Producer Insurance and Risk Management Options for Smallholder Farmers

Vincent H. Smith*

Many smallholder families are exceptionally prone to potentially catastrophic decreases in their incomes and access to food. Over the past decade, therefore, policy makers and economists have increasingly focused on potential mechanisms for expanding risk management strategies available to those families. Commercially provided weather-based index insurance products, perhaps partially funded by subsidies, have been of particular interest because of their apparent potential to provide payments to smallholder families when they are most in need of help. However, the empirical evidence from a wide range of studies indicates that, absent relatively substantial subsidies, small holder farmers will not purchase commercially priced index products or even "all risk" products where payments are tied to the farm's crop losses. There are three important reasons why this is the case. First, smallholder farmers already have many ways of managing their risks, including informal community-based initiatives, on-farm production decisions and off-farm work. Second, index insurance schemes are subject to considerable basis risk; families often do not receive an index insurance indemnity when they experience a substantial crop loss on their farms. Third, the fixed costs of delivering crop insurance to smallholders make such coverage expensive. The potential market for weather index insurance therefore may be limited to insuring relatively large groups of farmers, either directly or indirectly though providing micro finance and other lending institution with coverage against widespread loan defaults associated with catastrophic events like major droughts. Alternatively, weather indexes could simply be used to more accurately target emergency aid. Index insurance, Risk management, Food insecurity, Basis risk. JEL codes: D61, O13, Q18

Introduction

In low-income countries, many families are desperately poor and exceptionally prone to substantial and potentially catastrophic decreases in their incomes and

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access to food. Within rural communities in those countries, families with smallholder farms typically face extraordinary production risk challenges in dealing with income volatility and food insecurity. Those challenges are even more severe for the very poorest families in those communities, and not simply because as farmers they face periodically severe production risks. Often those families farm poor quality land on which crop yields are especially volatile because the household has neither the financial or other assets, nor the human capital to acquire, maintain, and develop the productivity of the land. A lack of human capital and, potentially, concerns about financial risks may also limit those families' abilities to adopt new crop and livestock production practices that have the potential to increase yields and farm incomes.

Over the past decade, therefore, economists who focus on rural poverty problems at the World Bank, governmental agencies, and throughout the global development economics community have increasingly been concerned with understanding how very poor farm households use risk management strategies to mitigate and cope with short-term food and income security crises resulting from crop failures and livestock losses (Barnett et al, 2008; Carter, 2008; Binswanger-Mkhize, 2010). A natural extension of this focus has been on the potential role of governments and international agencies in improving and expanding the array of risk management strategies available to those very poor farmers (for example, Boucher et al, 2005; Hazell and Hess, 2010; de Janvry et al, 2014).

The policy and infrastructure-related risk management and risk-coping strategies mentioned above include the following: smoothing household incomes and food consumption through a wide range of agricultural insurance schemes; improving access to finance from formal institutions (most typically microfinance institutions); facilitating local coping mechanisms (e.g., through informal credit systems at the village level in rural areas); providing improved technologies (including new crop varieties, improved access to irrigation, etc.) and targeted emergency disaster aid; and subsiding crop storage capacity at the household level, as well as providing savings incentives and emergency cash transfers. These strategies also involve traditional programs that have long been recognized as central to economic development and increasing smallholder families' farm incomes, for example, increasing general education and health services, developing roads, improving communications and water management and supply systems, and expanding agricultural R and D investments and agricultural extension services. In addition, these strategies include programs that mitigate the adverse effects of domestic tax and other policies on income volatility and agricultural productivity.

This paper examines the viability, scope, and availability to poor farmers of alternative risk management strategies for addressing short-term food security crises, with a focus on formal and informal insurance schemes. We then consider the potential costs and benefits of alternative government and international aid policies intended to expand and enhance the array of risk management strategies that very

poor farmers can use. A central issue in comparing alternative approaches is the opportunity cost of government and foreign aid funds, some of which over the past decade have been allocated to various crop insurance projects (see, e.g., Marenya, Smith, and Nkonya 2014) and, by straightforward extension, what constitutes efficient as opposed to inefficient policy (Alston and Hurd 1990).

