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Risk Management Challenges in Rural Financial Markets: Blending Risk Management Innovations with Rural Finance

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ABSTRACT

Rural finance is about managing risk. Lenders can effectively pool and aggregate risk held by a large number of borrowers if the risk they face is largely independent. A major advantage of microfinance entities and other forms of collective action has been the ability to pool risk. However, correlated risk can not be pooled. Small rural finance entities (RFEs) are simply not capable of pooling and managing correlated risk on their own.

Agriculture remains a dominant activity in many rural economies of the poorest nations in the world. A large majority of the poorest households in the world are directly linked to agriculture in some fashion. Risks in agriculture are correlated. When one household suffers bad fortune it is likely that many are suffering. When agricultural commodity prices decline everyone faces a lower price. When there is a natural disaster that destroys either crops or livestock, many suffer. Insurance markets are sorely lacking in most developing and emerging economies, and rarely do local insurance markets emerge to address correlated risk problems. There a numerous challenges in developing financial markets to manage risk in developing countries. Many of these are reviewed in this paper.

Nonetheless, there is hope. This paper builds upon that hope by reviewing innovations in global financial markets that provide unique opportunities for RFEs to manage correlated risk and expand their ability to help rural households. Two innovations offering the most hope are: 1) the use of global futures markets by intermediaries who can offer a form of price insurance; and 2) the use of index insurance contracts to shift natural disaster risk into the global markets. Recommendations are offered for blending these forms of index insurance and rural finance.

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RISK MANAGEMENT CHALLENGES IN RURAL FINANCIAL MARKETS: Blending Risk Management Innovations with Rural Finance

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Introduction

Rural financial markets in emerging and developing economies face numerous challenges. This conference focuses on many of those challenges, including one of the more formidable — that of managing and coping with risks. A complete set of financial markets would include both banking and insurance markets. Banking allows for *ex post* borrowing to smooth disruptions in consumption that result from unexpected shocks (risk) that beset a rural household. Insurance allows for *ex ante* indemnity payments for well-specified risk events that also disrupt consumption.

Financial markets are largely about pooling risk. In banking, users have the opportunity to save and borrow. Pooling savings allows banks to loan to individuals who need funds most urgently. When a household needs to borrow funds they must pay interest. With insurance, rather than having a group of investors, a firm collects premiums from many individuals so that unfortunate individuals in the group can be paid when bad luck besets them. In either case, if everyone has bad luck and needs funds at the same time, there will be trouble. Thus, to the extent that rural financial markets are capable of pooling risk, the risks that are pooled must be independent (i.e., the groups participating cannot have bad luck at the same time).

Agriculture remains a dominant activity in many rural economies of the poorest nations in the world. A large majority of the poorest households in the world are directly linked to agriculture in some fashion. Risks in agriculture are most certainly not independent in nature. When one household suffers bad fortune it is likely that many are suffering. These common risks are referred to as correlated risk. When agricultural commodity prices decline everyone faces a lower price. When there is a natural disaster that destroys either crops or livestock, many suffer. Insurance markets are sorely lacking in most developing and emerging economies, and rarely do local insurance markets emerge to address correlated risk problems.

Since both price and yield risk for agricultural commodities are spatially correlated, rural finance markets are often limited in their ability to help individuals either smooth consumption or manage the business risk associated with producing crops and livestock. For that matter, any form of collective or group action assisting individuals to manage correlated risk at the local level is doomed.

This paper focuses upon the challenge that rural financial markets face helping rural households manage correlated risk in agriculture. Small rural finance entities (RFEs) are simply not capable of pooling and managing correlated risk on their own. Nonetheless, there is hope. Innovations in global financial markets provide unique opportunities for RFEs to manage correlated risk and expand their ability to help rural households. Futures

exchange markets have long been used in developed countries to manage correlated price risk. For some globally traded agricultural commodities, opportunities also exist for RFEs in developing countries to manage price risk. Additionally, new approaches are available for shifting natural disaster risk. As will be developed, index insurance contracts that pay on an objective and independent measure of natural disasters are being used in a number of countries.

While much of the challenge of risk management for RFEs is rooted in the problems associated with correlated risk, there is nothing simple about taking on (or underwriting) risk for individuals. This is particularly true if the livelihood of those individuals is tied to some form of agricultural production activity. Problems of asymmetric information abound. Those involved in a production activity will always know more about their risk than a RFE can ever know. When the households are small, it is nearly impossible for the RFE to obtain enough information to fully understand the risk. Thus, mistakes will be made; bad loans will be made; bad insurance contracts will be written.

Asymmetric information problems create dual problems of adverse selection and moral hazard. When adverse selection occurs, the lender or the insurer has not properly assessed or classified the risk of their customer. Those who are more risky take out the loan with little intent to pay it back or those who are offered insurance decide that the insurance is underpriced and they are getting a good deal by purchasing it. Moral hazard occurs after a loan is taken or after the insurance contract is obtained. Moral hazard involves a change in behavior so that the customer represents more risk than what was believed to be the case. In the case of borrowers of funds, they may decide to use the loan for consumption rather than an income generating activity. Those who are insured may change their behavior in a way that increases the risks beyond what the insurer believed they would be when the insurance was developed.

To pool correlated price and yield risk, RFEs must develop a diversified portfolio of loans. Loans can be diversified by expanding the geographic area served and by expanding the diversity of customers. Thus, the quest for diversifying loans reduces what lenders know about their customers. Either the lending institution must become large or they lose the advantage of lending to a specialized clientele. In either case, the ability to know the customer and underwrite the risk of the individual diminishes significantly.

Given the prohibitive transaction costs associated with obtaining information and monitoring, collective action among neighbors who know already know one another via social networks becomes important. If one is to consider collective action it is also important to review some of the development literature regarding risk management and risk coping strategies that are used by the rural poor. That review is presented in the next section, reinforcing the premise that it is nearly impossible for the rural poor to manage or cope with correlated risk from natural disasters.

Next, the paper turns to the role of banking and insurance markets to aid in managing and coping with correlated risk. Here again, the limitations and challenges for both banking and insurance markets involve not only the inability to deal with correlated risk,

but also the difficulty of underwriting risk for small- sized rural households. Understanding these challenges also sets the stage for a more full explanation of the international experience with crop insurance. This experience clearly demonstrates that multiple-peril crop insurance has required significant subsidies from the public sector. Once the full social costs are measured, traditional crop insurance has been an unmitigated failure (Hazell, 1992; Hazell, et. al. 1996; Skees, 1999a, 1999b, and 2001b; Parchure, 2002).

Damage to crops, property, and person can be highly correlated if the source of the damage is a natural disaster. Since most forms of insurance, including local reciprocity and mutual insurance groups, have failed in providing relief from natural disasters, some form of *ex post* disaster relief is common (Cashdan, 1985; Rosenzweig and Binswanger, 1993; Fafchamps, 1992; Udry, 1994; Townsend, 1995).

Free disaster assistance is fraught with incentive and equity problems. Economists are rightly concerned with the incentives in such a system (Anderson, 1976; Dacy and Kunreuther, 1969; Freeman and Kunreuther, 1997; Kaplow, 1991; Kunreuther 1976, 1993, and 1996; Rettger and Boisvert, 1979; GAO, 1980 and 1989). If decision makers do not pay something for the risk associated with their decisions and free aid or debt forgiveness is used, vulnerability to disasters becomes self-perpetuating (Kaplow, 1991). While numerous equity issues can be raised regarding who gets the free aid, when it is packaged as debt forgiveness in a national banking system, such aid can be even more skewed toward those who already have assets.

Insurance markets that compensate for crop or livestock losses from natural disasters have long been touted as being an important component for recovery of poor households. Nonetheless, traditional insurance markets are missing or incomplete in most developing economies. As will be established, traditional crop and livestock insurance is a particularly bad idea for developing countries where asymmetric information and poor data create classic problems for insurance. Index insurance offers some promise for circumventing the problems with traditional crop insurance. Furthermore, innovation in global financial markets and in technology provides even more hope that index insurance contracts can be offered at more affordable prices. For example, satellite imagery may someday allow insurance providers to offer index insurance that is directly tied to vegetative growth given specific geographic coordinates.

After developing the conceptual foundation for understanding why index insurance can fit into the developing country's setting, the paper reviews some case studies that demonstrate that the use of index insurance in developing countries is growing. The World Bank has been heavily involved in many of these developments both in terms of price risk management and weather-yield risk management. However, as will be developed below, there are concerns about the basis risk for individuals who may use the futures markets or purchase index insurance. Basis risk occurs when an individual has a loss and does not receive payment or when there is payment and the individual has not suffered a loss. This can happen with index insurance that pays based upon an objective

measure of weather or area yields. Basis risk is also present when individuals use futures markets to protect against local price movements.

If a group of individuals working within a RFE purchase either price insurance (via put options) or yield insurance (via index insurance with indemnity payments based upon extreme weather events), there are opportunities to mitigate the basis risk. The collective group could form a mutual insurance company or they could be involved in formal or informal lending to members of the group. As will be developed below, the use of innovations presented in this paper could clear the way for blending mutual banking and financial innovations at a local level (Mahul, 2002). The focus of the conceptual model presented here will be on localized rural finance (both formal and informal). Still, the risk management instruments that are introduced have a wider application: They can be used by larger RFEs as well as by individual households.[1]

Linking the use of risk-shifting innovations that are being tried around the world directly to rural finance has been largely missing. This paper builds a set of recommendations for using index insurance and, in some cases, futures markets in combination with rural finance. The intent is for the RFE to have the opportunity to purchase index insurance and put options to protect against the correlated risk of crop disaster, livestock deaths due to natural disasters, and commodity price declines. The indemnity payments can be used by the small local banking interest to 1) protect against credit defaults that follow a risk event; 2) facilitate a form of mutual insurance, and 3) offer lower interest rates after the risk event.

