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NEW APPROACHES TO CROP YIELD INSURANCE IN DEVELOPING COUNTRIES

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ABSTRACT

Natural disasters can be extremely disruptive to farmers and to others whose incomes depend on a successful crop. Society can gain from more efficient sharing of crop and natural disaster risks. However, the costs associated with traditional agricultural risk programs have historically exceeded the gains from improved risk sharing. This paper explores government intervention in agricultural risk markets and discusses new approaches to risk sharing with limited government involvement. In particular, we build the case for introducing negotiable state-contingent contracts settled on area crop yield estimates or locally appropriate weather indices. These instruments could replace traditional crop insurance at a lower cost to government while meeting the risk management needs of a wider clientele.

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1. INTRODUCTION

Agricultural production is inherently a risky business, and farmers face a variety of weather, pest, disease, input supply and market related risks. Given an uncertain income each year, farmers must worry about their ability to repay debt, to meet overhead costs (e.g. land rents and taxes) and, in many cases, their ability to meet essential living costs for their families. These same risks are also of concern to agricultural lending institutions. Confronted with risky borrowers, lenders must seek to reduce the possibility of poor loan recovery rates in unfavorable years, even if this means only modest levels of lending to agriculture.

The prevalence of risk in agriculture is not new and farmers, rural institutions and lenders have, over generations, developed ways of reducing and coping with risk. Although the virtues of these traditional risk management mechanisms are widely recognized (see, for example, Hazell, Pomareda, and Valdes), they also have their limitations. They can be costly in terms of the income opportunities that farmers forego (e.g. crop diversification is typically less profitable than specialization). They can

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discourage investments and technological changes that, while risky, enhance long-term productivity growth. And they have limited capacity to spread covariate risks like droughts that affect most farmers in a region at the same time. In theory, these limitations would not exist if capital and insurance markets were perfect, but the reality for many risky agricultural regions in developing countries is quite the opposite; relevant capital and insurance markets are poorly developed and they are weakly linked across regions and with urban areas.

Arrow and Debreu long ago addressed the value of risk sharing markets for society. Failures in agricultural insurance markets provide a rationale for governmental intervention, providing governments can fix the problem at lower cost than the social benefits derived. And governments of all hue and color around the world have intervened with a range of risk management programs for farmers (crop insurance, price stabilization, drought relief, livestock feed subsidies, etc). Most have proved an expensive drain on the public purse, and there is little evidence to show that these interventions have generated any sizeable social benefits, or that the benefits exceed their costs. By the same token, crop and natural disaster relief can have profound redistributional impacts in smaller countries. For many small countries, such government assistance can be extremely costly and may represent a high percentage of GNP when the disaster is large. This can have serious consequences for the monetary and fiscal policies of small countries.

This paper focuses on production risks, and reviews the experience with public crop insurance programs. Recognizing their inherent limitations and inability to help many of the rural poor, some simple area-based index insurance options are proposed that could replace crop insurance, and at the same time satisfy the risk management needs of a much wider clientele or rural dwellers. Extension of the approach could also address other important insurance needs, especially against price and market risks. Recent developments with financial market instruments for spreading catastrophic risks have increased the opportunities for the kinds of index insurance proposed in this paper.

2. THE EXPERIENCE WITH PUBLIC CROP INSURANCE

PROGRAMS

Publicly provided crop yield insurance has been implemented in many developed and developing countries (Hazell, Pomareda, and Valdes). These crop insurance programs are generally multiple peril or all risk programs, meaning that the insurance compensates all yield losses, regardless of cause. Although insured hazards are often enumerated, the lists of covered hazards are so comprehensive that uninsured hazards cannot be excluded in practice, including losses from bad management. Indemnities are typically based on the difference between actual yield and a pre-specified target yield, not on actual crop damage or input costs lost. Setting the target yield can be difficult, as one must either base the target on a short history of yields for each farmer or accept the farmer's declaration of his/her potential yield. Most programs attempt to compute an average or expected yield and then guarantee some percentage of the value. Most programs include deductibles, so as to help control for adverse selection and moral hazard. In many countries insurance is tied to loans from an agricultural development bank (ADB), with the bank paying the premium and collecting the indemnities. In some countries the insurance is compulsory for all farmers growing the insured crops or borrowing from the ADB.