Incentives for Smallholder Farm Household Risk Management and Coping Mechanisms

Binswanger-Mkhize (2010) has long argued that, as a group, smallholder farmers understand the income and food security risks they face, and without any help from policy experts, address those risks in many important and often subtle ways. Thus, as Binswanger-Mkhize (2010) and Wright and Hewitt (1994) have pointed out, the costs and benefits of the often informal mechanisms for risk management and risk coping available to farmers play a major role in determining the real opportunity costs they face with respect to many of the risk management tools that have recently been considered by policy analysts and policy makers, such as formal crop and livestock insurance policies. However, as Binswanger-Mkhize (2010) and Miranda and Farrin (2012) have recently suggested, many of the analyses that have presented arguments for the introduction of new risk management strategies have not adequately considered the portfolio of existing risk management tools available to farmers and their costs and benefits. The consequence has been an overemphasis on the argument that, because the production risks that smallholders face have potentially catastrophic consequences, they must be extremely risk averse and, therefore, willing to expend considerable resources to access specific risk management tools such as crop insurance.[1]

Both Wright (2014) and Binswanger-Mkhize (2010) have emphasized that what matters for households, including smallholder households, is their consumption of goods and services, not just the income or food supply they obtain from any specific crop, and that the purpose of managing risk for most of those families is to smooth consumption. In particular, as some economists have also recently begun to reemphasize in several contexts, in their risk management and risk coping strategies those households are likely to place particular emphasis on mitigating the consequences of potential shocks that could result in "extreme left tail" events (Goodwin 2014).

These types of catastrophic events have been given considerable emphasis by some researchers as sources of disincentives for new technology adoption by very poor smallholders.[2] Such catastrophic events may also result in substantial reductions in asset holdings that undercut the household's future income stream. Selling livestock in order to obtain food is one example of what has been described as a poverty trap syndrome related to asset depletion (Carter 2008). The problem is

often compounded by the fact that the assets have to be sold in depressed markets. Livestock, for example, will bring a much lower price in an environment where feed is scarce because of drought. Various forms of crop insurance have been proposed as a (partial) solution to mitigating such poverty trap problems (Skees et al. 1999; Barnett et al. 2008).

In standard utility-based models of an economic agent's insurance decision, the optimal strategy is for the agent to perfectly smooth consumption (Borch 1990). In practice, whether the setting is a rich household in a rich country or a desperately poor family in a poor country, almost no one does that for a variety of reasons. First, such a goal is often infeasible because insurance companies are unwilling to offer contracts that perfectly smooth income (deductibles exist for a reason—often to mitigate moral hazard incentives). Second, it is also typically sub-optimal from the perspective of households that face liquidity and other constraints on access to financial capital markets. In addition, de Janvry, Dequiedt, and Sadoulet (2014) have recently pointed out that investing in individual crop insurance protection can be welfare-reducing for smallholder families who also rely on informal risk sharing arrangements within a group of families because of free riding problems. These authors also note, however, that as a group those families may benefit from jointly purchasing index-based insurance against adverse events such as drought.

Risk Management and Risk Coping Strategies

Taking actions to mitigate and reduce the frequency and effects of extreme left tail events is often feasible and all but the most inveterate gamblers (extremely risk loving individuals) are likely to make non-trivial short-term and, where feasible, longer-term investments to mitigate or avoid extreme or moderately extreme adverse outcomes. The extent to which longer-term investments in risk mitigating strategies will be made by smallholder farmers critically depends on the permanence of the property rights they believe they possess with respect to the land they farm.

In relation to strategies for mitigating risk, it may be useful to draw a taxonomic distinction between the strategies that smallholder farm households use to address production, income, and food security risks on an *ex ante* basis, here called risk management strategies, and what, in a reactive sense, happens *ex post*, that is, after a severe adverse event occurs, here called risk coping mechanisms. The distinction is somewhat arbitrary because the potential for *ex post* responses at the household, extended family, and community levels is taken into account by those households when they make *ex ante* plans for addressing risk.

For smallholder households, short-term (within a crop season) risk management investments include the following: on-farm enterprise diversification, diversification of household labor between on-farm and off-farm income-generating activities

(including working for other entities and self-employment/entrepreneurial activities), crop loss mitigation, spatial diversification of individual crop and livestock enterprises, and explicit self-insuring strategies such as food storage (Buschena, Smith, and Di 2005) and holding livestock as potentially marketable assets (Barnett et al. 2008).

Crop loss mitigation strategies may include the use of chemical inputs (e.g., pesticides and herbicides) and the adoption of new seed varieties that are more drought resistant but also more expensive. Such strategies may also include short-term investments in irrigation, either through access to an existing village canal-based irrigation system or well, or the use of family labor to carry water from available sources to where it is needed. Investments in communication systems (e.g., cellphones) can also help smallholder farmers to mitigate price risks associated with marketing their crops and livestock, enabling them to understand the range of price offers available in the markets in which they sell their crops and, as a result, substantially reducing price volatility and the frequency of low price offers for their crops (Jensen 2007).