To be clear, the ideas presented in this paper are developed with several implicit and explicit assumptions. For example, the legal framework must be in place to assure the integrity of contracts (Fleisig, 2003). Furthermore, in many cases, the macroeconomic environment within the country must be stable enough to allow financial markets to function (Gonzalez, 2003). While both of these requirements are formidable obstacles, they may be less so with the arrangements presented in this paper. To the extent that financially strong and reputable international firms are offering index insurance contracts to RFEs within a developing country, the primary requirement will be up-front premium payments by the RFE. Such an arrangement could also be structured so that premiums and indemnities are paid in a strong international currency (dollar or euro), thus circumventing exchange rate risk and some inherent problems associated with a poor macroeconomy.

Risk Management and Risk Coping Strategies

Risk management strategies attempt to address risk problems *ex ante*. Risk coping strategies address risk problems *ex post.* Siegel and Alwang (2001) develop a taxonomy of risk-coping strategies for rural households. An excellent example of *ex ante* risk

[1] See Skees et al. (2002) for more uses of the same information on weather disasters in several settings: 1) as a replacement for traditional crop insurance; 2) as a means to insure groups of farmers and facilitate mutual insurance; 3) as a means of providing more affordable reinsurance for traditional crop insurance, and 4) as a mechanism to trigger objective disaster payments.

management is enterprise diversification. Using off-farm income to offset risk from farming is one way to diversify. However, if members of the household go to work off the farm after the disaster, this would be a risk coping strategy. Another common risk coping strategy involves selling of assets after the disaster.

An important distinction between independent and correlated risk must be made.[2] The source of the risk influences the ability and means used to manage and cope with the risk. Independent risk can be pooled and shared among neighbors. When risks are independent, two individuals having the same average incomes with the same level or risk can combine incomes and lower their risk. They can do this without changing their average income. Pooling of independent risk is a precondition for insurance. When risks are highly correlated, the advantage of pooling or combining incomes disappears. To cope with correlated risk, income must come from outside the local community (insurance, credit, or savings).

Diversification is among the most common risk management strategies for the rural poor. Dercon (2002) develops an excellent review of literature that suggests not only that the rural poor are likely to give up significant income to lower risk but many times they fail to smooth risk when they diversify. Of particular interest to this paper, Dercon (2002) points out that while the quest to diversify income by using both farm and off-farm sources may be effective during normal years, it can be highly ineffective during abnormal years. Since many of the sources of off-farm income remain tied to the well-being of farming in the community, any shocks to local agricultural incomes can place the diversified income of the rural poor in jeopardy as well. Quoting from Dercon, 2002 (p. 12):

> "Czukas et al. (1998) find evidence that non-farm income is positively correlated with shocks affecting crop income: drought adversely affects not only crop income but also non-farm income. They refer to Sen's analysis of famine — crop failure leads to a collapse of the demand for local services and crafts, limiting the use of diversification to handle risk."

Studies that examine the multiplier effect of farm income in rural communities suggest that the non-farm economy growth rate is tied to the farm economy growth rate in many developing countries (Ellis, 1998). Thus, it is likely that correlated shocks that impact farm income also are likely to influence the growth rate of the non-farm economy.

Building savings is the most common risk coping strategy for the rural poor. Since rural finance markets are limited in developing countries, accumulation of assets that can be liquidated to smooth consumption when there are adverse events is a common form of savings (Binswanger and McIntire, 1987; Bromley and Chavas, 1989; Rosenzweig and Wolpin, 1993).

[2] When making this distinction, language becomes important, as the literature uses a variety of terms. Independent risk is also referred to as idiosyncratic risk. Several words replace correlated risk in the literature: 1) covariate; 2) common, and 3) systemic.

There are at least two significant problems with using accumulation of assets as a risk coping strategy: 1) the asset can be lumpy and not easily converted to the proper level of needed cash during a crisis, and 2) the value of the asset can be risky, and even more troublesome, the risk can be correlated with the very shocks that one is attempting to mitigate. For example, since livestock is commonly used as the asset to smooth income shocks, this may work well when the shock is created by an independent risk event — health problems in the household, death, weddings, etc. However, when the shock is from a natural disaster such as drought, one can expect that livestock will also suffer. The household will either be forced to purchase feed, sell the livestock, or move the livestock to a region not impacted by drought. All of these risk coping strategies will be costly. More problematic, if everyone is trying to sell livestock at the same time because of drought, the price of livestock will be greatly depressed.

Banking and Insurance to Manage and Cope with Risk

If rural finance markets were working properly, individuals could conceivably borrow to smooth consumption when shocks create either lower than expected incomes or low crop yields for household consumption. However, it is rare that rural finance markets in developing countries are fully integrated with international finance markets. Country currency risk and correlated natural disaster risk can create serious problems for anyone holding savings in a local bank. Additionally, if either low prices or low yields create lower than expected incomes, this adversely impacts the ability to repay existing loans provided for inputs in the production process. As a consequence, rural finance markets either charge higher interest rates or restrict access to credit.

Banking and insurance involve underwriting risks of individuals and offering individuals the opportunity to address the risks either *ex ante* (with insurance) or *ex post* (with bank loans). While there are important similarities in banking and insurance, there are also important differences. With banking, the borrower must either provide collateral or have an excellent history of repayment to obtain a loan. Poor households can rarely meet the conditions for a loan. By contrast to the banking requirements, an insurance contract requires no collateral or repayment history. The basic requirement is *ex ante* financing of the risk via a premium. If the poor can pay some level of premium, they are insured. Still, among the poorest of the poor the inability to pay premiums of any form may also preclude any form of insurance. In recent work, Goes and Skees (2003) are raising the question of how *ex ante* index insurance for natural disasters could be co-financed by charities. Some of this thinking is introduced below in the context of local self-financing groups (microfinance or cooperative).

Challenges for Traditional Banking and Insurance Markets[3]

Portfolio management is the key to successful banking and insurance. Having a well-diversified pool of risk allows both banks and insurance companies to spread risk among

[3] Debraj Ray's book, *Development Economics,* includes two excellent chapters that review credit and insurance markets.

customers with different sources of income, over geographic space, and through time. Lenders and insurance providers must be knowledgeable regarding the risk of their customers. Underwriting risk of individuals is critical and involves extremely high transaction costs. Asymmetric information heavily favors the borrower and the insured. Lenders who decide to make loans without collateral will need even more information about the borrower. Obtaining the needed information to underwrite the individual risk requires monitoring and relatively high transaction costs.

Monitoring the activity of small households of the rural poor who wish to borrow small sums or purchase a small value of traditional insurance is basically not possible. The revenues generated from the financial activity most certainly do not pay for the monitoring cost in many of these cases. Still, without proper underwriting and monitoring, credit defaults will become a problem when loans are made to the rural poor. Credit defaults can also be traced to a shock (either coming from an independent risk or a correlated risk). Thus, in principle, a strong case can be made for using insurance with credit.

Under special circumstances, insurance can become a form of collateral. RFEs making loans are requiring that the borrower purchase insurance and sign over indemnity payments to the RFE as a means of repaying loans when adverse events create cash flow shortages. The trend for this type of arrangement is growing and, in some cases, includes forward price contracts on crops. When banks make such requirements, they are effectively turning over some of the underwriting responsibility to the insurance provider. Given the high social cost of underwriting the risk of the same individual two times (once for the bank and once for the insurer), merging these activities at some level may be socially optimal.

However, combining banking and insurance functions is also a major challenge. Banking and insurance have important differences in terms of potential financial exposure. In countries with working legal systems, a RFE can require that some form of collateral be used to increase the likelihood that they will recover something from the loans they make. The RFE must be able to make assessments regarding the probability of repayment of loans. If there is considerable risk of default on the loans, then the RFE will would have to charge higher interest rates. Such loading of interest rates is akin to an insurance premium. In some cases, governments provide loan guarantees to protect against large credit defaults. These guarantees can become problematic as moral hazard on the part of the RFE can increase. Moral hazard in this case means that the RFE becomes more lax in underwriting the loans they make.

Insurance can involve considerably more risk than banking and there are many cautionary concerns that must be addressed before a RFE embarks upon providing insurance. Some have raised serious questions regarding the ability of microinsurance to be sustainable (Brown, Green, and Lindquist, 2000; McCord, 2003). If a microfinance entity offers insurance services, there is considerable risk that they may not have enough funds to cover their full range of exposure. Further, they must have more sophistication in their knowledge of risk. Index insurance circumvents many of these concerns. As will be made

clearer later, the microfinance entity would purchase index insurance and, in some cases, put options on price. As a collective group, they would have agreements about how the proceeds of these contracts would be used. They would not expose the collective group to more commitment than agreeing to distribute payments from the index insurance or the put options. In effect, they could distribute these payments using informal systems of mutual insurance (i.e., they could attempt to make certain that those suffering the biggest losses would receive the most payment).

Managing Correlated Risk in Global Financial Markets

Price Risk Management

When risks are nearly 100 percent correlated, futures exchange markets have emerged to allow many buyers and sellers of the risk to share risk in an organized fashion. These markets have allowed participants to protect common or correlated risks such as changing commodity prices, interest rates, and exchange rates. Futures markets have a much longer history of successful use than many of the ideas presented in this paper. Thus, less time will be spent explaining these markets. There are numerous excellent texts that can be used to become informed regarding futures markets (e.g., Luethold, Junkus and Cordier, 2000).

Despite well-functioning futures markets, because of the complexity of and the size needed to participate in futures markets, intermediaries are needed to facilitate participation in something that looks much more like direct price insurance. The World Bank has been working with investment banks and with the International Finance Corporation (IFC) to offer something that is much more akin to price insurance or an Asian put option. If the domestic price is highly correlated with a futures market price, it is possible to offer such contracts to local users in a developing country. The buyer (such as a RFE) would pay a premium for the right to obtain price protection at some level. For example, if the world price of coffee is trading at 40 cents, the RFE could purchase an option or insurance that would pay anytime the world price of coffee drops below 30 cents. The payment would be made in such a fashion as to make up the difference between the new lower world price and the 30-cent level. By packing various size contracts, the investment bankers and IFC hope to make these types of contracts more accessible to a wide array of users. Kenyan coffee is used in this paper as a case that may fit the necessary condition that domestic prices be highly correlated with an internationally traded exchange market.