RESULTS

The financial experience with publicly provided, multiple-peril crop insurance has been disastrous. In all cases, programs are heavily subsidized and governments not only pay part of the premium, but also most of the delivery and service costs, and they cover aggregate losses even when the losses exceed targeted levels over long periods of time. In order to be profitable, a purely private insurer would have to structure contracts so that premiums collected exceed the average payouts (indemnities plus administrative costs). Hazell quantifies the condition for sustainable insurance as follows:

$$(A + I)/P < 1$$

where A = average administrative costs

= average indemnities paid

P = average premiums paid

Hazell reports experience with public crop insurance programs in seven countries (Table 1). The loss ratio exceeds 2 in every case. Two extremes are noteworthy: in Brazil the ratio of indemnities to premiums is very high while the ratio of administrative cost to premiums was relatively low; while in Japan the situation is reversed. The lesson to be drawn is clear: one must invest a great deal in administrative cost and monitoring before having a crop insurance program that will be actuarially sound.

Table 1 Financial performance of crop insurance programs in seven countries

Country	**Period**	**I/P**	**A/P**	**(A+I)/P**
Brazil	75-81	4.29	0.28	4.57
Costa Rica	70-89	2.26	0.54	2.80
India	85-89	5.11	na	na
Japan	47-77	1.48	1.17	2.60
	85-89	0.99	3.57	4.56
Mexico	80-89	3.18	0.47	3.65
Philippines	81-89	3,94	1.80	5.74
USA	80-89	1.87	0.55	2.42

Source: Hazell

The ratio I/ P measures the average return to farmers' own investment in the insurance; i.e. the number of dollars received on average per dollar of premium they pay from their own pocket. Apart from Japan, most farmers appear to make a killing from crop insurance, receiving two to four times as much money back as they pay in. Surprisingly, they still don't line up to buy it and it typically has to be made compulsory. A likely reason for this is adverse selection. Because farmers are often grouped into risk categories when the premium rates are calculated, but receive benefits that are tailored to their individual losses, then farmers in each group facing lower than average risks may end up paying too much for the average benefits they receive. But sometimes farmers are reluctant to buy insurance even when it is profitable because they can expect to receive alternative payments from the government in catastrophic years without paying any premium up front (e.g. emergency drought relief programs). The I/P ratios reported above are unlikely to have improved in more recent years. Indeed, Mishra reports that India's I/P ratio increased to 6.1 for the period 1985-94, and Skees (1999a) reports that the U.S. program has an expected I/P of 4 for 1999.

Despite these high costs, there is little evidence to show that crop insurance has had any positive impacts on agricultural lending, agricultural production or farm income. For example, social cost-benefit analyses of the Mexican and Japanese schemes show negligible social returns in relation to their high costs (Bassoco et al and Tsujii). Pomareda found that a small increase in interest rates would have been just as beneficial to the ADB in Panama as the compulsory crop insurance program for its borrowers. Crop insurance, when heavily subsidized, can even have important negative social impacts. Subsidies for risk management have similar effects as subsidies on any other farm input;

it encourages over use. And since the reduction in production costs is partly paid for by the subsidy, the dead weight loss of the subsidy is always greater than the combined benefits to producers and consumers (Siamwalla and Valdes). In practice, this implies that risk management subsidies reduce risk costs to farmers to below their true social value, leading to excessive risk taking (e.g. growing unsuitable crops in high risk regions) and increased exposure to future drought losses by the farmer.

Subsidies not only create dependence on future drought assistance from the government, but also lower social welfare. Kunreuther and Kaplow demonstrate how such assistance sends the wrong signals for hurricanes and earthquakes. The implication is that, wherever possible, government interventions should be limited to risk management programs that decision-makers pay for themselves. Finally, crop insurance has at best helped farmers who grow insured crops, and it is of no assistance to many other rural dwellers whose livelihoods are also impacted by catastrophic agricultural production and income outcomes (e.g. landless laborers, agricultural traders and processors, farm input suppliers, and rural shopkeepers).

REASONS FOR FAILURE

Why has public crop insurance failed so badly? One of the most important reasons is that many of the risks covered by multiple risk insurance are inherently uninsurable, leading to large actuarial losses for the insurer. Vaughan reviews many of the conditions for insurance markets. An insurable risk has the following four characteristics:

1. The likelihood of the event must be readily quantifiable;

2. The damage it causes must be easy to attribute and value;
3. The probability of occurrence should not be too high to make the insurance unaffordable; and
4. Neither the occurrence of the event or the damage it causes should be affected by the insured's behavior (i.e. no moral hazard).

While the traditional insurance literature list a fifth characteristic (i.e., independent risk), many catastrophic risks that are co-variate are now insured by private markets (e.g. hurricanes, typhoons, earthquakes, floods). Private insurance companies typically do not insure yield losses due to pest and diseases, and prefer to write insurance against specific and insurable perils; it is rare to see a private company that writes multiple risk or all risk insurance, and the ones that have had had very short lives.

