Innovations of agricultural insurance products and schemes

<A Draft>

June 2005

Myong Goo KANG (myonggoo.kang@fao.org)

Contents

Tables

Figures

Preface

Farmers are exposed year round to a variety of risks, both market-related, such as price variations, and non-market-related, such as unfavourable weather, pests, and diseases. Such risks make agricultural production unstable from year to year, affecting the income and welfare of agricultural producers. If agricultural commodities are important food or export crops, the risks eventually reduce foreign exchange earnings and further lead to a lower national income and to reduced long-term productive investments in agriculture.

Agricultural insurance, a financial tool to minimize the adverse effects of agricultural risks, has been devised to address the agricultural production or yield risks mainly due to adverse climate. As agriculture became more sophisticated, however, producers were demanding insurance to cover a greater number of risks. Complying with this demand and in order to overcome the limitations of traditional agricultural insurance that originate from the characteristics of agricultural risks (occurring over a wide area at the same time, etc.), new insurance products and schemes and alternatives have continuously been developed.

This paper aims at identifying the recently developed innovative products and schemes of agricultural insurance, followed by some alternatives to insurance. It does not attempt to be a manual, but an introductory guide for policy-makers, farmers, and insurance planners.

Acknowledgements

The author wishes to express his special thanks to Calvin Miller, senior officer of the Rural Finance Group (RFG), Agricultural Management, Marketing and Finance Service (AGSF), who has given valuable suggestions and comments to improve the paper throughout the research period, and to Doyle Baker, Service Chief of AGSF, Richard Roberts, former Service Chief of the Agricultural Marketing and Rural Finance Service (AGSM), and Anton Slangen, former senior officer of the RFG, who provided constructive guidelines during the research design. The author also wishes to thank the colleagues at the RFG for their visible and invisible support. Finally, my particular thanks should go to Barbara Hall, consultant editor, who has encouraged me to write my first English paper ever in my life with the least number of flaws.

Acronyms and abbreviations

AGR	Adjusted Gross Revenue
APH	Actual Production History
CAT	Catastrophic Coverage
CBOT	Chicago Board of Trade
CME	Chicago Mercantile Exchange
CRC	Crop Revenue Coverage
FCIC	Federal Crop Insurance Corporation
GRIP	Group Risk Income Protection
GRP	Group Risk Plan
IFC	International Finance Corporation
IP	Income Protection
LGM	Livestock Gross Margin
LRP	Livestock Risk Protection
MPCI	Multiple Peril Crop Insurance
NASS	National Agricultural Statistics Service
RA	Revenue Assurance
RMA	Risk Management Agency
USDA	United States Department of Agriculture
WD	Weather Derivative
WTO	World Trade Organization

I. Introduction

The principle of insurance is risk-sharing. Agricultural insurance[1] is one of the financial tools used to manage the various risks that may arise in agricultural production. It operates by transferring the risks associated with farming to a third party via payment of a premium that reflects the true long-term cost of the insurer assuming those risks. In other words, the insurance agency is able to pool the risks by accepting appropriate premiums from a large number of clients.

Agricultural insurance is able to reduce risk costs by spreading risks in such three ways, as shown in Table 1 (Hazell *et al.*1986, 37-38).

Table 1
Risk spreading in agricultural insurance

Where to spread risk	How to spread risk
(1) Among farmers	Except in the case where crop risks are perfectly and positively correlated among farms, insurance pools among farms leads to an automatic reduction in the aggregate risk facing the insurance agency.
(2) To other sectors of economy	An insurance agency can diffuse crop risks to other sectors of the economy by offering a mix of insurance products and by reinsuring its policies with other institutions. If it is a government agency, it can also rely on the ultimate security afforded by the taxpayer.
(3) Over time	An insurance agency can spread risks over time by accumulating reserves. Since the proportion of farmers requiring indemnities in any one year is largely controllable, an insurer would also have a much better chance than an individual of surviving a run of bad years.

In the recent past, the advent of some influential factors has renewed interest in agricultural insurance. Such factors for growth in demand for agricultural insurance are pointed out in Table 2 (Roberts, 2005 11-12).

