similarly, the more closely a given weather index actually represents weather events on the farm, the more effective the index will be as a farm-level risk management tool.[3]

[2]By contrast, area-yield indexes in developing countries often are not measured in a reliable and timely manner.

[3]Basis risk also exists with traditional farm-level, multiple-peril crop yield insurance. Typically, a small sample size is used to develop estimates of the central tendency in farm-level yields (for example, 4–10 years in the United States). Given simple statistics about the error of small sample estimates, it can be demonstrated that these procedures can generate large mistakes when estimating expected farm-level yield. This makes it possible for farmers to receive insurance payments when yield losses have not occurred and to fail to receive payments when yields are indeed below normal. Thus, basis risk occurs not only in index insurance but also in farm-level yield insurance. Another type of basis risk results from the estimate of realized yield. Even with careful farm-level loss adjustment procedures, it is impossible to avoid errors in estimating the true realized yield. These errors can also result in under- and overpayments.

8. Relative advantages and disadvantages of index insurance

Index insurance can sometimes offer superior risk protection compared to traditional farm-level, multiple-peril crop insurance. Asymmetric information problems are much lower with index insurance because, first, a producer has about the same information as the insurer regarding the index value, and second, individual producers are generally unable to influence the index value. This characteristic of index insurance means that there is less need for deductibles and co-payments. Similarly, unlike traditional insurance, few restrictions need be placed on the amount of coverage an individual purchases. As long as the individual farmer cannot influence the realized value of the index, liability need not be restricted. An exception occurs when governments offer premium subsidies as a percentage of total premiums. In this case, the government may want to restrict liability (and thus, premium) to limit the amount of subsidy paid to a given policyholder. Key advantages and challenges are summarized in Table 1.

As more sophisticated systems (such as satellite imagery and accompanying models) are developed to measure events causing widespread losses, indexing major events should become more straightforward and quite acceptable to international capital markets. Under these conditions, traditional reinsurers and primary providers may begin offering insurance in countries they would never previously have considered. New risk management opportunities can develop if relevant, reliable, and trustworthy indexes can be constructed.

9. The trade-off between basis risk and transaction costs

Among the most significant issues for any insurance product is the question of how much monitoring and administration is needed to keep moral hazard and adverse selection to a minimum. To accomplish this goal, coinsurance and deductibles are used so that the insured shares the risk and any mistakes in offering too generous coverage are mitigated. Considerable information is needed to tailor insurance products and to minimize the basis risk even for individual insurance contracts. Increased information gathering and monitoring involve higher transaction costs, which convert directly into the higher premiums needed to cover them. Index insurance significantly reduces these transaction costs and can be written with lower deductibles and without introducing coinsurance. When farm yields are highly correlated with the index being used to provide insurance, offering higher levels of protection can result in risk transfer superior even to individual multiple-peril crop insurance (Barnett et al., 2005).

The direct trade-off between basis risk and transaction costs has implications for achieving sustainable product designs and for outlining the role of governments and markets. These concepts also greatly depend on understanding the trade-off between basis risk and transaction

Table 1
Advantages and disadvantages of index insurance

Advantages	Challenges
Less moral hazard The indemnity does not depend on the individual producer's realized yield	*Basis risk* Without sufficient correlation between the index and actual losses, index insurance is not an effective risk management tool. This is mitigated by self-insurance of smaller basis risk by the farmer; supplemental products underwritten by private insurers; blending index insurance and rural finance; and offering coverage only for extreme events
Less adverse selection The indemnity is based on widely available information, so there are few informational asymmetries to be exploited	
Lower administrative costs Underwriting and inspections of individual farms are not required	*Precise actuarial modeling* Insurers must understand the statistical properties of the underlying index *Education*
Standardized and transparent structure	Users must be able to assess whether index insurance will provide effective risk management
Contracts can be uniformly structured	*Market size*
Availability and negotiability Standardized and transparent, the contracts may be traded in secondary markets	*The market is still in its infancy in lower-income countries and has some start-up costs*
Reinsurance function Index insurance can be used to transfer the risk of widespread correlated agricultural production losses more easily	*Weather cycles* Actuarial soundness of the premium could be undermined by weather cycles that change the probability of the insured events, such as El Niño, for example
Versatility Index contracts can be easily bundled with other financial services, mitigating basis risk problems via savings and lending	*Microclimates* *These production conditions make rainfall or area-yield index based contracts difficult for frequent and localized events* *Forecasts* Asymmetric information about the likelihood of an event in the near future creates the potential for intertemporal adverse selection

Source: Authors. Please note that nearly all of the challenges listed above are challenges for any insurance products.

costs. At every level of risk transfer, someone must accept a certain degree of basis risk if the products are to be both sustainable and affordable. In short, extremely high transaction costs must be paid for. The social cost of having products with some basis risk may be significantly lower than the social cost associated with the high transaction cost entailed in attempting to design products that have no basis risk. Additionally, to the extent that the basis risk is relatively small, diversification can be used to manage basis risk.