Another important reason for failure in agricultural insurance is that public insurers are often mandated to extend their insurance to small farms, and this can add enormously to administration costs. By the same token, programs that offer contracts on a field-by-field basis (as in the U.S.) are also expensive to administer.

A third reason for failure is that inappropriate incentive problems arise within insurance institutions when the government underwrites most of their programs. When insurers know that the government will automatically cover most losses, they have little incentive to pursue sound insurance practices when assessing losses. In fact, they may find it profitable to collude with farmers in filing exaggerated or falsified claims. Hazell reports that in Mexico prior to closing the national agricultural insurance agency, it was not uncommon for inspectors to receive bribes of about 30 percent of the value of the indemnity payments made to farmers. When the insurer underwrites the loans of an ADB, these incentive problems can easily infect the bank too, leading to a serious loss of discipline in banking practices. Why, for example, should ADB staff try to collect loans from tardy borrowers if they can more easily obtain repayment from the insurer?

Another common reason for failure has been that governments undermine public insurers for political reasons. Hazell gives examples where insurers have had to pay out against exaggerated losses in election years. In the U.S., the government has repeatedly undermined its crop insurance program by providing direct assistance to producers in disaster areas (Goodwin and Smith; Skees, 1999a). Why should farmers purchase crop insurance against major calamities (including drought) if they know that farm lobbies can usually apply the necessary political pressure to obtain direct assistance for them in times of need at no financial cost?

Many crop insurance programs also tend to be too specialized, focusing on specific crops, regions and types of farmers, particularly when the insurance is tied to the loans of an ADB that has a mandate to serve particular target groups identified by the government. Without a well-diversified insurance portfolio, crop insurers are susceptible to covariability problems, and face the prospect of sizeable losses in some years. Since public insurers are rarely able to obtain commercial insurance or contingent loan arrangements, this specialization increases their dependence on the government.

Guidelines for Improving Government Sponsored Insurance

Publicly owned crop insurance programs are probably impossible to design as sustainable financial entities without some level of government support if they are to continue to reach intended target groups. However, the following principles for sound insurance could lead to considerable improvement in performance in most cases.

1. Make the insurer responsible for its own financial affairs, and deny it automatic access to government funds when they incur losses. Subsidies are not necessarily ruled out, particularly for important target groups, but they should be fixed in advance on a pro-rated basis.
2. Only insure “insurable” risks to the maximum extent possible, e.g. specific perils like hail damage. Where moral hazard cannot be avoided, then use deductibles and other co-insurance arrangements.
3. Premiums should be based on sound, actuarial calculations, and adjusted over time to reflect actual loss payments.
4. The insurer should develop a rational insurance portfolio for managing risk, and should not be tied rigidly to the lending portfolio of an agricultural development bank. They should be required to purchase realistic levels of re-insurance in the national or international insurance markets.
5. The insurance should be voluntary and in competition with the private sector.
6. To avoid adverse selection, premium rates should be tailored to the indemnity payments that individual farmers receive, to the largest extent possible.
7. Administrative costs must be controlled.

Commercial insurers rigorously adhere to such principles, not least because they know that the government is unlikely to bail them out should they incur large losses. Even so, the volume of private crop insurance is not trivial. Gudger estimated total premium income at about $1 billion per year, and it seems to have grown since then. The drawback is that private insurance is almost exclusively sold to large-scale, commercial farmers growing high value crops. If public crop insurance were operated strictly along the same principles, it would not be able to serve many of the medium- to smaller-sized farms that are the traditional targets of government assistance programs.

The situation is similar to the experience with the reform of rural financial markets. As financial markets are liberalized and banks become more efficient and financially sound, they also become less willing to lend to small-scale farmers. In the finance case, the lending vacuum for small borrowers has been filled by an explosion of agencies offering microfinance. Microfinace is not only reaching many of the small-scale farmers previously targeted by ADBs, but it is also reaching many other kinds of small-scale borrowers who were previously ignored by formal lending institutions. As more governments begin to reform their agricultural insurance markets, and to set their insurers on a financially sound basis, the same kind of service vacuum seems likely to emerge for small scale farmers. As yet, the insurance equivalent of microfinance has not emerged, but is clearly needed to reach both small-scale farmers and other rural dwellers that are impacted by catastrophic weather events. We turn now to some new developments in insurance that offers not only "micro-insurance" possibilities for the poor, but which could also be attractive to large farms and many other commercial enterprises in rural areas.