While stipulating reduction and phase out of direct support payments to farmers, the WTO regulations, *inter alia*, exempted "the payments made by way of government financial participation in crop insurance schemes"[2] from reduction commitment. These regulations have prompted an upsurge of interest of both developed and developing countries, as well as of insurance businesses.

---

[1] Typically "crop insurance": hereafter these two terms will be used interchangeably except when their distinction is necessary.

[2] Item 8 of Annex 2 (Domestic Support: the Basis for Exemption from the Reduction Commitments) to the 1994 WTO Agreement on Agriculture:

8. Payments (made either directly or by way of government financial participation in crop insurance schemes) for relief from natural disasters

(a) Eligibility for such payments shall arise only following a formal recognition by government authorities that a natural or like disaster (including disease outbreaks, pest infestations, nuclear accidents, and war on the territory of the Member concerned) has occurred or is occurring; and shall be determined by a production loss which exceeds 30 per cent of the average of production in the preceding three-year period or a three-year average based on the preceding five-year period, excluding the highest and the lowest entry.

(b) Payments made following a disaster shall be applied only in respect of losses of income, livestock (including payments in connection with the veterinary treatment of animals), land or other production factors due to the natural disaster in question.

In light of this strong interest in and demand for agricultural insurance, this paper will at review how agricultural insurance products have evolved and then examine which innovative products have recently been developed and how they have been applied into practices. This paper is organized as follows:

Chapter II reviews the evolution of traditional products of agricultural insurance, mainly insurance against yield risk and their inherent problems. Chapters III and IV examine several innovative insurance products and schemes as well as alternatives to insurance developed in the recent decade to cope with such problems using case examples of their application. Finally, Chapter V provides a summary and policy recommendations.

Table 2
Renewed interest in agricultural insurance

Factors	Remarks
1. Increasing incidence of **crop-damaging weather events** of extreme severity	
2. Farming becoming steadily more **commercialized**, with greater levels of financial investment	Farmers/investors and their banks will frequently examine the feasibility of using a financial mechanism, i.e. insurance, in order to address part of the risk to their financial investment. As a part of this trend to commercialization, greater use is now being made of contract farming arrangements, where insurance is one of many services provided to growers along with inputs.
3. The **WTO regulations** exempting the governments from their subsidy reduction commitments, as regards assistance to agricultural insurance	The WTO regulations generally forbid governments from subsidizing agriculture directly; however, they permit the subsidization of agricultural insurance.
4. **New insurance products**	To reflect the dynamism of the farming sector and its environment, some new insurance products have been introduced in the last decade, such as crop revenue products and index or derivative products.
5. **Accidental introduction of exotic pests/diseases**	This involves all countries where agriculture is an important part of the economy. Insurance can address the risk of a breakdown of these measures.
6. Expanded **quality** and **food safety concerns** for farm products as well as increasing **environmental protection requirements** including stricter rules for use of fertilizers, herbicides and medicines for animals	Such trends are also likely to increase production risk. Insurance can also assist in managing the on-farm production risks as a result of changes in pest management practices, which are increasingly necessary in order to address environmental protection and food safety concerns.
7. **Liberalization of agricultural trade**	This can be expected to lead to price volatility and to greater exposure of farmers to competitive market forces and income instability.

(c) Payments shall compensate for not more than the total cost of replacing such losses and shall not require or specify the type or quantity of future production.

(d) Payments made during a disaster shall not exceed the level required to prevent or alleviate further loss as defined in criterion (b) above.

(e) Where a producer receives in the same year payments under this paragraph and under paragraph 7 (income insurance and income safety-net programmes), the total of such payments shall be less than 100 per cent of the producer's total loss.”