10. Where index insurance is inappropriate

Index insurance contracts will not work well for all agricultural producers. Many agricultural commodities are grown in microclimates—areas with very large differences in weather patterns within only a few miles. In highly spatially heterogeneous production areas, basis risk will likely be so high that index insurance will not work. Under these conditions, index insurance will work only if it is highly localized[4] and/or can be written to protect only against the most extreme loss events. Even in these cases, it may be critical to tie index insurance to lending, since loans are one method of mitigating basis risk. Again, diversification can be the other mechanism for mitigating basis risk. Finally, it should be noted that microinsurance could potentially work for areas where the weather risk is largely independent.

Overfitting the data is another concern with index insurance. If one has a limited amount of crop yield data, fitting the statistical relationship between the index and that limited data can become problematic. Small sample sizes and fitting regressions within the sample can lead to complex contract designs that may or may not be effective hedging mechanisms for individual farmers. Standard procedures that assume linear relationships between the index and realized farm-level losses may be inappropriate. While scientists are tempted to fit complex relationships to crop patterns, interviews with farmers may reveal more about the types of weather events of most concern. When designing a weather index contract, one may be tempted to focus on the relationship between weather events and a single crop. When it fails to rain for an extended period of time, however, many crops will be adversely affected. Likewise, when it rains for an extended period of time, resulting in significant cloud cover during critical photosynthesis periods, a number of crops may suffer. Part of the development of index insurance for weather risk in India has involved offering insurance that is tied to different periods within the growing season so as to protect against a common problem that impacts a number of crops.

Finally, when designing index insurance contracts, significant care must be taken to assure that the insured has no better information about the likelihood and magnitude of loss than does the insurer. Farmers' weather forecasts are quite often highly accurate. Potato farmers in Peru, using celestial observations and other indicators in nature, are able to forecast El Niño at least as well as many climate experts (Orlove et al., 2002).

In 1988, an insurer offered drought insurance in the US Midwest. As the sales closing date neared, the company noted that farmers were significantly increasing their purchases of these contracts. Rather than recognize that these farmers had already made a conditional forecast that the summer was going to be very dry, the company extended the sales closing date and sold even more rainfall insurance contracts. The company experienced very high losses and was unable to meet the full commitment of the contracts. Rainfall insurance for agriculture in the United States suffered a significant setback. The lesson learned is that when writing insurance based on weather events, it is crucial to be diligent in following and understanding weather forecasts and any relevant information available to farmers.

Farmers have a vested interest in understanding the weather and climate. Insurance providers who venture into weather index insurance must know at least as much as farmers do about conditional weather forecasts. If not, intertemporal adverse selection will render the index insurance product unsustainable. These issues can be addressed; typically, the sales closing date must be established in advance of any potential forecasting information that would change the probability of a loss beyond the norm. But beyond simply setting a sales closing date, the insurance provider must have the discipline and the systems in place to ensure that no policies are sold beyond that date.

11. Summary and conclusions

This article provides an overview of why traditional approaches to agricultural insurance are not appropriate for many lower-income countries that are dominated by a large number of small farms. By framing the problem as one of high transaction costs and correlated risk due to common weather events, scholars have argued that use of weather index insurance may offer more appropriate approaches. Still these products are in their early stages of development and are not without their own problems—basis risk and data constraints in lower-income countries are among the largest problems.

Some progress is being made in the implementation of index-based agricultural insurance products. India has adopted a number of weather-based insurance products in recent years. Both the government agricultural insurer and private insurers are offering index insurance for weather risk in India. The World Bank and others are involved in a large number of feasibility studies to determine how such innovations can be introduced to ease the suffering and losses associated with weather related crop failure (Hess et al., 2005). A critical aspect of all of

[4]Temperature, for example, can be measured with field lodged temperature gauges that automatically transmit data to a central server.

this thinking is the explicit recognition that many weather events impacted a large number of individuals at the same time creating larges losses. The need to transfer this type of correlated risk out of local communities is large. Index-based weather insurance products can be a key ingredient in meeting that need. Nonetheless, in every case the adoption of these innovations must be put into a local context that explicitly recognizes the nature of the risk, the current risk-coping and risk management strategies of rural households, and the markets and institutions within the country.

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