3. NEW APPROACHES TO INSURANCE: USING INDEX AND AREA-BASED CONTRACTS TO INSURE NATURAL DISASTERS

What is needed is a system of insurance that meets the following requirements:

1. It is affordable and accessible to all kinds of rural people, including the poor.
2. It compensates for catastrophic income losses to protect consumption and debt repayment capacity.
3. It is practical to implement given the limited kinds of data available.
4. It can be provided by the private sector with little or no government subsidies.
5. It avoids the moral hazard and adverse selection problems that have bedeviled crop insurance programs.

Area-based index contracts, such as regional rainfall (and other weather) insurance could meet all these requirements.

The essential principle of area-based index insurance is that contracts are written against specific perils or events (e.g. area yield loss, drought, or flood) defined and recorded at a regional level (e.g. at a local weather station). Insurance is sold in standard units (e.g. $10 or $100), with a standard contract (certificate) for each unit purchased called a Standard Unit Contract (SUC). The premium rate for a SUC is the same for all buyers who buy the same contract in a given region, and all buyers receive the same indemnity per SUC if the insured event occurs. Buyers are free to purchase as many units of the insurance as they wish.

Area-based crop yield insurance is a good example of such a scheme. In this case the insurance is written against the average yield for a region (e.g. a county or district), and a payment is made whenever the measured yield for the region falls below some predefined limit (say 80 percent of normal). Such schemes already exist in the US, India, Sweden, and the Canadian province of Quebec (Miranda; Mishra; Skees, Black, and Barnett). In the U.S., the Group Risk Plan uses county yields to trigger a payment, and coverage up to 90 percent of the county yield is available. Payments are made based on the protection (liability) selected by the farmer and the percentage below the trigger yield (coverage times the expected county yield). Since county yield data are available for long periods of time, adjustments to the trigger yield are made for technical advances.

Area-based yield insurance requires long and reliable series of area-yield data, and this kind of data is not available in many countries. Hence alternative indices may be more attractive, such as area rainfall or soil moisture indexes. Rainfall and soil moisture contracts could effectively protect against crop losses due to drought or excess rainfall. Improved ground instruments coupled with satellite and remote sensing technologies make measuring rainfall and soil moisture less expensive than in years past. These technologies can also be used to add credibility to the measurement so that those outside the country have confidence in the numbers.

Area-based index insurance has a number of attractive features:

- Because buyers in a region pay the same premium and receive the same indemnity per SUC, it avoids all adverse selection problems. Moreover, the insured’s management decisions after planting a crop will not be influenced by the index contract, eliminating moral hazard. A farmer with rainfall insurance possesses the same economic incentives to produce a profitable a crop as the uninsured farmer.

- It could be very inexpensive to administer, since there are no individual contracts to write, no on-farm inspections, and no individual loss assessments. It uses only data on a single regional index, and this can be based on data that is available and generally reliable. It is also easy to market; SUCs could be sold rather like travelers' checks or lottery tickets, and presentation of the certificate would be sufficient to claim a payment when one is due.
- The insurance can be sold to anyone. Purchasers need not be farmers, nor even have to live or work in the region. The insurance should be attractive to anybody whose income is correlated with the insured event, including agricultural traders and processors, input suppliers, banks, shopkeepers, and laborers. Defining SUCs in small denominations would raise their appeal to poor people.
- It would be easy for the private sector to run, and might even provide an entry point for private insurers to develop other kinds of insurance products for rural people. For example, once an area-based index removes much of the co-variate risk, an insurer can wrap individual coverage around such a policy to handle independent risk (i.e., certain situations where the individual has a loss and does not receive a payment from the area-based index).
- As long as the insurance is voluntary and unsubsidized, it will only be purchased when it is a less expensive or more effective alternative to existing risk management strategies.
- A secondary market for insurance certificates could emerge that would enable people to cash in the tradable value of a SUC at any time.

- Recent developments in micro-finance also make area-based index insurance an increasingly viable proposition for helping poor people better manage risk. The same borrowing groups established for micro-finance could be used as a conduit for selling index insurance, either to the group as a whole, or to individuals who might wish to insure their loans.

A key question is whether the insurance would prove attractive to individuals. An index product should be more affordable than individual insurance, particularly if government does not subsidize either. Moreover, by offering an index contract that removes most of the systemic correlated risk that an individual faces, he/she only faces independent risks that may more easily be insured through conventional insurance or credit markets.