II. Traditional insurance products and their problems

(1) Traditional yield insurance products

Single and named peril insurance

The coverage of single peril insurance is against actual damage caused by single perils such as fire, hail, windstorm (and perils directly associated with this occurrence) or frost. Named peril insurance refers to insurance of specifically identified perils, typically covering approximately four specific ones. In some cases this number may be extended to six perils when two or more are very closely related (e.g. flood, excessive rain, or humidity) (FAO 1991, 76). In Western European countries, privately run hail crop insurance has been successfully practiced for around one century because it has been possible to set actuarially sound premiums and easy to verify damages and losses.

There are a number of factors specific to hail damage that make it a much more favourable candidate for insurance than multi-peril or all risk cover insurance, which offer yield assurance in general (Quiggin 1994, 120-121):

(i) Hail damage risks are amenable to pooling. Given a moderate spread of locations, the likelihood that a large proportion will suffer from hail damage in any one year is fairly small.

(ii) The lack of any major moral hazard problem[3] is another factor. There is nothing that can be done to mitigate its impact. This makes hail insurance more attractive.

(iii) Adverse selection problems are also unlikely to be serious. While some localities are more hail-prone than others and some crops are more susceptible to damage than others, these facts can easily be taken into account in setting the premium rates.

(iv) The absence of a correlation between hail damage for farmers in different regions means that prices are unlikely to be negatively correlated with hail damage. This reduces to some extent the problems of insufficient indemnity for covering the losses incurred by the farmer (measured by the differences between actual and expected yield at the price expected at the time the contract is sold), which are likely to occur in the multi-peril insurance.

(v) A wide clientele has led to the successful development of private insurance markets against single peril (e.g. excess rainfall) including a certain number of agricultural industries, for example, tomato-related industries, and some non-agricultural industries, for example, outdoor entertainment.

Although commercially viable, single or named peril insurance, however, is not sufficient to address a variety of agricultural risks from natural hazards to pests and diseases. As such, farmers are frequently interested in and demand multi-peril or all risk-inclusive insurance due to the broader impact of perils affecting all crop enterprises.

Multi-peril or all risk insurance

[3] Concerning moral hazard and adverse selection, see (2) "Problems with the traditional yield insurance products" in this chapter.

This insurance covers all perils[4] that could affect yield. Indemnities are paid when a farmer's actual yield falls below some predetermined threshold yield, and indemnity amounts are the shortfall in yield below that threshold multiplied by some predetermined price. According to a study, "every multi-peril insurance programme that has progressed beyond infancy has been underwritten by a government. To our knowledge, attempts by private underwriters to provide multi-peril insurance have all failed." (Wright and Hewitt 1994, 76)

In countries with multiple risk insurance schemes in place, government intervention or heavy support to agricultural insurance operations has been regarded as justifiable and inevitable due to market failures.[5] Such supports have been provided in the form of (i) subsidies on premiums to farmers; (ii) operation subsidies to private insurers to cover some of the high administrative costs associated with agricultural insurance contract underwriting; and (iii) subsidized reinsurance.

The methods of government intervention also vary from country to country. For example, in Canada, Japan and the Philippines, the insurance schemes are operated under a central government or local government-commissioned body, while in the United States, Spain and Mexico, they are operated under a partnership between the government and private insurance companies with the former assuming the role of reinsurer of the latter. However, government support programmes are often fiscally burdensome, as seen in Table 3.

To be profitable, the ratio of average administrative costs plus average indemnity payments to the average premiums collected must be less than one. Unfortunately, for most countries, the ratio has far exceeded one, indicating that the programmes have been unsustainable without subsidization. On the positive side, however, the current agricultural insurance programmes are also deemed "an important vehicle for transferring support to the farm sector" (Goodwin 2001) or "a permanent income-transfer mechanism to benefit farmers" (Siamwalla and Valdés 1986).

---

[4] Events excluded from insurance are very exceptional (e.g. Art. 12, Basic Provisions, Common Crop Insurance Policy of FCIC under RMA, USDA available at RMA website www.rma.usda.gov/FTP/Policies/2001/crops/pdf/01brbasi.pdf)
(a) negligence, mismanagement, or wrongdoing by the insured, his or her family, tenants or employees;
(b) the failure to follow recognized good farming practices for the insured crop;
(c) water contained by any governmental, public, or private dam or reservoir project;
(d) failure or breakdown of irrigation equipment or facilities: or
(e) failure to carry out a good irrigation practice for the insured crop if applicable.