Natural Disaster Risk Management

When a hurricane or an earthquake occurs not everyone has a total loss. Still, many losses do occur at the same time. Crop losses have similar characteristics. While events such as too little rain, too much rain, or widespread frost create widespread crop losses, not every farm experiences the same loss. The challenge for those insuring losses from hurricanes, earthquakes, and crop disasters is to have access to enough capital to cover worst-case scenarios.

Since catastrophic risks are not independent, and in the classic sense are uninsurable, special global markets have emerged to share these risks. The traditional mechanism is to share catastrophic risk with another insurance entity by what is called reinsurance. Reinsurance can take many forms. The simplest form to consider is another insurance policy on the insurance losses for a local insurance provider. Such a policy can be arranged as a ”stop loss” policy: The local insurance provider pays a premium to the global reinsurer who agrees to pay for all losses beyond a certain threshold. As long as the reinsurer mixes this into a global book of business, then what were correlated risks at the local level become independent risks at the global level.

While reinsurance markets are extremely effective and have grown in recent years, there are significant limitations. First, price discovery is difficult. There is no price transparency. The international reinsurance market is a classic thin market with few buyers and sellers. Second, transaction costs are high. Reinsurance contracts can be unique, requiring costly legal fees to tailor the contract to the special circumstances. The local insurance provider will know more about the risk they are writing than the international reinsurer can expect to learn. Thus, the hidden and asymmetric information problems that plague local insurance providers are also present between the local insurer and the global reinsurer. It is expensive for the reinsurer to attempt to balance the information and monitor the local insurer. Third, the prices that must be charged for reinsurance may simply not match the willingness to pay. In addition to covering the transaction costs, the price of reinsurance reflects extra “loading” to build reserves and account for the ambiguity of catastrophic risk (Jaffee and Russell, 1997; Skees and Barnett, 1999). A lack of understanding about the risks and events being insured may cause insurers and reinsurers to set premiums too high (Camerer and Kunreuther, 1989).

Froot (1999) develops four explanations for the high price and low use of catastrophic reinsurance: 1) reinsurers have market power; 2) the corporate form for reinsurance is inefficient; 3) frictional costs of reinsurance are high, and 4) moral hazard and adverse selection at the insurer level are high. Froot (1999) goes on to point out how insurance regulations increase the transaction costs even further and how free government disaster assistance crowds out development of reinsurance markets. Finally, he discusses how decision makers may underestimate or simply not consider the very low likelihood of payment from reinsurance.

New Market Instruments for Sharing Catastrophic Risk[4]

In the past decade a number of innovations have been tried to offset the limits of reinsurance through the use of insurance securitization (Cole and Chiarenza, 1999; Doherty, 1997; Lamm, 1997). Insurance securitization involves the creation of marketable security that is financed by premiums flowing from a contingent claims transaction — generally the traditional insurance and reinsurance transactions. The concept is relatively straightforward: if the risk can be standardized in some fashion and packaged into a marketable security, then many investors can participate in the risk

[4] Parts of some sections of this paper appear in other works by the author. They have been modified and added as important components of this paper.

sharing. Since capital markets trade many times the value of the entire reinsurance capacity, this access to additional capital with lower transaction costs should compensate for many of the limitations in the reinsurance markets.

These innovations offer potential applications for insuring against catastrophic and agricultural risks that may be especially beneficial for developing countries lacking traditional insurance markets. Despite significant growth in the volume of insurance securities, however, they remain a small percentage of the overall reinsurance market (roughly 5 percent). Still these markets hold promise, and there is considerable excitement in the industry about their potential (Elliott, 1998). Reinsurance companies have hired professionals experienced in weather trading markets to foster development of index-based insurance for managing highly correlated risks.

Two classes of equity instruments are currently being used to securitize insurance risk: exchange-traded indexes [e.g., the CAT contract on the Chicago Board of Trade (CBOT)] and risk-linked securities (e.g., Catastrophic or CAT bonds). Both instruments provide a mechanism of risk transfer from a primary insurer to a large group of investors/speculators. As such, they serve as another type of reinsurance. The actual arrangement for these equity instruments can take many forms. In some cases, they will look very similar to reinsurance and protect against excess monetary losses of the primary insurer. In other cases, they may simply be structured as an index product with an event-triggered risk (explained below). Beyond the security instruments that have emerged, event-triggered risks are being traded in other ways. The most significant event-triggered risk trades are in the new weather market where both temperature and rainfall are being traded.

Exchange-Traded Indexes

Exchange-traded indexes offer the opportunity to receive payments based on the occurrence of some event. Sandor, Berg, and Cole (1994) write about the attributes needed for successful futures and options contracts on indexes. Indexes should be standardized, verifiable, and well understood. When an index contract is properly constructed, it is largely free of moral hazard since an individual who uses the index contract should be unable to influence the outcome that determines payments from the contract. Monitoring needs are reduced as indemnity payments are solely based on the index, not upon what happens to the insured's individual losses. And while this may lower the price as it controls moral hazard and lowers transaction costs, it does mean that the insured faces a basis risk — they can have a loss even when the index does not trigger a payment.

The trade-off between increased basis risk and lower moral hazard is key for index contracts. This type of structure should encourage better management practices and risk mitigation measures. Since incentives are more properly ordered with an index contract, one can expect that there are opportunities for more price transparency and increased liquidity. Ultimately, secondary markets may also emerge where individuals who purchase index contracts to protect against their risk exposure can sell the contracts as conditions change and become more valuable to someone else who is at risk.

The Property Claim Services (PCS) CAT options that trade on the CBOT are the first exchange-traded indices. PCS is an industry authority that has provided estimates of catastrophic property damage since 1949. PCS provides the data needed to trade and settle PCS CAT options. There are nine indices (one national, five regional, and three state) that track the PCS estimates for insurance losses resulting from catastrophes in each defined region for a specified loss period. The loss period is the time during which the catastrophe must occur — the most common loss period is set for quarterly losses. Thus, purchasing a call option at some specified loss level will give a form of reinsurance when losses during a three-month period exceed the "strike" loss level. The options are European, meaning they can only be exercised at the end of the contract. Cummins and Geman (1995) develop the economics of how to use and price the CAT contracts.

In the spring of 1995, the CBOT introduced crop-yield insurance and futures options for corn. Sandor, Berg, and Cole (1994) were leaders in writing about what was needed and how such a contract might be designed. In the first year, there was considerable interest. Iowa corn was the most active contract as open interest exceeded 2,000 contracts. U.S. Department of Agriculture (USDA) estimates of harvested corn yield per acre provide the basis for the index. One advantage of these contracts is that they could be traded throughout the season. This offered opportunities to offset risk positions at any time. There are a number of reasons why crop-yield contracts have not been successful. Government subsidized reinsurance offered to crop insurance companies and constraints in the regulatory environment are likely major reasons.

The concept of area-yield contracts in the United States was introduced when USDA began a pilot program on area yields indexed at the county level in 1993. Numerous articles have been written about area-yield insurance (Skees, Black and Barnett, 1997; Mahul, 1999; Miranda, 1991).

Risk-Linked Securities

CAT bonds are the most common risk-linked securities, mainly used to provide reinsurance protection for primary insurers. CAT bonds, just like corporate bonds, are debt instruments providing capital contingent upon the occurrence of a specific event. Those seeking catastrophic coverage pay a premium based on the risk. The premiums generate the interest payments for the bond investors. In exchange for assuming the risk, those purchasing CAT bonds receive a relatively high rate of return if there are no catastrophes. However, they may lose some or all of their investment or earnings on their investment if a catastrophe does occur. Since catastrophes should be independent of the general economic trends, fund managers may use CAT bonds to diversify their portfolios with an equity instrument that has zero correlation to traditional equity markets.

CAT bonds can be written to replace insurance losses from a single event such as an earthquake or a hurricane or they can be written to cover risk of aggregate losses for a portfolio of risk. In both cases, the likely trigger would be some high level of loss thus making them work just like a stop loss in reinsurance or as a call option on losses beyond some level. An advantage CAT bonds offer over reinsurance is that CAT bonds eliminate

the default risk by holding capital in escrow throughout the term of the bond. With a traditional reinsurer, defaults are more likely because reinsurers do not have to guarantee their ability to pay future losses.

Numerous risk-modeling firms have emerged to model catastrophes and educate potential purchasers of catastrophic-linked securities. The more complex the risks, the higher the transaction costs associated with defining terms, modeling, and developing the unique characteristics needed to develop the contract. While most of the CAT bonds issued to date have transferred catastrophic risk to strengthen reinsurance capacity, there are many other potential uses. Any risks where a well-defined trigger can be identified could be packaged into a CAT bond. An easily defined trigger will reduce transaction costs since no one has to worry about moral hazard or how well the business at risk is underwriting their risks. In these cases, the parametric features (the full probability distribution function) can be estimated. Such contracts are known as parametric reinsurance. For example, at least two Richter scale CAT bonds have been developed in recent years. Payments are triggered by a certain value on the Richter scale at a certain location. Sophisticated models are designed to estimate the losses generated by incremental increases in the Richter scale measurements. These CAT bonds have been as large as $100 million. Agriculture has many risks that can be parameterized: weather risk, area crop yields, some environmental risks, and others. Any of these risks could be packaged into a CAT bond possibly with very low transaction costs.

Markets for Weather-Based Securities

Weather indexes began trading in 1996 as the U.S. power industry was deregulated. Some people lose and others win when certain weather events occur. When the same event has different impacts on different parties, a trade is possible. When the power industry was deregulated, revenues became more volatile. Extremely low and high temperatures create peak load problems for the electricity industry. By using index contracts that pay when the temperature is either too cold or too hot, the company can hedge against the added cost of buying power on the open market when demand is high. In some cases, power companies may also want to protect against normal temperatures since benign weather creates low demand.

As information systems improve and we learn more about the relationships between weather and crop yields and crop quality, it may soon be more useful to have a portfolio of weather contracts that meet particular needs. Farmers or agribusinesses may find that such contracts are more dynamic than traditional crop insurance. For example, different weather events will have varying influence depending on the cumulative weather events that create a unique growing season. If the crop starts slow due to a cold wet spring, the timing of the weather may influence yields differently than a season with a quick start. Further, new varieties may be expected to respond differently to weather events than old varieties. This knowledge may be used to tailor the rainfall contracts to the new varieties rather than using historic yield records. Improvements in information systems will continue. Credible and inexpensive ways of measuring weather events could make it more likely that market makers will be willing to write weather-base instruments that are linked to crop yields.