However, a problem with index contracts is that an individual can suffer a loss and not be paid because the major event trigging a payment has not occurred. For example, a farmer with rainfall insurance could lose his/her crop to drought at a micro-location, but not receive an indemnity if the rainfall at the region's weather station remains above the trigger point. With index contracts it is also possible for an individual to be paid when they suffer no losses. In futures markets, this type of risk is referred to as basis risk. Index contracts essentially tradeoff basis risks for transaction costs, and the insurance will not be attractive if the basis risk becomes too high.

Individual decisions to purchase area-based index insurance can be analyzed through extensions of portfolio theory, including those evolving from Markowitz and capital asset pricing models, hedging models, and contingent claims models. Index insurance becomes another asset in the individual's portfolio. In some cases, index insurance may improve the performance of the portfolio more than adding another activity (e.g. another crop in the case of a farmer who is trying to manage risk by diversifying), especially if better terms of credit are available when the insurance index is purchased.

For a rainfall index, the degree of correlation between net receipts from the index and farm income will play a large role in the effectiveness of the risk protection offered to a farmer. With higher correlation there will be less basis risk. Understanding income-rainfall correlation requires crop yield modeling. Further, it is possible that a set of rainfall indexes may fit best for different farming systems. Farm income risks for certain crops may be most sensitive to rainfall shortfalls at different times during the season (e.g. planting and blooming). Income may also be at risk during harvest if there is excess rain. The specific design of the index contract will also have a bearing. Models such as the capital asset pricing models (CAPM) can be used to determine the optimal level of these contracts once the income-rainfall relationships are understood (Miranda does this for an area yield contract). One advantage of CAPM type models is they also help identify the independent risk and the covariate or systemic risk. Having a high covariate risk improves the efficacy of an index insurance contract. Therefore, index products are a bit different than traditional insurance in that the very presence of high levels of covariate risks improves their attractiveness.

But the presence of high covariance risk is potentially troublesome for the insurer. When a payment is due, then all those who have purchased insurance against the regional index must be paid at the same time. Moreover, if the insured risks in different regions are highly correlated, then the insurer faces the possibility of having to make huge payments in some years. To hedge against this risk, the insurer can either diversify regionally by selecting indices and sites that are not highly (positively) correlated, or sell part of the risk to the international and financial markets either through reinsurance or the emerging markets for sharing catastrophic risk. We shall return to this issue later.

RAINFALL INSURANCE CONTRACTS (RICS)

Even though either area-yield or area-soil moisture indexes may be better contracts, rainfall insurance contracts (RICs) may be technically more feasible for most countries because of the existence of long data series at regional weather stations. Although excess rainfall insurance contracts have existed for years, drought rainfall contracts are relatively new. Nonetheless, there is a growing interest in drought rainfall contracts among insurers and reinsurers. Part of the reason for this interest is the growing weather derivative market in the US. Temperature is now traded in the U.S., allowing energy companies to hedge against swings in revenue when there are extremely high or low temperatures (Dischel). Some significant work has taken place by the World Bank in investigating rainfall contracts for Nicaragua. Still, to our knowledge, there are no rainfall contracts in developing countries at present.

The essential principle of rainfall insurance is that contracts are written against specific rainfall outcomes (e.g. drought or flood) recorded at a local weather station. The rainfall outcomes should be defined at catastrophic levels and should be highly correlated with the value of regional agricultural production or income. For example, an insured event might be that rainfall during the most critical month of the growing season falls 70 percent below normal. In years when the insured event occurs, all the people who purchased the insurance receive the same payment per unit of insurance. In all other years, no payments are made. Such a zero/one contract could be very important for individual insured in areas that are subjected to large losses when rainfall drops below a certain level. This design is easy to understand and should be offered to small growers.

While there are many ways to design rainfall contracts, the simplest is to sell the insurance in standard SUCs. The insurance would be sold on a full cost basis, and the price of the SUC is the premium. The insurance must be sold before season-specific information about the insured risk becomes available. This requires a purchasing deadline, after which new SUCs are not sold. In some cases, the deadline may be as much as a full year ahead. For example, emerging ENSO events can now be forecast up to 12 months ahead.

Besides the zero/one contract, one can envision contracts that pay in layers. For example if rainfall is between 40 and 60 percent of normal the insured might get a payment equal to 1/3; the next 1/3 would come if rainfall equaled 20 to 40 percent of normal; a full payment would come for rainfall below the 20 % of normal level. Finally, a percentage contract could also be offered where payments would be calculated on the basis of percentage below a certain rainfall level (a strike rainfall). The percentage would be multiplied by the protection (liability) purchased.