[5] Wenner and Arias (2003) state: "Private insurers have not been able to cope with systemic, non-diversifiable risk in crop yields stemming from say natural disasters affecting a large number of farms over a widespread region…Portfolios of geographically dispersed crop insurance contracts can be as much as 20 times more risky than a equally valued portfolio of health and automobile insurance contracts…Because of the geographic dispersion of clients in rural areas and the highly differentiated production characteristics of each farm, the administrative costs of effectively monitoring effort and differentiating between legitimate and fraudulent loss claims can be prohibitive."

Makki (2003) adds another reason for public support: "Farmers are not very risk averse or are unwilling to pay actuarially sound premiums because they find their own less costly methods to protect against loss, including savings, futures markets, and off-farm incomes."

Berg (2002) presents more simply the specific preconditions to be fulfilled for an insurance market to be formed in which multiple risks can be covered:
- identifiability and measurability of damage;
- a large number of homogeneous and separate insured parties;
- randomness and inalterability of damage;
- calculability of risk; and
- economically viable premiums. (pp 94-133 as cited in Meyer 2002)

Table 3 Financial performance of agricultural insurance programmes: costs vs. premiums

Country	Time period	(I+A)/P*
Brazil	1975-1981	4.57
Costa Rica	1970-1989	2.80
Japan	1947-1977	2.60
	1985-1989	4.56
Mexico	1980-1989	3.65
Philippines	1981-1989	5.74
USA.	1980-1989	2.42
	1999	3.67

* **I** – indemnity payments; **A** –administrative costs; **P** – collected premiums
Source: Skees 2003a.

(2) Problems with the traditional yield insurance products

Most basic insurance textbooks enumerate the necessary conditions for risks to be insurable. In assessing the insurability of crop loss risks, two of these conditions are particularly relevant: [6]

(i) The risks should occur highly independently across insured individuals.

(ii) The insurer and insured should have very nearly symmetric information regarding the probability distribution of the underlying risk.

Traditional yield insurance, however, does not satisfy such conditions in the following respects:[7]

(i) Correlation of crop risks

Risks in agriculture stemming from natural disasters, pests or diseases affecting farms over a widespread region are systemic and not independent. These common risks are referred to as correlated risk. Unlike in other types of property and casualty insurance (e.g. automobile, fire), in agricultural insurance, all the farms in a given district are likely to suffer adverse conditions at the same time. Such correlation of systemic risks "undermines an insurer's ability to diversify risks across farms, crops, or even regions, and prevents it from performing the essential function of an insurance intermediary: the pooling of risk across individuals." (Miranda and Glauber 1997)

(ii) Asymmetric information

Successful insurance programmes require that the insurer has adequate information about the nature of risks being insured. However, this is very difficult for farm-level yield insurance where farmers always know more about their potential crop yields than any insurer. Such asymmetric information exists in agriculture "because of differences in inherent farm risks arising from factors such as the farm's location characteristics and farmers' managerial abilities."[8] Asymmetry of information between the insurer and the insured brings about two types of problems: adverse selection and moral hazard.

[6] Berliner, 1982, as cited in Miranda and Glauber (1997, 207)
[7] Makki (2003); Miranda and Glauber (1997); Quiggin (1994); Skees (2003b); Wenner and Arias (2003); and World Bank (2004)
[8] Knight and Coble (1997) cited in Makki (2003)

Adverse selection in insurance markets refers to the situation where insurers find it impossible or very expensive to distinguish between high-risk and low-risk insurance applicants and thus fail to set premiums commensurate with risk. Over time the low-risk clients drop out of the market, which is left with a very high-risk pool of clients with higher expected indemnities that negatively affect the insurer's profitability (Wenner and Arias 2003).