Short-term risk coping strategies (what smallholder farmers may be able to do after they experience an extreme or relatively extreme adverse event) include borrowing or receiving gifts from extended family members, borrowing from lenders in the local community who offer informal access to credit (e.g., relatively wealthy farmers in the village), borrowing from semi-formal organizations such as "iddirs" (groups of households that, within a local community, jointly provide semi-formal insurance for burial expenses incurred by members of the group), and borrowing from formal financial credit institutions (e.g., microfinance agencies or banks). These strategies also include selling assets such as livestock and whatever farm equipment they may have to obtain food, often (as noted above) in depressed "fire sale" markets for those assets.

Longer term (multi-season) investments in risk management strategies by smallholder farmers may include improvements in land quality (through soil conservation practices such as agroforestry and terracing), development of a well or a site-specific irrigation system (e.g., through damming a local stream), participation in developing and maintaining a long term community irrigation system, investments in livestock herds as a longer-run enterprise diversification strategy, and resource-sharing arrangements among villagers to obtain risk reducing inputs like agricultural chemicals at a lower cost. Such investments may also include longer term social arrangements; for example, through marriages that create incentives for expanded risk sharing among extended families by creating family ties with households in other locations (effectively, creating spatial diversification of crop yield and income risk within the horizontally extended family), and maintaining ties with siblings who have established their own nuclear families elsewhere.

Informal Insurance Programs

Many family and community-based risk coping and risk sharing schemes are, in effect, informal insurance programs. In those schemes, implicitly or explicitly, households agree to help one another in times of trouble, as among the iddirs in Ethiopia that provide informal burial insurance (Dercon et al. 2014). As a result, in those informal arrangements, indemnities in the form of "gifts" are likely to be provided when a potentially catastrophic decrease in an individual household's income occurs, but often payment of those indemnities is uncertain because implicit obligations to help a household in times of trouble may not be fulfilled. So too are the analogs of premium payments, and for the same reason: the "premium" is the reciprocal promise to provide resources to the other families in the group when they are in need of help. For example, within an extended family there may well be an expectation that, if one household experiences a catastrophic loss event, then other households in the extended family who are not affected, or much less severely affected, will "step up to the plate" and help out.

Importantly, these schemes tend to have very low financial overhead costs, although non-cash expenditures of social relationship capital may not be so low. For example, the household, which is likely to face severe liquidity constraints, does not have to make any cash outlays in the form of pre-loss premium payments to participate in the informal insurance scheme, as the "premium" is the promise to help out after an adverse event has occurred if another family is in trouble. The schemes are also extremely flexible, and do not typically involve binding legal commitments, although the requirement to conform to well-understood customs established by the community may be just as binding in many circumstances.

However, these arrangements are perhaps most likely to fail when help is most needed because the catastrophic event that severely curtails the household-in-need's real income (e.g., a region-wide drought) also has similar adverse impacts on all participants in the informal risk sharing arrangement. Some policy analysts have argued that such problems provide an obvious rationale for more formal insurance programs in which policies are guaranteed by reinsurance through commercial reinsurance companies and/or the domestic government, and/or aid agencies, while not using an explicit market failure argument for their subsidization.

Essentially, the argument is that such policies are complements to the informal risk management strategies that already exist and will therefore be valuable and commercially viable. Others have also suggested that formal insurance is more likely to be taken up by individual farmers when leaders of informal insurance arrangements or local communities are well-educated about formal insurance products (e.g., Dercon et al. 2014, and Giné et al. 2008). In that sense, commercial or subsidized index insurance products may be somewhat complementary to informal schemes, especially if they address risks common to the participants in the group

(e.g., drought) while the informal schemes address risks that are idiosyncratic to individual households (Mobarak and Rosenzweig 2013).

However, de Janvry, Dequiedt, and Sadoulet (2014) show that insurance against a common shock purchased by a member of a common group can and is perhaps likely to lead to free riding by other members of that group. Thus, for the individual, such insurance may have a negative value. The authors therefore suggest that group insurance policies that exclude the feasibility of free riding are likely to be preferred and, from a commercial perspective, are likely to be offered at a lower per hectare cost because they spread fixed costs over a larger insured area.

Commercial and Other Formal Insurance Programs

Formal crop and livestock insurance programs offered on a commercial basis have been proposed as a viable risk management tool for individual farmers by a wide range of policy makers and analysts (see, e.g., Barnett et al. 2008; Vedenov and Barnett 2004; Skees et al. 1999). However, as Hazell, Pomerada, and Valdes pointed out in 1986, absent substantial government subsidies, farm-specific all risk yield- or revenue-based insurance programs have never been offered on a commercially successful basis. The reason is that, given the premium rates the private insurance sector requires to offer all risk crop insurance policies, smallholder farmers do not buy them. Binswanger-Mkhize (2010) and Miranda and Farrin (2012) essentially draw similar conclusions for weather index-based insurance programs, even though the administrative costs associated with index insurance products are lower and adverse selection problems less extensive.[3] As Smith and Glauber (2012) and, almost twenty years before them, Wright and Hewitt (1994) noted, citing Patrick's (1988) seminal study of Mallee Valley wheat farmers in Australia, such is also the case in developed countries for both index insurance and individual farm yield-based insurance programs.[4]