The alternative designs should be based on the sophistication of the customer and the incentives and opportunities that might exist to manipulate the rainfall measures. When people know that the rainfall is close to trigger a full payment (for the zero/one) contract, they have more incentives to tamper with the rainfall measures. Thus, a zero/one contract may require more monitoring, even though it is the simplest design.

In principle, one might expect the private sector to take the initiative in developing rainfall insurance, but there are several setup problems that might require a public intervention to jump start activity in many developing countries. Setting up the basic infrastructure to get started may be an important government activity. Start up activities include a) the research costs of identifying key catastrophic rainfall events that correlate strongly with agricultural production and income in different types of rainfed agricultural regions; b) educating rural people about the value of rainfall insurance; c) ensuring secure rainfall stations; d) establishing an appropriate legal and regulatory framework for rainfall insurance; and e) underwriting the insurance in some way (perhaps through contingent loans) until a sufficient volume of business has been established that international reinsurers or banks are willing to come in and assume the underwriting role for themselves. These roles need not be costly but could prove crucial in launching rainfall insurance. But it is also important not to launch the insurance on a heavily subsidized basis, so as not to distort incentives for private insurers or farmers.

Despite the promise of rainfall insurance, there are significant issues that must be resolved. These are a) the need for secure rainfall measurements, b) the actuarial challenges that are present due to the El Nino Southern Oscillation (ENSO), and c) the covariate risk problem for the insurer mentioned earlier.

SECURE RAINFALL MEASURES

Secure and reliable rainfall measures are critical for all parties. New technologies hold significant promise. One company in the U.S. offers a rain gauge operated by a battery with a five-year life. Tiny buckets trip the measuring device so that rainfall at .01 of an inch can be recorded, but no rain is actually collected and stored. By using a data jack with windows based software, a worker simply plugs into the rainfall-measuring device and downloads the data. It is not necessary to take frequent readings; in fact intervals of up to a month are adequate. A complete system of 50 such gauges, software and data jack cost about $240 each. This is affordable and offers the opportunity to densely populate a region with rain gauges. Such coverage would permit readings from several adjacent gauges to be averaged to provide more reliable point estimates for a region. It would also reduce the danger of distorted readings should an individual tamper with a single gauge. Security can be enhanced by placing the rain gauges on telephone poles with shields around them from below.

EL NIÑO SOUTHERN OSCILLATION

The actuarial soundness of the insurance could be undermined by the ENSO phenomenon that changes the probability of the insured events. It may be necessary to adjust the cost of the insurance when an ENSO event is confirmed, although this would require sufficient lead-time between knowledge of the pending event and the time of selling insurance. It might also be necessary to sell contracts a few years into the future before anyone has knowledge of the ENSO. For example, RICs that cover individual years for three years into the future may need to be sold as a package. The most troublesome aspect of ENSO events in some parts of the world is that they extend across multiple crop seasons. Again, multiple year contracts can be used to address this issue. However, this problem is similar to the large loss problem created by the covariate risk. The covariate risk may have both a spatial and a temporal dimension, making it even more important to consider some of the new alternatives for sharing catastrophe risk.

FINDING EFFICIENT AND AFFORDABLE MECHANISMS TO SHARE COVARIATE RISK

Insurance is available for natural disaster risk in many developed economies. Homeowners can insure against damage from hurricanes and earthquakes. These risks are clearly different than most insurable risk. Unlike automobile insurance where the risks are largely independent, natural disaster risks are correlated with some low probability of very high losses as a widespread area is damaged by a single event. This requires special arrangements to share these risks in the capital markets. Primary insurers pass on certain levels of risk to an international reinsurance market (Miranda and Glauber; Cutler and Zeckhauser; Skees and Barnett).

The simplest form of reinsurance is a stop loss where the primary insurer pays a premium to get protection if their losses exceed certain levels. Other forms of reinsurance are also common. Quota-share arrangements involve simply sharing both premiums and indemnities. If an insurance company has a book of business that is concentrated in a hurricane-prone area they would likely need such reinsurance. Suppose they have $100 million of property value insured with an average premium rate of 10 percent, then they would collect $10 million in premiums. While this company may have financial reserves of say another $10 million to cover significant losses, they cannot cover losses beyond the combined $20 million level, or beyond a loss ratio of 2 (indemnities / premiums). They may therefore decide to buy a stop loss where the reinsurer pays for all losses above the $20 million level.