Reinsurance and Weather Markets

Much can be said about the international reinsurance community and their resistance to entering new and untested markets. The use of the capital markets for sharing "in-between" risks remains in the infant stages, leaving the issue of capacity and efficiency in doubt. This raises questions about the role of government in sharing such risk. For the United States, Lewis and Murdock (1996) recommend government catastrophic options that are auctioned to reinsurers. Part of the thinking is that the government has adequate capital to back stop such options and may be less likely to load these options as much as the reinsurance market. Skees and Barnett (1999) have also written about a role for government in offering insurance options for catastrophes as a means of getting affordable capital into the market. However, the demand for catastrophic insurance will be limited where free disaster assistance is available.

Reinsurers have now acquired many of the professionals who were trading weather. SwissRe acquired professionals from Enron and PartnerRe and ACE acquired professionals from Aquila. *Reinsurers are now in a position to offer reinsurance using weather-based indexes.* This type of reinsurance should be more affordable since it is not subject to the same adverse selection and moral hazard problems as traditional insurance.

Problems with Traditional Crop Insurance

When agricultural risks are discussed, many of those discussions gravitate to the need for insurance. The background for understanding why traditional approaches to agricultural insurance are problematic has been developed above. Two themes will be repeated in this section: 1) crop risks are correlated, and 2) hidden and asymmetric information problems create ample opportunity for abuse. These same information problems also exacerbate the dual problems of adverse selection and moral hazard.

Traditional crop insurance has been an expensive social experiment in developed countries where data is much better than in developing countries. Numerous scholars have repeatedly emphasized that traditional crop insurance is simply not workable in developing countries. This section is included to reemphasize that point so that practitioners in developing countries have a very solid understanding of the problems with traditional crop insurance. The proliferation of international consultants who are touting traditional crop insurance as a workable solution for developing countries should be of significant concern to the development community.

Successful insurance programs require that the insurer have adequate information about the nature of the risks being insured. This has proven to be extremely difficult for farm-level yield insurance. Farmers will always know more about their potential crop yields than any insurer. This asymmetric information is the major problem with insuring farm yields. If an insurer cannot properly classify risk, then it is impossible to provide sustainable insurance. Those who know that they have been favorably classified will buy the insurance; those who have not been favorably classified will not buy. This phenomenon, known as "adverse selection," initiates a cycle of losses (Goodwin and Smith, 1995; Ahsan, Ali, and Kurian, 1982; Skees and Reed, 1986; Quiggin, Karagiannis

and Stanton, 1993). The insurer will typically respond with "across the board" premium rate increases. But this only exacerbates the problem, as only the most risky individuals will continue to purchase the insurance. The problem can only be corrected if the insurer can acquire better information to properly classify and assign premium rates to potential insureds.

Insurers must also be able to monitor policyholder behavior. Moral hazard occurs when insured individuals change their behavior in a way that increases the potential likelihood or magnitude of a loss. In crop-yield insurance, moral hazard occurs when, as a result of having purchased insurance, farmers reduce fertilizer or pesticide use or simply become more lax in their management. At the extreme, moral hazard becomes fraud where policyholders actually attempt to create a loss. Again, the problem is asymmetric information. Unless the insurer can adequately monitor these changes in behavior and penalize policyholders accordingly, the resulting increase in losses will cause premium rates to increase to the point where it becomes too expensive for all but those engaged in these practices.

Insurers must also be able to identify the cause of loss and assess the magnitude of loss *without relying on information provided by the insured*. For automobile or fire insurance the insurer can generally identify whether or not a covered loss event has occurred and the magnitude of any resulting loss. For multiple-peril crop-yield insurance this is not always the case. It is not always easy to tell whether a loss occurred due to some covered natural loss event or due to poor management. Nor is it easy to measure the magnitude of loss without relying on yield information provided by the farmer.

Actuarial Performance of Crop Insurance Programs

Performance of publicly supported multiple-peril crop insurance has been poor when all costs are considered. If companies were private, the premiums collected would have to exceed the administrative cost and the indemnities paid out. Hazell (1992) quantifies the condition for sustainable insurance as follows:

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

where A = average administrative costs
I = average indemnities paid
P = average premiums paid

Given this ratio, Hazell finds that in every case the value exceeds 2 (Table 1). This means that government support is at least 50 percent. However, there are cases where farmers are clearly paying only pennies on the dollar of the real cost of the crop insurance program. A ratio of 4 means that the farmer pays 25 cents per 1 dollar of total costs. Skees (2001) reports a ratio of 4 for the current U.S. crop insurance program and Mishra reports that India's I/P ratio increased to 6.1 for the period 1985-94.

Table 1 has only one case where the loss ratio of indemnities over premiums approaches 1 — Japan. In this case, the administrative costs needed to achieve this lost ratio are quite

unbelievable — over 4 ½ times higher than the farmer premium. It seems a very high price to pay to obtain "actuarially sound" crop insurance.

Table 1: Financial Performance of Crop Insurance 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 1992

The other strategy in reaching the goal of an actuarially sound social crop insurance program is via premium subsidies. As subsidy rates have increased from 30 percent of premium to 59 percent in the United States, more farmers have purchased crop insurance. In 2002 as much as 80 percent of the eligible acreage for some crops is insured. These subsidies have masked the adverse selection and moral hazard problems by bringing the lower risk farmers into the pool of very high risk farmers. Once these lower risk farmers are in the risk pool, this can improve the actuarially performance, especially when the system is measuring the unsubsidized premium against the loss experience. Obviously this is an accounting ploy and reflects little about the true performance of the program. This is what the United States has done in recent years (Skees 2001).

In the processes of bringing in the lower risk farmers via higher subsidies, little has been done to improve the classification problems or to fix moral hazard. When subsidies are increased, those high risk farmers who have obtained the most benefit from crop insurance in the past obtain even more benefit. The distribution of benefits from subsidies is strongly skewed toward the abusive set of farmers.

Index Insurance Alternatives

There are lower cost approaches to providing crop insurance that also mitigate the traditional problems associated with multiple-peril crop insurance. Index-based insurance products are an alternative form of insurance that make payments based not on measures of farm yields, but rather on either area yields or some objective weather event such as temperature or rainfall. Index insurance products are also akin to the entire discussion above regarding innovations in global financial markets that promise to offer better pricing for sharing catastrophic risk.

In some situations, index insurance offers superior risk protection when compared to traditional multiple-peril crop insurance that pays indemnities based on individual farm

yields. This happens when the provider of traditional insurance must impose large deductibles. A deductible basically means that the insurance policy will not pay until the loss is very serious. Deductibles and co-payments (or partial payment for losses) are commonly used to combat adverse selection and moral hazard problems. Since these problems are not present with index insurance, there is less need for deductibles and co-payments.

Index insurance provides an effective policy alternative as it seeks to protect the agricultural production sector from widespread, positively correlated, crop-yield losses (e.g., drought). When index insurance is used to shift the risk of widespread crop losses to financial and reinsurance markets, the residual idiosyncratic risk often has characteristics that make it more likely that rural banks can work to smooth consumption shortfalls with loans.

Two types of index insurance products are considered; those that are based on area yields where the area is some unit of geographical aggregation larger than the farm, and those that are based on weather events. An area-based yield contract has been offered in the United States since 1993. This policy was developed by the author and is named the Group Risk Plan (GRP). There are numerous ways to calculate payments on index contracts (Skees, 2000). For the U.S. GRP program, indemnity is calculated as

$$Indemnity = \max\left(0,\ \frac{Index\ Trigger - Realized\ \ Index}{Index\ Trigger}\right) \times Liability$$

where the index is the yield for the county where the farm is located (Skees, Black and Barnett, 1997). The *Index Trigger* is the product of a coverage level selected by the policyholder and the official estimate of the expected county yield per acre. Coverage levels range from 70 to 90 percent in 5 percent increments.
Expected county yields are estimated using up to 45 years of historical county yield data. For GRP, liability is calculated as

$$Liability = Expected\ \ County\ Yield \times Indemnity\ \ Price \times Scale \times Farmer's\ Planted\ \ Acreage$$

where *Expected County Revenue per Acre* in the equation above is equal to the product of the official estimate of price and expected county yield per acre and *Scale* is chosen by the policyholder but is limited to between 90 and 150 percent.[5]

To be clear, an example of how the Group Risk Plan works is in order. Estimates of the county yield are made using forecasting procedures that account for trends in yields due to technology. If the corn yield forecast for the county yield is 100 bushels, the farmer can obtain a contract that will pay any time the actual estimate of the county yield is

[5] The limitations on both *Coverage* and *Scale* were politically dictated. In principle, there is no reason that these parameters would need to be limited with index contracts. Still it is common to set some limits on how much index insurance a farmer can purchase. Some estimates of value-at-risk may be used for this purpose. For the GRP program, the farmer must certify the planted acreage used to calculate liability.

below 90 bushels (the trigger= 90 bushels). Assume that the expected price on corn is $2.00 per bushel. The farmer can purchase a liability that is equal to 150 percent of the product of the expected county yield and the expected price, times their acres planted. The calculations for a farmer with 100 acres follow:

Liability = 100 x $2 x 1.5 x 100; or $30,000

If the farmer has a yield average that is above the county they have incentives to purchase the maximum protection or liability by using the maximum scale factor of 1.5. For a farmer who purchases a 90 percent coverage level, indemnity payments will be calculated by multiplying the percent shortfall in county yields times the $30,000 of liability. Thus, if the realized estimate of county yields for the year is 60 bushel (which is 1/3 below the 90 bushel trigger) the indemnity payment calculation is

Indemnity = (90 -60) / 90 * $30,000; or $10,000

Premium payments are based upon premium rates. Thus, if the rate is 5 percent for the 90 percent coverage level policy, the calculations for the premium would be

Premium = .05 x $30,000; or $1,500.