Index Insurance

Over the past ten years, as discussed above, both insurance practitioners and some economists have argued that some form of crop or livestock insurance products can be offered successfully on a commercial basis to smallholder farmers because the required administration and operations loading factors are much lower than for all risk insurance (see, e.g., Hazell and Hess (2010); Vedenov and Barnett 2004; and Skees et al. 1999). Further, these advocates have argued that access to such insurance products will mitigate the negative impacts of adverse events on both the families' degree of food insecurity and their willingness to adopt new technologies that on average increase their real incomes but also increase the volatility of their crop yields.

The infeasibility of implementing all risk or multiple peril crop insurance contracts that provide indemnities based on a farmer's actual yields and yield histories for major subsistence crops to smallholder farmers has been almost universally acknowledged (see, e.g., Binswanger-Mkhize 2010; Miranda and Farrin 2012), just as they are widely acknowledged to be infeasible in developed countries in the absence of substantial subsidies (Kramer 1983; Wright and Hewitt 1994; Goodwin and Smith 1995; Smith and Glauber 2012). The loading factor—the amount in excess of the premium needed to cover expected indemnities—required by a private insurance company to cover their administrative and operations costs is widely viewed as simply far more than almost all farmers are willing to pay. Self-insurance and other risk mitigating strategies are less costly and more efficient.

One reason for the costliness of all-risk crop and livestock insurance contracts is that monitoring moral hazard behaviors (sometimes called hidden action behaviors) is perceived to be expensive. Automobile insurance and property/casualty insurance, which on the supply side are typically competitive markets, have been described as comparable lines in the insurance business with respect to moral hazard effects (e.g., see Smith and Goodwin 2011). Loading factors for such lines of business are typically in the range of 40–50% of expected indemnities. In the context of smallholder farmers, another factor is that the fixed costs associated with issuing and managing such policies are relatively high and have to be spread over an area of crops that is very small.

However, it should be noted that a similar overhead fixed cost problem exists for index insurance programs marketed to individual smallholders farming one or two hectares of land (Boucher, Barham, and Carter 2005). As discussed above, that is one reason why de Janvry et al. (2013) argue that group-based index insurance contracts are more viable. In addition, participation in all risk crop insurance programs is likely to be relatively low because of adverse selection (hidden information) effects. The reason is that premium rates cannot be tailored to individual farms' actual loss experiences because of inadequate data on yields and ancillary farm-specific information (Goodwin 1993; Smith and Baquet 1996).

These are not new insights. Halcrow (1949), in a developed country context, laid out the moral hazard and adverse selection issues associated with "all risk" crop insurance at the farm level over sixty years ago, and the issues were reexamined by Miranda (1991) in his seminal analysis of area (county) yield-based index insurance contracts. Both Halcrow and Miranda argued that area yield index contracts that cover dozens of farmers in a specific region (say a county or a sub-county grid area that is 20 kilometers by 20 kilometers) rarely create incentives for moral hazard behaviors and are likely to substantially mitigate adverse selection problems. In a development context, however, reliable historical data on area yields are typically not available on an adequate basis to estimate premium rates and develop

actuarially viable contracts. Hence, it is natural to think of using an index based on a variable (or set of variables) that is closely related to area and farm crop yields in developing an insurance policy.

Weather is a major factor in determining crop yields and the availability of forage. Weather indexes have thus become the focus of much of the work on potential agricultural insurance products. As rainfall can be measured relatively easily and inexpensively, it has received considerable attention in pilot projects and theoretical and simulation analyses as the basis for, or the sole component of, a weather index.[5] Satellite images of plant growth have also been proposed as the basis for a vegetation growth index. In the United States, such indexes are used in a heavily subsidized area-based insurance contract to provide coverage against forage loss in regions with relatively low levels of annual rainfall. However, vegetation indexes based on satellite images can only effectively be utilized in areas where thick cloud cover occurs relatively infrequently.

Basis Risk in Index Insurance

No matter how refined the weather index or any other area-based index may be, as Miranda (1991) emphasized, crop insurance based on an area index is subject to what he called basis risk. Basis risk exists in two forms, both of which derive from the underlying problem that the index on which indemnity payments are based is not perfectly positively correlated with an individual farm's actual loss experience. The first type of basis risk is that the farm may receive an indemnity when it has not suffered any substantial loss. This sort of basis risk is not especially important in the context of enabling a smallholder household to cope with a severe adverse change in their real income and food security from crop and livestock losses. The second type of basis risk is important; the farm may not receive an indemnity when it does experience a substantial loss.