In writing such a stop loss, the reinsurer has an interesting problem – how does one rate a policy for a low probability, high-loss event? While there are very sophisticated models to address this problem, most prudent reinsurers will load the risk premium to cover larger losses than have been experienced in the past simply as a precaution against unexpectedly large losses (Anderson; Hogarth and Kunreuther 1989, 1992). The reinsurer must also consider the possibility that a large loss will occur early on and before an adequate financial reserve has been built up. Again, the premium is loaded to build these reserves quickly. Reinsurers must also invest in monitoring and information systems to ensure that they are not cheated, and this increases transaction costs. In the end, all of these costs must be summed together with the pure risk of the contract to develop a premium rate.

Premium Rate = Pure premium rate + Catastrophic Load + Reserve Load
+ Charge to cover transaction costs + Return on equity

Premium rates quickly become expensive, and often exceed the expectations of decision-makers who tend to quickly forget the severity of their losses from natural disasters (Kunreuther and Slovic; Camerer and Kunreuther). If premium rates are to be kept low, then significant efficiency gains are required in the reinsurance industry. The most promising prospect is if large international reinsurers can spread risks around the world, so that what may be low-probability high catastrophic events for a small company become largely independent and diversifiable risks for the large reinsurer.

Despite significant growth in the international reinsurance markets in recent years, reinsurance markets are still thin with few large international firms and limited capacity. Kunreuther, Stipp, and Froot review some of the problems with reinsurance markets. Reinsurers have short memories and, after a major catastrophe, reinsurance prices increase greatly or the reinsurer simply pulls out of the market. This happened in Florida after Hurricane Andrew and in California after the Northridge earthquake. State reinsurance pools were created in both Florida and California to offset these problems (Noonan; Jaffee and Russell).

As an alternative to formal reinsurance, recent developments in global financial markets are making it increasingly feasible to use new financial instruments to spread covariate risks, like regional rainfall, more widely (Cole and Chiarenza; Doherty; Lamm; Skees 1999b; Skees and Barnett). For example, "catastrophe" bonds offer innovative ways of packaging the risks assumed by a rainfall insurer to sell in the international financial markets. "Catastrophe" bonds issued against rainfall events in developing countries could be very appealing to international investment bankers because their risk would be uncorrelated with the risks of most other financial investments.

Since ENSO is a major source of risk, it might be possible to develop an exchange-traded index on ENSO in a major futures exchange market like the Chicago Board of Trade (CBOT). There is also some promise that exchange markets can be used as risk-sharing institutions for disasters. The Chicago Board of Trade (CBOT) trades a Catastrophic Insurance Options Contract (CAT). Property Claim Services (PCS) catastrophe loss indices are traded for nine geographic regions in the U.S. As such, the contract allows those at risk from large property and causality losses due to hurricanes or earthquakes to share some of that risk with a larger community of traders in an exchange market. The contract has grown a good deal in recent years but still comprises only about two percent of the total market.

Skees and Barnett go further by proposing that governments could offer some very low-level index contracts to reinsurers to assure that adequate capital is forthcoming.

Lewis and Murdock make a similar proposal for the U.S. government to offer excess of loss contracts to the private sector. Since the insurer will likely load for events that have not happened yet, this may be important. One way to facilitate this would be to have the government offer options on rainfall that is at the lowest level experienced in recent decades. Primary insurers and reinsures would determine how many and what mix of such contracts to purchase from the government. These contracts could be simply rated at the historical break-even rate, or they could be auctioned to the highest bidder. The World Bank or others in the capital markets could back up these contracts with a contingency loan so that the government would have sufficient capital to pay all losses if the bad year came before an adequate reserve had been built up. In effect, the capital markets would be offering a stop-loss type contract to the government.

To clarify these principles, consider the following hypothetical scenario. A primary insurance company decides to offer drought insurance contracts to farmers, bankers, and others for a limited test period in three weather stations areas. For simplicity, assume that only one contract is available at each weather station, and the contract pays when cumulative rainfall in the months of May through July is less than 75 percent of the average rainfall at the station. If the rainfall is between 75 and 50 percent, the contract pays 1/3 the face value; if the rainfall is between 50 and 25 percent of the average, the contract pays 2/3s the face value; and if the rainfall is 25 percent or less of the average the contract pays the full face value. Assume that the primary insurer writes $1 million in premium for RICS. If the face value were $10 million then, in the worst case, each rainfall station would have rainfall of less than 25 percent of average, and the insurer would pay $10 million. It happens that for these three stations such an event has never occurred, at least not all at the same time. However, that does not mean it could not happen in the future, and any prudent reinsurer would want to load the reinsurance premium to cover this possibility. This might make the reinsurance too expensive for the primary insurer.