Of course, one could easily adapt this contract design to any number of other indexes such as aggregate rainfall measured over a stated period at a specific weather station or the number of days with temperatures above or below a specified level. The contract design used in GRP is sometimes called a “proportional contract” because the loss is measured as a percentage of the trigger. Proportional contracts contain an interesting feature called a “disappearing deductible.” As the realized index approaches zero, the indemnity approaches 100 percent of liability, regardless of the coverage chosen.

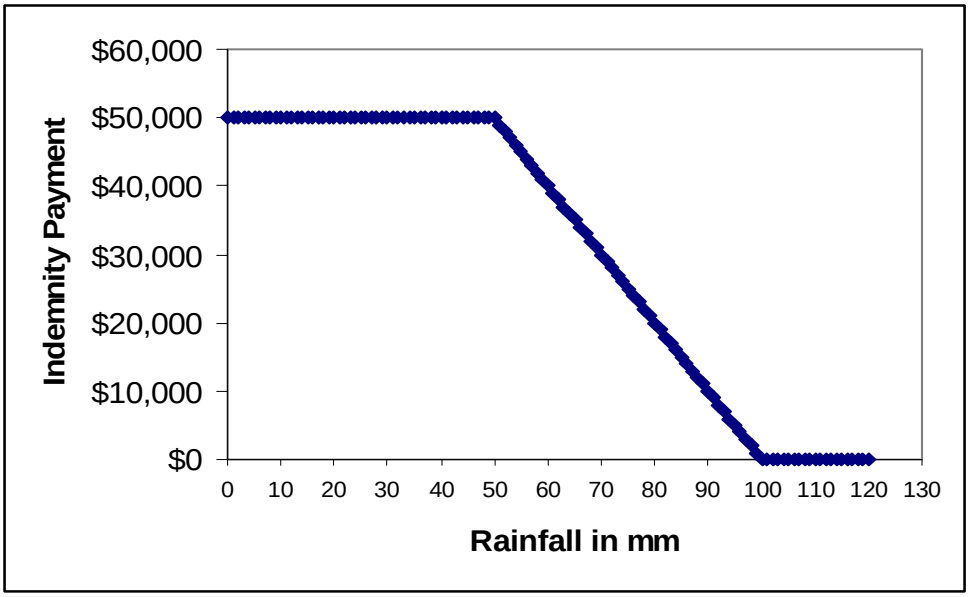
The weather markets developed contracts that look very much like what Martin et al. (2001) proposed. They use unique language that is very similar to that used in futures markets. For example, rather than referring to the threshold where payments will begin as a ”trigger,” they refer to it as the ”strike.” In an attempt to make things more straightforward, they also pay in increments or what they call ”ticks.” Consider a situation where a contract is being written to protect against shortfall in rain. The writer of that contract may choose to make a fixed payment for every 1 mm of rainfall below the *strike/trigger*. If an individual or a RFE purchase a contract where the *strike/trigger* is 100 mm of rain and the *limit* is 50 mm, the amount of payment for each *tick* would be a function of how much liability was purchased. There are 50 ticks between the 100 mm and the *limit* of 50 mm. Thus, if $50,000 of insurance were purchased, the payment for each 1 mm below 100 mm would be equal to

$50,000/(100-50) or $1,000

Once the tick and the payment for each tick are known, the indemnity payments are easy to calculate. For example, if the rainfall is measured at 90 mm, there are 10 ticks of

payment at $1,000 each; the indemnity payment will equal $10,000. Figure 1 maps the payout structure for a hypothetical $50,000 rainfall contract with a strike of 100 mm and a limit of 50 mm.

Figure 1: Payout structure for a hypothetical rainfall contract



Experiences in Index Insurance

Various area-yield insurance products have been offered in Quebec, Canada, Sweden, India, and, since 1993, in the United States (Miranda, 1991; Mishra, 1997; Skees, Black, and Barnett, 1997). Ontario, Canada currently offers an index insurance instrument based on rainfall. The Canadians are also experimenting with other index insurance plans. Alberta corn growers can use a temperature-based index to insure against yield losses in corn. Alberta is also using an index, based on satellite imagery to insure against pasture losses. Mexico is the first non-developed country to enter into a reinsurance arrangement that was based on weather derivatives.

In the United States, participation in the area-yield based Group Risk Plan has been relatively low. Nonetheless, in 2002, over 12 million acres were insured under GRP or the GRIP (Group Revenue Insurance Program). Participation is strongest is some markets where sales agents have focused on GRP. The loss experience (indemnities divided by premiums) since the introduction of GRP has been good, around 90 percent.

The Ontario rainfall insurance product was fully subscribed in the first year that it was introduced (2000). However, this is a limited pilot test of only 150 farmers and the product was introduced following a major drought. By 2001, 235 farmers had purchased

about $5.5 million in liability with payments of $1.9 million.[6] This policy was targeted toward alfalfa hay production. Alberta has also introduced a rainfall index insurance product for forage production. This contract has been available for two years. In 2002, over 4000 ranchers subscribed to the contract.

For many emerging economies or developing countries, weather index insurance merits consideration (Hazell, 1992; Skees, Hazell, and Miranda, 1999). While basis risk may generally be lower with area-yield index insurance, there are several reasons why weather index insurance may be preferable in a developing or emerging economy. First, the quality of historical weather data is generally much better than the quality of yield data in developing countries. Quality data are essential in pricing an insurance contract. Second, it may be less costly to set up a system to measure weather events for specific locations than to develop a reliable yield estimation procedure for small geographical areas. Finally, either insufficient or excess rainfall is a major source of risk for crop losses in many regions. Drought causes low yields and excess rainfall can cause either low yields or serious losses of yield and quality during harvest (Martin, Barnett, and Coble, 2001).

The World Bank Group is pursuing the feasibility of rainfall index insurance in a number of countries. The International Finance Corporation (IFC) of the World Bank is interested in supporting these innovations so that developing countries can participate in emerging weather markets. The feasibility of weather-based index insurance is being considered for a number of countries, including Nicaragua, Morocco, Ethiopia, Tunisia, Mexico, and Argentina.

A major challenge in designing an index insurance product is minimizing basis risk. The phrase “basis risk” is most commonly heard in reference to commodity futures markets. In that context, “basis” is the difference between the futures market price for the commodity and the cash market price in a given location. Basis risk also occurs in insurance. It occurs when an insured has a loss and does not receive an insurance payment sufficient to cover the loss (minus any deductible). It also occurs when an insured has a loss and receives a payment that exceeds the amount of loss.

Since index insurance indemnities are triggered by area-yield shortfalls or weather events, an index insurance policyholder can experience a yield loss and not receive an indemnity. The policyholder may also not experience a farm-yield loss and yet, receive an indemnity. *The effectiveness of index insurance as a risk management tool depends on how positively correlated farm-yield losses are with the underlying area yield or weather index.* In general, the more homogeneous the area, the lower the basis risk and the more effective area-yield insurance will be as a farm-yield risk management tool. Similarly, the more a given weather index actually represents weather events on the farm, the more effective the index will be as farm-yield risk management tool.

While most of the academic literature has focused on basis risk for index type insurance products, it is important to recognize that farm-level multiple-peril crop insurance has

[6] Personal email communication with Mr. Paul Cudmore of Agricorp, Canada, October 23, 2001.

basis risk as well. To begin, a very small sample size is used to develop estimates of the central tendency in yields. Given simple statistics about the error of the estimates with small samples, it can be easily demonstrated that large mistakes are made on estimating central tendency. This makes it possible for farmers to receive insurance payments when yield losses have not occurred. It is also possible for farmers to not receive payments when payable losses have occurred. Thus, basis risk occurs not only in index insurance but also in farm-level yield insurance.

Another type of basis risk results from the estimate of realized yield. Even with careful farm-level loss adjustment procedures, it is impossible to avoid errors in estimating the true realized yield. These errors can also result in under- and over-payments. Between the two sources of error, measuring expected yields and measuring realized yields, farm-level crop insurance programs also have significant basis risk.

Longer series of data are generally available for area yields or weather events than for farm yields. The standard deviation of area yields is also lower than that of farm yields. Since the number of observations (n) is higher and σ (the standard deviation) is lower, the square root of n rule suggests that there will be less measurement error for area-yield insurance than for farm-yield insurance in estimating both the central tendency and the realization. In most developing countries, long series of weather data are available.

Summary of Relative Advantages and Disadvantages of Index Insurance

Index contracts offer numerous advantages over more traditional forms of farm-level multiple-peril crop insurance. These advantages include

1. *No moral hazard:* Moral hazard arises with traditional insurance when insured parties can alter their behavior so as to increase the potential likelihood or magnitude of a loss. This is not possible with index insurance because the indemnity does not depend on the individual producer's realized yield.
2. *No adverse selection:* Adverse selection is a misclassification problem caused by asymmetric information. If the potential insured has better information than the insurer about the potential likelihood or magnitude of a loss, the potential insured can use that information to self-select whether or not to purchase insurance. Index insurance on the other hand is based on widely available information, so there are no informational asymmetries to be exploited.
3. *Low administrative costs:* Unlike farm-level multiple-peril crop insurance policies, index insurance products do not require underwriting and inspections of individual farms. Indemnities are paid solely on the realized value of the underlying index as measured by government agencies or other third parties.
4. *Standardized and transparent structure:* Index insurance policies can be sold in various denominations as simple certificates with a structure that is uniform across underlying indexes. The terms of the contracts would therefore be relatively easy for purchasers to understand.
5. *Availability and negotiability:* Since they are standardized and transparent, index insurance policies can easily be traded in secondary markets. Such markets would create liquidity and allow policies to flow where they are most highly valued.

Individuals could buy or sell policies as the realization of the underlying index begins to unfold. Moreover, the contracts could be made available to a wide variety of parties, including farmers, agricultural lenders, traders, processors, input suppliers, shopkeepers, consumers, and agricultural workers.

6. *Reinsurance function:* Index insurance can be used to transfer the risk of widespread correlated agricultural production losses. Thus, it can be used as a mechanism to reinsure insurance company portfolios of farm-level insurance policies. Index insurance instruments allow farm-level insurers to transfer their exposure to undiversifiable correlated loss risk while retaining the residual risk that is idiosyncratic and diversifiable (Black, Barnett, and Hu, 1999).