Over the past six years, the issue of basis risk has been given increasingly more serious attention than it received in some relatively early analyses of index insurance.[6] For example, Smith and Watts (2009) examined the extent of basis risk in a rainfall index insurance instrument that reflected typically estimated correlations between plant growth and rainfall at the location of the weather station where rainfall is being measured (which they report as about 0.7) and the correlation between plant growth at that location and other locations in a typical area to be covered by the index (which they also report as about 0.7). Under somewhat restrictive independence assumptions, using a Monte Carlo approach and allowing correlations between the index and on-farm crop yields to vary, these authors' results indicate that basis risk is likely to be substantial.

Smith and Watts' findings are presented in table 1 for farms that experience fairly substantial crop losses of between 50–70% of expected yields and who insure at an

Table 1. Indemnity Payment Outcomes for Farmers Experiencing Significant Yield Losses (yields between 50–70% of average)

	Probability of Indemnity Event		
Rainfall Index-Area Yield Correlation	No Indemnity	Small Indemnity[a]	Large Indemnity[b]
0.00	0.784	0.114	0.103
0.20	0.723	0.145	0.132
0.40	0.661	0.179	0.159
0.60	0.590	0.219	0.192
0.80	0.479	0.316	0.205
0.90	0.377	0.429	0.194
0.95	0.278	0.559	0.163
1.00	0.000	1.000	0.000

Notes: [a]A small indemnity is an indemnity paid when the rainfall index has a value of between 50–70%; [b]a large indemnity is an indemnity paid when the rainfall index has a value of less than 50%.

index strike trigger of 70% (an indemnity payment is made when the rainfall index's value falls below 70% of its expected value). These authors report that even if the correlation coefficient between the farm's yields and the index is as high as 0.9, there is 37.3% probability that the farm will not receive an indemnity. If the correlation coefficient is 0.6, which is perhaps a more realistic estimate, then the probability of no indemnity payment increases to 59% and the likelihood of a substantial indemnity payment is only about 20%.

A recent study by Jensen, Mude, and Barrett (2014) examines basis risk in the context of the demand for a livestock mortality insurance product for Northern Kenya farmers, which was specifically designed to minimize basis risk and cover losses of livestock. The product was offered to households for which the livestock enterprise provides about 70% of the smallholder household's income. The index on which the insurance product was based was derived from a Normalized Difference Vegetation Index (NDVI), the index first used by the USDA Risk Management Agency to provide forage index insurance to farmers in similarly arid regions of the United States.[7] The northern Kenya product was priced to cover the costs of providing the insurance and, while initially 28% of eligible farmers purchased coverage in the first period the insurance was available, participation subsequently declined rapidly. This is a widely observed pattern for pilot index insurance schemes offered to smallholder farmers at a commercial or near full cost basis (Miranda and Farrin 2012).

Jensen Mude, and Barrett (2014) estimate correlation coefficients between individual farm mortality rates and the index that applies to those farms in the insurance product. Consistently among the five districts covered by the product, for well over half of the farmers, the correlation coefficient is less than 70%. For between 9–29%

of the farms in each of the five districts, these authors report a negative correlation between on-farm losses and losses indicated by the forage-based index. Not surprisingly, but importantly, Jensen Mude, and Barrett find that basis risk has a major adverse influence on the household's willingness to buy insurance coverage and that, as a household's understanding of that basis risk improves, the household becomes less likely to purchase the insurance coverage. Similar results on the adverse effects of indicators of increased basis risk are reported for smallholder farmers in rural India by Giné et al. (2008) and by Mobaruk and Rosenzweig (2012, 2013).

Elabed, Bellermare, Carter, and Guirkinger (2013) have proposed the use of a double trigger contract to mitigate basis risk. In that contract, village-wide cotton yields in Mali are used to make payments to individual farmers for losses only if district yields are sufficiently low to indicate that low village yields are not the result of moral hazard behaviors (in other words, the village is effectively viewed as a "collective" farm operated as a single entity). As such, even though described as an index product, the product has substantive elements of an all risk contract. The double trigger concept is not new; for example, Watts and Associates proposed a double trigger index product to the USDA Risk Management Agency in the mid-1990s when index insurance products were first being developed as part of the US crop insurance program. Certainly, index insurance products based on a double trigger can be designed to mitigate basis risk. However, by increasing the frequency with which payments are made (even though a double trigger can also mitigate the frequency with which farmers receive indemnities when they do not experience losses), such contracts are often likely to increase premium rates.