To counter this, the host-country government could offer to sell individual rainfall contracts to reinsurers. For example, the government might sell a rainfall contract for each station that pays in two stages: 1) 50 percent of the face value for rainfall below 40 percent of the average; and 2) 100 percent of the face value for rainfall below 20 percent of the average. Reinsurers could then purchase a mixture of these contracts to best protect their risk, and this would reduce their need to load the premium for the primary insurer. However, if the government sells these contracts, it must have the capital to pay if the bad year comes early. This could be particularly difficult for small countries that have limited risk-pooling opportunities. To address the small country problem, the World Bank, an international reinsurer, or a financial entity that is ready to write catastrophe bonds, could offer simple stop-loss coverage via a contingency loan. For example, if the government sold premium of $500,000 for these contracts, at premium rates of 5 percent, the maximum possible loss would be 20 times the total premium, or $10 million. While the expectations are that the government would break-even over the long run, they could have serious losses if losses of this magnitude occurred early. The World Bank or the international capital markets could cover such an event with a loan. To initiate things, the government might want to offer these contracts in limited numbers through an auction to create an insurance market. Or the government might be able to build a reserve fund and offer the contracts without outside capital after some time. The primary objective should be to move to a market-based system with little or no government involvement in reinsurance.

4. CONCLUSIONS

A market-based, risk-sharing insurance alternative for agriculture has many potential advantages. The link between risk and credit markets is important. If risks are not mitigated, then credit will be more expensive and less readily available. Credit is one key to development, as producers generally must borrow to invest in new technologies. Beyond the credit linkages, market-based insurance should reduce the burden on government budgets. By making insurance available, the government may not have to provide free disaster aid. Other efficiency gains should be expected as well as farmers may be more flexible in taking advantage of the benefits of specialization. To the extent that market-based insurance can serve the risk management needs of the rural poor, it can also help redress important food security problems.

While all of the potential benefits associated with offering crop insurance may be used to justify some level of government involvement, great care is needed. World experience has demonstrated that public efforts at delivering farm-level, multiple-peril crop insurance have been flawed. The total public cost of these programs has far exceeded their public benefits. These programs have proved far more costly than expected because a) they have been poorly designed to deal with basic insurance problems such as moral hazard and adverse selection, and b) they have suffered from poor management, high administration costs and exceptional losses arising from government interference in the form of open-ended financial support, restrictions on the insurance portfolio, and meddling in the payment of indemnities for political reasons. Searching for effective solutions requires both lower transaction costs and reduced opportunities for rent seeking. The best way to reduce rent-seeking opportunities is to make the government's role explicit and transparent, and not to change the rules when large losses occur.

Our diagnosis of the problems with traditional crop insurance has led us to area-based index insurance contracts. Properly designed area-yield, rainfall, or soil moisture index insurance contracts require less monitoring to control adverse selection and moral hazard. In addition, administrative costs should be low. A variety of rural people could purchase area-index insurance contracts in addition to small-scale farmers. They could also be sold in small units that might appeal to poor people. Finally, creative forces within financial markets should be able to use index insurance contracts to handle covariate risk. Wrap-around products that cover some additional risk are possible. Microfinance entities could use the contracts to handle major risk and offer better terms of credit. Many possibilities exist for using this type of insurance to further develop markets for sharing risk

Despite our enthusiasm for index insurance contracts, we recognize that some key issues must be addressed. All parties must be confident that the measurement of what will trigger payments is secure and accurate. The system of measurement must be free of any possibility of tampering. There must also be confidence and transparency in the procedures used to develop premium rates. Great care must be used in designing contracts that match what is at risk. Marketing plans must be developed that address how, when, and where index contracts are to be sold. Also, the government and other involved institutions must consider whether to facilitate and regulate secondary markets of exchange for the contracts. Finally, reinsurance or effective and efficient use of other financial markets will be critical for sharing the covariate risk represented in index contracts. These risks must be spread around the world to obtain the best pricing.

Once properly constructed index contracts are in place, it should be possible to obtain efficient pricing in the international markets. Governments can build the infrastructure for measuring the index and monitoring the information to add credibility. Governments may also become involved in selling very low options on the index in order to improve the pricing. These options could be secured by contingency loans with an international bank (e.g., the World Bank). Again, there are many possible evolutions in the market once an effective index contract is trading. These developments should be oriented toward market-based insurance. Governments should not engage in attempting to protect farmers from independent risk. This effort should be left to the private sector.

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