There are also challenges that must be addressed if index insurance markets are to be successful.

1. *Basis Risk:* The occurrence of basis risk depends on the extent to which the insured's losses are positively correlated with the index. Without sufficient correlation, "basis risk" becomes too severe, and index insurance is not an effective risk management tool. Careful design of index insurance policy parameters (coverage period, trigger, measurement site, etc.) can help reduce basis risk. Selling the index insurance to microfinance or other collective groups can also pass the issue of basis risk to a local group that can develop mutual insurance at some level. Such a group is in the best position to know their neighbors and determine how to allocate index insurance payments within the group.
2. *Security and dissemination of measurements:* The viability of index insurance depends critically on the underlying index being objectively and accurately measured. The index measurements must then be made widely available in a timely manner. Whether provided by governments or other third party sources, index measurements must be widely disseminated and secure from tampering.
3. *Precise actuarial modeling:* Insurers will not sell index insurance products unless they can understand the statistical properties of the underlying index. This requires both sufficient historical data on the index and actuarial models that use these data to predict the likelihood of various index measures.
4. *Education:* Index insurance policies are typically much simpler than traditional farm-level insurance policies. However, since the policies are significantly different than traditional insurance policies, some education is generally required to help potential users assess whether or not index insurance instruments can provide them with effective risk management. Insurers and/or government agencies can help by providing training strategies and materials not only for farmers, but also for other potential users such as bankers and agribusinesses.
5. *Marketing:* A marketing plan must be developed that addresses how, when, and where index insurance policies are to be sold. Also, the government and other involved institutions must consider whether to allow secondary markets in index insurance instruments and, if so, how to facilitate and regulate those markets.
6. *Reinsurance:* In most transition economies, insurance companies do not have the financial resources to offer index insurance without adequate and affordable reinsurance. Effective arrangements must therefore be forged between local insurers,

international reinsurers, national governments, and possibly international development organizations.

Index insurance is a different approach to insuring crop yields. Unlike most insurance where independent risk is a precondition, the precondition for index insurance to work best for the individual farmer is correlated risk. It is possible to offer index contracts to anyone at risk when there is an areawide (correlated) crop failure. Furthermore, unlike traditional insurance, there is no reason to place the same limits on the amount of liability an individual purchases.

As long as the individual farmer cannot influence the outcome that results in payments, then placing limits on liability is not necessary as it is with individual insurance contracts. Finally, the true advantage of blending index insurance into banking is that the banking entity can use such contracts to manage correlated risk. In turn, the bank should be able to work with the individual to help them manage the residual risk or basis risk. In simple terms, if the individual has an independent loss when the index insurance does not pay, they should be able to borrow from the bank to smooth that shock. This could effectively remove the primary concern associated with index insurance contracts — that someone can have a loss and not be paid.

As more sophisticated systems are developed to measure events that cause widespread problems (such as satellite imagery) it is possible that indexing major events will be more straightforward and accepted by international capital markets. Under these conditions, it may become possible to offer insurance to countries where traditional reinsurers and primary providers would previously have never considered. Insurance is about trust. If the system to index a major event is reliable and trustworthy, there are truly new opportunities in the world to offer a wide array of index insurance products.

The Role of Technology in Providing Needed Information

In recent years, state-of-the-art methods to forecast food shortages created by bad weather have significantly improved. For example, the East African Livestock Early Warning System (LEWS) is now able to provide reliable estimates of the deviation below normal up to 90 days prior to serious problems. These systems use a variety of information: 1) satellite images; 2) weather data from traditional ground instruments; 3) weather data from new systems, and 4) sampling from grasslands to determine nutrient content. More importantly, these systems allow problems to be forecast at a local level using geographic information systems. Since many of the early warning systems have now been in place for as long as twenty years, it is now possible to model the risk and begin pricing insurance contracts that match the risk profile.

Country Case Examples for Using Index Insurance

Mexico: Use of Weather Index Insurance for Mutual Insurance, Reinsurance, and to Facilitate Water Markets

Mexico has experience with using weather indexes to reinsure their crop insurance. Developments within the weather markets prompted new thinking about sharing

catastrophic risk in agriculture. In 2001, the Mexican agricultural insurance program (Agroasemex) used the weather markets to reinsure part of their multiple crop insurance programs. By using weather indexes that were based on temperature and rainfall in the major production regions, a weather index was created that was highly correlated with the Mexican crop insurance loss experience. This method of reinsurance proved to be more efficient than traditional reinsurance.

The Mexican contract is an important development for many of the ideas presented in this paper. But beyond the use of weather indexes for reinsurance, Agroasemex also has begun working with *Fondos*, mutual insurance funds whose members are commercially oriented small farmers, to implement programs whereby they would purchase weather index insurance and then decide what type of mutual insurance to provide their members. These efforts remain in the early development stages.

Agroasemex researchers are also pursing the idea of using index insurance as a means of providing important linkages to the emerging water markets in Mexico. Under such a plan, the water irrigation authority would offer a certain amount of water or indemnity payments in years when water availability restricted how much irrigation water could be delivered. In principle, such an offering should improve the efficiency of water markets and provide improved incentives to irrigation authorities to manage water in such a fashion that they are making commitments to users (Skees and Zeuli, 1999).

Mongolia — Using Livestock Mortality Rates as Index Insurance to Cover Deaths of Large Numbers of Animals in Mongolia

Herders in Mongolia have suffered tremendous losses in recent *dzud* (major event, ex. winter disasters) with mortality rates of over 50 percent of the livestock in some locales. Recent work by the World Bank has focused on the feasibility of offering insurance to compensate for animal deaths. Such an undertaking is challenging in any country. Mongolia offers even more challenges given the vast territory in which herders tend over 30 million animals. Traditional insurance approaches that insure individual animals are simply not workable. The ability to understand even the simplest issue of who owns specific livestock would require very high transaction costs. The opportunities for fraud and abuse are significant. Monitoring costs required to mitigate this behavior would be very high.

Work is moving ahead for using the livestock mortality rate at a local level (e.g. the *sum* or rural district) as the basis for indemnifying herders. No country has so far implemented such insurance for livestock deaths. But few countries have such frequent and high rates of localized animal deaths as does Mongolia, and Mongolia is one of the few countries to perform an animal census every year. This concept may therefore be precisely what is needed to start a social livestock insurance program.

The mortality index insurance would pay anytime the mortality rate (adult livestock deaths divided by the total census number of livestock in the area at the beginning of the year) exceeds a well-specified threshold. The payment would be a function of the mortality rate times the amount of protection (or liability) purchased by the herder. To

illustrate how such insurance might be implemented Skees and Enkh-Amgalan (2002) developed a prototype insurance contract that is reproduced below.

> *DRAFT LANGUAGE FOR ILLUSTATION ONLY*
> *MONGOLIAN LIVESTOCK INSURANCE*
>
> *This insurance is solely based on the official sum statistics on adult livestock losses for cattle and yak in sum Saintsagaan in aimag Dundgobi.[7] The insurance will pay you when the mortality rate (the ratio of adult losses during the year 2002 divided by the total herd population at the beginning of the year) exceeds a value of 6.5%. To be eligible, you must register for this insurance by May 1. Registration involves a statement of intent to purchase, and a reporting of your animal numbers by species at that time.*
>
> *Value of Insurance*
> *While we believe the average value of cattle and yak to be about Tg 100,000, you may purchase any value of insurance between Tg 20,000 and Tg 200,000 per animal reported.*
>
> *Paying Premium*
> *You will pay a premium rate of 4% times the value of insurance you chose. The premium payment is due on January 1. Should no payment be received by that time, we will cancel this insurance policy.*
>
> *Paying for losses:*
> *If the mortality rate for the sum of Saintsagaan in aimag Dundgobi exceeds 6.5%, we will pay you the product of the mortality rate times the value of insurance you have chosen. For example, if you purchased Tg 10,000,000 and the mortality rate was 10%, you would receive a payment of Tg 1,000,000. While this insurance should provide compensation under most circumstances when you have large losses of animals, please understand that you may have livestock losses when the sum mortality rate does not trigger a payment.*

Data for a limited number of sum in nearly every aimag were available from 1969-2000. These data afforded the opportunity to perform an assessment of the risk associated with offering a mortality index insurance program across Mongolia. While anyone who knows the recent history of losses understands that a very high level of covariate risk is present, these data show that serious losses occur in livestock in about 1 in 5 years. This is the frequency of loss ratios (indemnity divided by pure premium) in excess of 200 percent in the simulated mortality index insurance program that would be spread across Mongolia. And while 2000 is the worst year in the 30 years of data, 1969 is nearly as bad. Historical records also suggest that 1944 was more serious with mortality rates in excess of 30

[7] A Sum is the local county and an Aimag is the state or provincial government.

percent. These losses would make a mortality index insurance program costly and require some risk sharing in the international capital markets. The report provides ideas about how this might occur with both traditional reinsurance and the emerging weather markets.

There are a number of reasons why livestock mortality insurance is being pursued in Mongolia under the Livelihoods Sustainability Project: 1) it is simple; 2) it is largely free of the common problems of adverse selection and moral hazard; 3) it is easy to administer with low administrative cost, and 4) it is largely effective for getting ready cash to herders in a region during a *dzud*. However, the most fundamental reason why this concept is being pursued is the strong desire that whatever is offered must not interfere with the exceptional efforts that experienced herders take to save animals during severe weather. Using individual insurance would likely diminish these efforts. Herders would likely ask; "Why should I work so hard to save my animals if I will simply be compensated for those that are lost?" Since the index insurance would pay all herders in the same region at the same rate, the incentives for management to mitigate livestock losses remain strong. No one would reduce their effort to collect on insurance. Those who increase their efforts during a *dzud* would likely be compensated for this effort even though they do not lose livestock. In some cases, they could reasonably expect to receive payments that would compensate for the added effort or the added cost of trying to save their livestock.