Unambiguously, then, the literature seems to be clear about three aspects of basis risk in the context of index insurance. First, the theoretical literature indicates that an increase in basis risk will reduce a farmer's willingness to pay for an index insurance product (see, e.g., Dercon et al. 2014; Miranda and Farrin 2012; and de Janvry et al. 2014). Second, even though the potential exists for innovative product designs to mitigate basis risk to some extent, basis risk is pervasive, extensive, and substantial in almost all index insurance products. Third, the empirical evidence consistently shows that basis risk has substantial adverse effects on smallholder farmers' participation in crop insurance products. As Jensen, Mude and Barrett (2014) note, it seems likely that in many pilot index insurance schemes, as farmers come to realize the extent of that risk and, as a corollary, more accurately assess the expected net payoff from the insurance policy, they abandon the program.

Pricing Index Insurance Products and Farmers' Willingness to Pay for Them

The price of a competitively-offered commercially-provided insurance policy has two components; the expected indemnity and the operating and administration

costs associated with delivering the product. A risk neutral or risk averse economic agent facing no liquidity constraints will therefore be willing to purchase an actuarially fair insurance policy for which the price is simply the expected indemnity. However, errors in rate setting associated with differences in the information sets available to the insured individual and the insurance company often result in adverse selection problems that are typically extensive in all risk crop insurance contracts but widely viewed as less pervasive in index insurance contracts. Positive loading factors mean that only risk averse economic agents will purchase a commercially offered insurance policy. Further, if those risk averse agents face liquidity constraints, the requirement that, in contrast to many informal insurance schemes, premiums be paid when purchasing coverage at planting time rather than after harvest will further diminish the likelihood of purchasing the insurance.

Consistently, studies of willingness to pay for either multiple peril insurance products based on the farm's actual yields or index insurance products have reported that farmers are not willing to pay very much, if anything at all, for crop insurance coverage (Wright and Hewitt 1994). That finding holds whether the farmers being investigated are located in rich countries like the United States and Australia or poor countries like Morocco and Tanzania (Smith and Watts 2009). Basis risk simply makes matters worse for index-based insurance products as compared to all-risk insurance products that always pay indemnities when a farmer incurs an insured loss.

In effect, as Smith and Watts (2009) suggested in their review of the then extant willingness-to-pay studies, once the loading factor for an insurance product exceeds about 9%, only extremely risk averse farmers are willing to buy coverage. Numerous studies of risk preferences among smallholder farmers have done little more than replicate Binswanger's (1981) finding that most are moderately risk averse and in fact, on average, extreme risk aversion attitudes occur about as frequently as risk loving attitudes occur (i.e., relatively infrequently). This finding is consistent with the results of most studies of farmers' willingness to pay for agricultural insurance and goes a long way to explaining why so few smallholder farmers have participated in most of the pilot index insurance programs that have been offered over the past decade.

If a 9% loading factor is effectively the demand side choke price for multiple peril insurance, then the choke price for index insurance is likely to be lower. An important question, therefore, concerns what sort of loading factor is required by private insurers to deliver index insurance to farmers. Very early estimates by some academics that index insurance could be provided with loads of 2–5% now appear to be very optimistic. For example, BASIX in India was initially willing to offer an index product to smallholder farmers with about a 15% loading factor, but then estimated that a minimum load of 25% would be required to cover the company's operations and administration costs.

Even in developed countries, where a single policy is likely to cover hundreds or thousands of hectares over which fixed costs can be spread, insurance companies

appear to require a loading factor well in excess of 15% to offer an index insurance product (either via subsidies or underwriting gains). For example, two types of cost that are always incurred by primary insurance companies are often overlooked in discussions about agricultural insurance. These are the primary companies' reinsurance costs and the costs of the financial capital they have to hold in order to offer the insurance in the first place. Those costs, by themselves, are likely be close to or exceed 9% of the expected indemnity associated with the policy.[8]

Using Government and Aid Agency Resources to Support Risk Management and Risk Coping Strategies

There are clearly important limits to the value of commercially-provided and priced index insurance as a risk management strategy that would alleviate the food and income insecurity effects on smallholder households of catastrophic and moderate adverse crop and livestock production shocks. The question is then whether domestic government or foreign aid resources should be used to subsidize access to those products.[9] Too little attention seems to have been given to this issue. However, the theoretical and empirical evidence that does exist suggests that subsidizing access to such products may be sub-optimal. For example, as discussed above, de Janvry et al show that where informal risk sharing occurs, purchasing individual insurance is likely to have a negative impact on the farm's welfare because of free riding effects. A better way to go that, as de Janvry, Dequiedt, and Sadoulet (2014) also show, may have the potential to increase the group's economic welfare would be to offer such coverage to the group. However, if the product is to be subsidized, why not just provide disaster aid when an area-wide adverse event occurs and avoid many of the costs associated with private delivery of the insurance product? As Smith and Glauber (2012) note, these costs are often substantial relative to the amount of aid to be provided.

One argument for private delivery of foreign aid dollars though crop insurance schemes, instead of allocating the aid through the government, is that governments are more likely to divert aid from the communities that need the help than are private insurance companies.[10] However, as Hazell and Hess (2010) suggest, one potential use for weather and plant growth indexes is to more accurately target foreign emergency and other aid dollars to the communities who most need them. If all farmers in a community come to expect aid when widespread adverse outcomes for the community occur, then informal risk sharing programs are less likely to fail in those circumstances because on a community-wide basis, resources are enhanced. To some extent, some of the anti-poverty trap benefits claimed for individually purchased index insurance products might then accrue in terms of technology adoption and reductions in fire sales of livestock assets because smallholder families become more certain that those informal risk sharing networks will work when they need help.

A recent study by Marenya, Smith, and Nkonya (2014) suggests that index insurance may also not be an optimal policy for encouraging longer-term investments in risk management practices. These authors carried out stated-choice experiments with respect to alternative incentives for the adoption of agroforestry yield-enhancing conservation practices by Malawi smallholder farmers in the Shire River Valley. Their results indicate that farmers will choose cash payment incentives that are substantially smaller than the subsidies associated with an ideal index insurance product (essentially an index product that has no basis risk) as their preferred incentive for adopting the same conservation practices that would increase yields and reduce the frequency of extreme adverse shocks.

If index insurance targeted to individual smallholder farmers is not a silver bullet solution for improving their ability to manage and cope with income and food security risks, then what would be a more effective and efficient use of domestic government and foreign aid funds? The answer is both discouraging and encouraging because many of the public policy and aid-driven initiatives that are most likely to benefit smallholder farmers are programs that have been supported for a long time. For example, public investments have high returns when they are made in agricultural research targeted towards both enhancing yields and reducing their volatility (e.g., improving drought resistance) and in extension programs that enable smallholder farmers to minimize production risks associated with adopting new varieties. Programs that allow smallholder farmers to cope with climate change-driven reductions in growing season rainfall and changes in the timing of that rainfall are likely to substantially mitigate the volatility of their yields and incomes. These programs clearly include investments in water storage and irrigation systems.

Finally, two alternative uses of agriculture-related index insurance products have been extensively discussed. One approach is to offer index insurance to private credit institutions that would otherwise not offer loans to smallholder farmers. To the extent that such an approach is a least cost way of ensuring those farmers have some access to financing for purchasing inputs that are likely to improve and stabilize their crop yields and livestock operations, there may be a genuine economic justification for such an approach. However, an alternative that accomplishes the same objective is to establish a farm credit system underwritten by the government and/or aid agencies. Whether the former or latter approaches would be more effective is not clear, as in the former case the financial intermediaries' actions may be subject to moral hazard effects, and in the latter case there may be several reasons for a "government failure" problem.

The other use of index insurance products is for the lending institution to bundle loans to farmers with an insurance policy; the effect, absent subsidies, is to increase the cost of the loan to the farmer, which reduces their return from the inputs they purchase with the loan. In addition, as Miranda and Farrin (2012, p 413) and, earlier, Goodwin and Smith (1995) note, (assuming that the lending institution

receives the indemnity payment when a farmer defaults on the loan) the incentives for the lending institution to monitor loans and invest in strong loan recovery actions may be mitigated. If the insurance product is subsidized, one result could be that a substantial number of low quality loans are made with potentially serious adverse consequences for the financial systems and government expenditures.

Summary

Smallholder households in many developing countries have many ways of managing the income and agricultural production risks they face. These approaches include production practices such as enterprise diversification, the use of risk reducing resources, storage, and household investments in marketable assets such as livestock, as well as participation in extended family- and community-based risk sharing arrangements. Nevertheless, those households are still subject to relatively frequent crop and household income losses that have potentially catastrophic consequences for the welfare of their members.

In response, especially over the past decade, economists and policy makers have searched for innovative ways of improving those households' resiliency with respect to such adverse events. A particular focus has been the potential for smallholder households to use commercially viable weather-based index insurance products to improve their welfare. However, increasingly, the empirical evidence indicates that, as is the case for very rich farmers in developed countries, smallholder farmers in developing countries are unlikely to purchase such products absent substantial subsidies, which their governments probably cannot afford.

There are several reasons why those farmers are not willing to pay for such insurance. Fundamentally, and perhaps most importantly, many smallholder farmers appear to have less expensive ways of managing risk through practices that are already available to them. In addition, the overwhelming majority of those farmers do not appear to be sufficiently risk averse to be willing to pay premiums that cover the loading costs that would be incurred by the insurance companies who would supply the insurance. Further, the extensive degree of basis risk associated with most index-based agricultural insurance products severely exacerbates the problem.