Uganda —Rural Bank Use of Weather Index Insurance for Bank Customers

Mosley describes a form of index-based insurance available in six provinces in Uganda through the Centenary Rural Development Bank (CERUDEB). CERUDEB offers weather insurance to bank customers to hedge against correlated risks from natural disasters. This system eliminates moral hazard by insuring against a single verifiable weather event. Additionally, this program encourages risk mitigation by requiring a deductible based on the amount of expected income loss. Structuring insurance in this manner reduces administrative costs so premiums are kept low, at 6 percent. The spatial distribution of the provinces has ensured that weather events between provinces are not correlated; that is, there is never a triggering drought in all provinces simultaneously.

India —A Case of Microfinance Insurance (BASIX)

Mosley also describes an alternative form of insurance in India that has been offered through an NGO microfinance organization (BASIX). The BASIX program operates similarly to a cooperative and relies on peer monitoring to reduce incidences of moral hazard and adverse selection. Village committees perform individual loss adjustments. Because payments are based on individual losses, premium rates are higher than the Ugandan CERUDEB program, at 20 percent. Half of the premium is deposited into the village fund, a quarter goes to BASIX, and the remainder goes towards the inter-village fund that provides indemnity payments.

Kenya — The Potential for Using Coffee Futures Markets for Price Risk Management[8]

Like a number of developing countries, Kenya has worked to deregulate prices of international traded commodities. In the Kenyan coffee sector, this has imposed significant hardships coffee price declined and the within season volatility of coffee prices increased significantly within the country. To be clear, no futures market could have protected against the price declines. However, the data suggest that there is some potential to use the international futures markets for coffee to hedge prices in Kenya.

Coffee production in Kenya is dominated by small holders; 65 percent of the coffee is produced by roughly 500,000 small holders. A network of about 200 cooperative societies processes all coffee from small producers and delivers it to the auctions market. Coffee estates process and deliver their own produce to the same auctions market. Nonetheless, the small holders bear both yield and price risk from growing coffee.

Coffee prices received by growers in Kenya are strongly correlated with futures prices at the New York Board of Trade (NYBOT). In unpublished work, Miriti found the following relationship:

$$LNKP = -.47 + 0.622D + .97*NYBOT$$
$$\text{Std error}=(.06) \qquad (.08) \quad \text{and } R^2 = 0.74$$

Where

LNKP = the natural log of prices received by Kenyan farmers (International Coffee Organization (Monthly data, 1982 – 2001)

D = a dummy where D=1 since post market liberalization since 1993.

NYBOT = the natural log of the nearest NYBOT futures price

Since the regression is fit using natural logs, the coefficient of .97 on the futures price suggest that there is nearly a one to one correspondence between movement in Kenyan domestic prices and the NYBOT futures prices. Thus, the opportunity exists for farmer cooperatives to hedge their prices. Such arrangements are being facilitated by the World Bank in Nicaragua, Uganda, and Tanzania. The Bank has used intermediaries who have used futures contracts to hedge their risk and, in turn, have offered local groups what is effectively a form of price insurance.

Recommendations for Blending Index Insurance and Rural Finance

Progress has been made in designing and offering index insurance contracts for a variety of correlated risk in developing countries. The motivation for using index insurance contracts rather than individual indemnity has been developed. Index insurance can shift correlated risk out of small countries into the global market. To the extent that the index

[8] This contribution was made in unpublished work performed in Spring 2003, by Mr. Kimathi Miriti a Ph.D. candidate at the University of Kentucky.

is based upon a secure and objective measure of risk, this approach provides an important risk shifting innovation for developing countries where the legal structure for more sophisticated insurance products is commonly woefully inadequate. Index insurance contracts involve significantly lower transaction costs and can be offered directly to end users from companies that operate in a global market, particularly if the end user is positioned to aggregate large amounts of risk (e.g., RFEs).

It is possible that offering index insurance directly to the RFE can circumvent bad government, poor macroeconomic policies, and inadequate legal frameworks. To the extent that the writer of the index insurance is a reputable global partner, the RFE could pay premiums in dollars and be paid indemnities in dollars as well. This would mitigate inflation risk within the country. The legal framework that is needed to allow RFEs to purchase these contracts from a global writer should be much more straightforward than the legal framework needed to offer traditional insurance. The major challenge within the developing country will be in knowing that the global partner has the reputation and the resources to pay indemnities. Should the International Finance Corporation of the World Bank Group become more involved in partnering on writing index insurance contracts for price, yield, weather, and livestock, many of these concerns could be eased.

The issue of basis risk has been of some concern if one is selling index insurance contracts to individuals. However, if these contracts are sold to RFEs, the RFE should be in a position to mitigate basis risk in a number of creative ways. It is useful to illustrate some potential arrangements that could emerge between global sellers of index insurance contracts and rural finance entities. Consider a microfinance group or a small rural finance entity (RFE) with members having household activities in the same neighborhood. While this group of individuals may use many informal mechanisms to pool risk and assist individuals when bad fortune visits one of their members, they are unable to cope with a major event such as drought that adversely impacts all members at the same time.

If the group could purchase an index insurance contract that would simply make payments based upon the level of rainfall (an excellent proxy for drought), the group would be in a much better position to cope when everyone suffers a loss at the same time. The RFE would need to develop *ex ante* rules regarding how indemnity payments from index insurance would be used. Three examples of how those *ex ante* rules may be developed are presented for illustration.

Indemnity Payments Could be Used to Forgive Debt

Since making loans is a major activity of most RFEs, the ability to repay the loans will likely be in jeopardy when there is an event that adversely impacts everyone. Having loan defaults from a large number of borrowers at the same time is likely to put the RFE at some risk. Thus, indemnity payments from index insurance can be used to offset defaults that occur due to natural disaster. Effectively, indemnity payments become a form of credit default insurance. The RFE would still need to implement rules regarding debt forgiveness for individuals.

Indemnity Payments Could be Used to Facilitate a Form of Mutual Insurance

The indemnity payment from index insurance could be directly distributed to members of the RFE via insurance-like rules that are determined by the members. Given that only actual indemnity payments received would be distributed, a common problem among mutual insurance providers in developing countries would be avoided — inadequate cash to pay for indemnities that are specified in insurance contracts (McCord, 2003). To the extent that the RFE is relatively small and members know one another, the asymmetric information problems discussed earlier would be avoided. This, of course, is the advantage of mutual insurance.

Indemnity Payments Could be Used to Facilitate Better Terms of Credit

Since lending is an excellent means of smoothing consumption when there are unexpected cash flow problems, the RFE could tie the index insurance directly into the loan arrangements. Loans that are made immediately following a good season where no indemnity payments are made could be higher than normal to collect premiums that would pay for the index insurance. Interest rates could be lowered using indemnity payments directly, immediately after a major event. Interest rate reductions could be tied directly to the severity of the event. (Parchure, 2002).

Challenges and the Road Ahead: Who Will Pay?

While there are many challenges to making some of the ideas presented here work, possibly the most significant among them involves paying for insurance. This is especially true if one expects the rural poor to pay. Premiums for some natural disaster risk could be quite expensive. Goes and Skees (2003) have been working with the concept of persuading those who give to victims of natural disasters *ex post,* that *ex ante* giving might be more effective. In fact, there are potentially some financial advantages to individuals to provide *ex ante* donations. NGOs and charities of all types have been quick to respond when a natural disaster such as a major drought or the Mongolia *dzud* victimizes the rural poor. Dumping in supplies or even large sums of money after the event is highly inefficient and many questions can be raised about who obtains the benefits.

To the extent that a credible risk consortium could be developed to write index-based insurance contracts for a wide array of disaster risk, NGOs and charities may be better served by purchasing these contracts. This would give them the needed resources for quick response. Further, they would have more influence in working with local groups regarding *ex ante* rules about how to spend the money. Given that a number of groups are involved in financially supporting microfinance, these same groups could also co-pay premiums when they are convinced that a local rural finance entity has a true need for the type of index insurance contracts that have been presented in this paper. Such undertakings could motivate many of the *ex ante* approaches presented. The RFE would know what they are going to do with indemnity payments to facilitate improved management of correlated risk; someday making the challenge of coping with correlated risk at the local level much less formidable.

REFERENCES

Ahsan, S. M., A. Ali, and N. Kurian. 1982. "Toward a Theory of Agricultural Insurance." *American Journal of Agricultural Economics* 64: 520-529.

Anderson, D. R. 1976. "All Risks Rating Within a Catastrophe Insurance System." *Journal of Risk and Insurance* 43: 629-651.

Binswanger, H. P. 1980. "Attitudes toward Risk: Experimental Measurement in Rural India." *American Journal of Agricultural Economics* 62(3): 395 407.

Binswanger, H. P., and J. McIntire. 1987. Behavioral and material determinants of production relations in land-abundant tropical agriculture. Economic Development and Cultural Change 36(1): 73-99.

Black, J. R., B. J. Barnett, and Y. Hu. 1999. "Cooperatives and Capital Markets: The Case of Minnesota-Dakota Sugar Cooperatives." *American Journal of Agricultural Economics* 81: 1240-1246.

Bouriaux, S. and M. Himick. 1998. Exchange-Traded Insurance Derivatives: Catastrophe Options and Swaps. In M. Himick (Editor), *Securitized Insurance Risk.* The Glenlake Publishing Company. Ltd.

Bromley, D. A. and J. P. Chavas. 1989. "On Risk, Transactions, and Economic Development in the Semiarid Tropics." *Economic Development and Cultural Change* 3(4): 719 – 736.

Brown, W., C. Green, and G. Lindquist. December, 2000. "A Cautionary Note for Microfinance Institutions and Donors Considering Developing Microinsurance Products." USAID Microenterprise Best Management Practices Project.

Camerer, C. F. and H. Kunreuther. 1989. "Decision Processes for Low Probability Events: Policy Implications." *Journal of Policy Analysis and Management* 8: 565-592.

Cashdan, E. 1985. "Coping With Risk: Reciprocity among the Basarwa of Northern Botswana." *Man* 20: 454 – 474.

Cole, J. B. and A. Chiarenza. 1999. "Convergence in the Markets for Insurance Risk and Capital." *Risk Magazine*.

Cummins, J. D. and H. Geman. 1995. "Pricing Catastrophe Insurance Futures and Call Spreads: An Arbitrage Approach." *The Journal of Fixed Income.* March: 46-57.

Dacy, D.C. and H. Kunreuther. 1969. *The Economics of Natural Disasters: Implications for Federal Policy.* New York: The Free Press.

Debraj Ray. 1998. Development Economics, Princeton University Press. Princeton, New Jersey.

Dercon, S. 2002. "Income Risk, Coping Strategies, and Safety Nets." Discussion Paper No.2002/22. World Institute for Development Economics Research, United Nations University.

Doherty, N. A. 2000. *Integrated Risk Management: Techniques and Strategies for Reducing Risk.* McGraw-Hill.

———. August 1997. "Financial Innovation in the Management of Catastrophe Risk." Fifth Alexander Howden Conference on Disaster Insurance, Gold Coast, Australia.

Elliott, M. W. 1998. "Insurance Securitization — An Educator's Perspective." Presentation at the Employers Reinsurance Corporation Seminar Six Series '98, November 17, Toronto, Ontario, Canada.

Ellis, F. 1998. "Household Strategies and Rural Livelihood Diversification." *The Journal of Development Studies* 35.

Fafchamps, M. 1992. "Solidarity Network in Pre-Industrial Societies: Rational Peasants with a Moral Economy" *Economic Development and Cultural Change* October 41(1): 147-175.

Fleisig, H. W. 2003. "Legal and Regulatory Requirements for Effective Rural Financial Markets." Theme Paper for USAID International Conference on Best Management Practices in Rural Finance, June 2-5, Washington, DC.

Freeman, P. K. and H. Kunreuther. 1997. *Managing Environmental Risk Through Insurance*. Boston: Kluwer Academic Press.

Froot K. A. (Ed.). 1999. *The Financing of Catastrophic Risk.* Chicago and London: The University of Chicago Press.

Goes, A. and J. R. Skees. 2003. "Financing Natural Disaster Risk Using Charity Contributions and *Ex Ante* Index Insurance." Presented Paper for the American Agricultural Economics Association Annual Meetings, July 27-30, Montreal, Canada.

Gonzalez-Vega, C. 2003. "Deepening Rural Financial Markets: Macroeconomic, Policy and Political Dimensions." Theme Paper for USAID International Conference on Best Management Practices in Rural Finance, June 2-5, Washington DC.

Goodwin, B. K. and V. H. Smith. 1995. *The Economics of Crop Insurance and Disaster Aid*. Washington, D.C.: The AEI Press.

Hazell, P. B. R. 1992. "The Appropriate Role of Agricultural Insurance in Developing Countries." *Journal of International Development* 4: 567-581.

Hazell, P. B. R., C. Pomareda, and A. Valdes. 1986. *Crop Insurance for Agricultural Development: Issues and Experience.* Baltimore: The John Hopkins University Press.

Hogarth, R. M. and H. Kunreuther. 1989. "Risk, Ambiguity, and Insurance." *Journal of Risk and Uncertainty* 2: 5-35.

Jaffee, D. M. and T. Russell. 1997. "Catastrophe Insurance, Capital Markets, and Uninsurable Risks." *Journal of Risk and Insurance 64*: 205-230.

Kaplow, L. 1991. "Incentives and Government Relief for Risk." *Journal of Risk and Uncertainty* 4: 167-175.

Kunreuther, H. 1996. "Mitigating Disaster Losses through Insurance." *Journal of Risk and Uncertainty* 12: 171-187.

———. 1993. "Combining Insurance with Hazard Mitigation to Reduce Disaster Losses." *Natural Hazards Observer* 17: 1-3.

———. 1976. "Limited Knowledge and Insurance Protection." *Public Policy* 24: 227-261.

———. 1973. *Recovery From Natural Disasters: Insurance or Federal Aid?* Washington, DC: American Enterprise Institute for Public Policy Research.

Lamm, R. M. Jr. 1997. "The Catastrophe Reinsurance Market: Gyrations and Innovations amid Major Structural Transformation." Bankers Trust Research, Bankers Trust Company, New York, NY. February 3, pp 1-13.

Leuthold, R. M., J. C. Junkus, and J. E. Cordier. 2000. *The Theory and Practice of Futures Markets.* Stipes Publishing L.L.C. Champaign, IL.

Lewis, C. M. and K. C. Murdock. 1996. "The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters." *Journal of Risk and Insurance* 63: 567-597.

Mahul, O. 1999. "Optimum Area Yield Crop Insurance." *American Journal of Agricultural Economics* 81: 75-82.

Mahul, O. 2002. "Coping with Catastrophic Risk: The Role of (Non-) Participating Contracts." Working paper.

Martin, S. W., B. J. Barnett and K. H. Coble. 2001. "Developing and Pricing Precipitation Insurance." *Journal of Agricultural and Resource Economics* 26(1): 261-274.

McCord, M. J. January 2003. "The Lure of Microinsurance: Why MFI's Should Work with Insurers." Microinsurance Centre Briefing Note #1.

Miranda, M. J. 1991. "Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 73: 233-42.

Mishra, P. K. 1996. *Agricultural Risk, Insurance and Income: A Study of the Impact and Design of India's Comprehensive Crop Insurance Scheme.* Brookfield: Avebury Press.

Mosley, P. and R. Krishnamurthy: 1995. "Can Crop Insurance Work? The Case of India." *Journal of Development Studies* 31: 428-50.

Parchure, R. 2002. "Varsha Bonds and Options: Capital Market Solutions for Crop Insurance Problems." National Insurance Academy Working Paper Balewadi, India. http://www.utiicm.com/rajaskparchure.html.

Quiggin, J., G. Karagiannis, and J. Stanton. 1993. "Crop Insurance and Crop Production: An Empirical Study of Moral Hazard and Adverse Selection." *American Journal of Agricultural Economics* 73: 695-713.

Rettger, M.J. and R.N. Boisvert. 1979. "Flood Insurance or Disaster Loans: An Economic Evaluation." *American Journal of Agricultural Economics* 61: 496-505.

Rosenzweig, M. R. and H. P. Binswanger. 1993. "Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments." *The Economic Journal* January (103): 56 - 78.

Rosenzweig, M.R. and K. Wolpin. 1993. "Credit Market Constraints and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks." *Journal of Political Economy*.

Sandor, R. L., A. Berg, and J. B. Cole. August 1994. "Crop Yield Futures and Options Contracts: A Proposal for Market Architecture." Paper presented at the American Agricultural Economics Association Preconference, San Diego, CA.

Siamwalla, A. and A. Valdes. 1986. "Should Crop Insurance be Subsidized?" In *Crop Insurance for Agricultural Development: Issues and Experience*, P. Hazell, C. Pomareda, and A. Valdes (eds.) Johns Hopkins University Press, Baltimore.

Skees, J. R. 2001a. "The Potential Role of Weather Markets for U.S. Agriculture." *The Climate Report* Vol. 2, No 4.

———. 2001b. "The Bad Harvest: More Crop Insurance Reform: A Good Idea Gone Awry." *Regulation: The CATO Review of Business and Government* 1st Quarter 24: 16-21.

———. 2000. "A Role for Capital Markets in Natural Disasters: A Piece of the Food Security Puzzle." *Food Policy* 25: 365-378.

———. 1999a. "Agricultural Risk Management or Income Enhancement?" *Regulation: The CATO Review of Business and Government* 22: 35-43.

———. 1999b. "Opportunities for Improved Efficiency in Risk-Sharing Using Capital Markets." *American Journal of Agricultural Economics* 81: 1228-1223.

———. 1999c. "Policy Lessons of Income Insurance: Lessons Learned from the US and Canada." Principle Paper for the European Agricultural Economics Meeting, August 25-28, Warsaw, Poland.

Skees, J. R. and A. Enkh-Amgalan. 2002. "Examining the feasibility of livestock insurance in Mongolia." World Bank Working Paper 2886, September 17.

Skees, J. R. and B. J. Barnett. 1999. "Conceptual and Practical Considerations for Sharing Catastrophic/Systemic Risks." *Review of Agricultural Economics* 21: 424-441.

Skees, J. R. and K. A. Zeuli. 1999. "Using Capital Markets to Increase Water Market Efficiency." Paper Presented at the 1999 International Symposium on Society and Resource Management, July 8, Brisbane, Australia.

Skees, J. R. and M. R. Reed. 1986. "Rate Making for Farm-Level Crop Insurance: Implications for Adverse Selection." *American Journal of Agricultural Economics* 68: 653-59.

Skees, J. R., P. B. R. Hazell, and M. Miranda. 1999. "New Approaches to Crop Yield Insurance in Developing Countries." International Food Policy Research Institute: Environment and Production Technology Division Discussion Paper No. 55.

Skees, J. R., B. J. Barnett, and J. R. Black. 1997. "Designing and Rating an Area Yield Crop Insurance Contract." *American Journal of Agricultural Economics* 79: 430-438.

Skees, J. R., P. Varangis, D. Larson, and P. Siegel. 2002. "Can Financial Markets be Tapped to Help Poor People Cope with Weather Risks?" Wider Press of the United Nations, Discussion Paper.

Skees, J. R., J. Harwood, A. Somwaru, and J. Perry. 1998. "The Potential for Revenue Insurance Policies in the South." *Journal of Agricultural and Applied Economics* 30: 46-71.

Townsend, R.M. 1995. "Consumption Insurance: An Evaluation of Risk-Bearing Systems in Low-Income Economies." *Journal of Economic Perspectives* 9(3): 83-102.

U.S. General Accounting Office. 1989. "Disaster Assistance: Crop Insurance Can Provide Assistance More Effectively than Other Programs." RCED-89-211. Washington, DC: U.S. Government Printing Office.

———. 1980. "Federal Disaster Assistance: What Should the Policy Be?" PAD-80-39. Washington, DC: U.S. Government Printing Office.

Udry, C. 1994. "Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria." *Review of Economic Studies* 61: 495 – 526.

Zeuli, K. 1999. "New Risk Management Strategies for Agricultural Cooperatives." *American Journal of Agricultural Economics.*