Index insurance, however, might be helpful in other contexts. For example, if communities purchase such insurance, perhaps on a subsidized basis, the indemnities provided when the community experiences broad-based crop losses may facilitate the performance of informal or semiformal risk sharing agreements within the community. Alternatively, providing index insurance products to smallholder households by tying them to operating loans used to purchase improved inputs may reduce the impacts of adverse events on the household, although such bundling raises the cost of the loan to the household and may provide a moral hazard

disincentive for the bank that receives the indemnity in cases of loan default to be diligent in its loan management practices.

Finally, using government and/or international aid agency resources to subsidize access to index insurance may seem like a potentially useful use of such funds, especially if the consequence is the adoption of more productive but perhaps higher risk technologies by very poor smallholder households. However, those funds have many other potential uses and the empirical evidence that very poor farmers who purchase such insurance are likely to adopt new technologies is weak. Perhaps more evidence is needed about the relative returns from subsidizing crop insurance as opposed to the returns from those other uses (such as subsiding the adoption of conservation practices, providing education, and increasing location-specific agricultural research and extension programs). However, much of the evidence currently available indicates that many of those other programs are likely to provide substantially higher returns.

Notes

* Vincent Smith is a professor of Economics at Montana State University.

1. Very recently, however, researchers have begun to question the utility of index and other insurance products as vehicles for risk management by small holders. See, for example: Binswinger Mkhize's (2010) assessment of the potential value of such products, which he begins by asking whether their utility has been overhyped: Macours (2013) recent review of the evidence from randomized control experiments with respect to index insurance; and the survey by Miranda and Farrin (2012) of the academic literature and practitioner experiences with respect to index insurance.

2. While not the primary focus of their study, McIntosh, Sarris, and Papadopoulos (2013) report that when smallholder farmers in Ethiopia were given a voucher to purchase a weather index insurance product, for the most part the farmers used the voucher to fully subsidize insurance coverage for a part of the land they farmed, leaving the rest of the land uninsured. At the very least, these authors' findings suggest that unsubsidized index insurance is not viewed as a viable risk management tool by those farmers.

3. See, for example, Binswanger-Mkhize (2010), Carter (2008), Dercon et al. (2014), and Miranda and Farrin (2012).

4. To the best of our knowledge, the only commercially sustainable form of "stand alone" agricultural insurance has been insurance against specific perils such as hail or fire (Kramer 1983; Goodwin and Smith 1995; Smith and Glauber 2012) and markets for such insurance have tended to be small in scale. All other "successful" insurance programs have either encouraged extensive voluntary participation through large subsidies, as in the United States, Canada, India, and Brazil (Hazell, Pomerada, and Valdes 1986; Mahul and Stutley 2010; Smith and Glauber 2012; and Wright 2014), by mandating participation as a condition for participating in other government programs (Goodwin and Smith 1995), or, perhaps, by bundling the insurance with another commodity. Approaches like Syngenta's bundling an insurance policy with the purchase of seed by a smallholder is a scheme that makes the insurance product a tied good; in effect, it is a way of extracting economic surplus associated with seed purchases to cover insurance policy costs.

5. Weather indexes can be relatively simple or complex. For example, a lack of rainfall and excessive heat during the growing season are both major causes of crop loss for commodities like maize and corn. A more optimal insurance index for those crops would include measures of both rainfall and heat. Reliable estimates of daytime temperatures are much more difficult to acquire on a consistent

basis, however, and may be less meaningful for even relatively small areas when measured at a specific location. Hence, most attention has focused on rainfall or indexes based on satellite measures of vegetation growth. However, as a reviewer pointed out, index insurance may also cover floods and hurricanes.

6. For example, Vedenov and Barnett (2004) suggested that correlations between weather indexes and crop yields would be sufficiently large to ensure that basis risk would not be a major problem for farmers.

7. Uptake for the U.S. NDVI product has been relatively substantial, mainly because US farmers pay a premium that is less than 50% of the expected indemnity (Glauber 2013; Goodwin and Smith 2013).

8. Industry sources suggest that reinsurance and financial capital costs each are likely to be 3–5% of the expected indemnity, and that reinsurance costs will be substantially higher than that for books of business that are relatively small (less than $100 million of premium).

9. A reviewer pointed out that aid agencies typically have development funds and emergency relief funds and that insurance programs are typically defined as development programs but essentially are used to provide emergency relief. Thus, for many aid agencies, the internal incentive structure for the use of funds to support insurance is misaligned.

10. Private insurance companies cannot always be relied on to deliver aid dollars where they are most needed. Issues about the integrity of insurance companies abound, even in countries where the regulatory and legal systems are well developed.

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