Moral hazard occurs when producers, after purchasing insurance, alter their production practices in a manner that increases their chances of collecting indemnities. This problem "arises from the fact that farmers can take a great many actions which affect their final yield" (Quiggin 1994). [9]Many studies show that moral hazard affects the actuarial soundness of the multiple peril crop yield insurance and that it is likely to be a significant cause of excess losses in the crop insurance programme. Furthermore, they argue that the insured parties change their behaviour only in the years when losses appear imminent, and conclude that better monitoring in regions where substantial losses appear likely in a particular season or year could substantially reduce losses (Makki 2003).

These two problems affect all insurance markets but more so in agricultural markets because obtaining information on clients is more difficult and monitoring client behavior is more costly. Moreover, because of the geographic dispersion of clients in rural areas and the highly differentiated production characteristics of each farm, the administrative costs of effectively monitoring effort and differentiating between legitimate and fraudulent loss claims can be prohibitive. If, on the other hand, loss coverage is set too low to discourage carelessness and negligence, the market can become very thin and the advantages gained by pooling risk types, – the essence of insurance intermediation – is lost (Wenner and Arias 2003).

(3) Need for innovations

As seen above, both correlation of crop risks and asymmetric information problems are likely to make risk pooling, the essential function of insurance ineffective. Therefore, the recent innovative instruments focus on tackling the traditional problems with agricultural insurance such as moral hazard, high transaction costs, adverse selection, and, most importantly, the problem of systemic climatic shocks to the agricultural sector.

Although many of these instruments have been conceived and practiced in developed countries, they are also very promising for developing countries where most have high exposure to weather risks. Further, typical problems with traditional multi-crop insurance products, such as moral hazard and adverse selection, are exacerbated in developing countries with relatively higher numbers of smallholder farmers (Wenner and Arias 2003). Hence, international lending institutions such as the World Bank have recently intensified their role in enhancing the feasibility of the instruments in developing countries and complementing weak institutional capacity, weak infrastructure and a lack of information inherent in those countries.[10]

[9] "For example, farmers can choose whether or not to apply pesticides and, if so, how much. They can choose varieties which have high yields but are highly susceptible to drought or insect attack, or instead, more robust but lower-yielding varieties. More subtle factors such as the care with which soil preparation and ploughing is undertaken may also have an impact. In all of these cases, it will be rational for insured farmers to choose techniques which involve a greater risk of failure. In the case of choosing between high yielding and robust varieties, an insured farmer will tend to choose the high yielding variety. If the season is good, he reaps the benefit. If it is bad, the insurer bears part of the cost" (Quiggin 1994).

[10] World Bank has set its future directions for lending with respect to agricultural risk management as the following, among others: (i) improving information systems; (ii) testing new approaches to agricultural insurance; (iii) promoting market-based price risk management; and (iv) emphasizing disaster planning rather than relief (World Bank 2004).

In the following two chapters, we will examine such innovative insurance products and schemes developed or being applied on trial in recent years.

III. Innovations of agricultural insurance products and schemes

(1) Revenue insurance

Insurance based on yield might not be very good compensation for income fluctuation, if price is variable. Revenue insurance was designed to provide a degree of price protection – not just yield protection as under multi-peril crop insurance. It covers sharp drops in expected revenue, which may result from yield or price declines or a combination of the two.

The revenue insurance products, which combine yield and price coverage, cover loss in value due to a change in market price during the insurance period, in addition to the perils covered by the standard loss of yield coverage. Indemnities are paid to farmers based on gross revenue shortfalls instead of yield or price shortfalls only.

History in brief[11]

The stage for revenue insurance was first set by the Congress and the Administration of the United States in the early 1980s. In the 1981 Farm Act, Congress mandated a study on the feasibility of revenue insurance. In nearly every relevant act since 1981, Congress mentioned revenue insurance. In both the 1994 Federal Crop Insurance Reform Act and the 1996 Federal Agriculture Improvement and Reform Act, Congress provided clear indications to the United States Department of Agriculture (USDA) Risk Management Agency (RMA) on pilot testing of revenue insurance. Meanwhile in 1991, Canada's Gross Revenue Insurance Programme (GRIP) first introduced revenue insurance, but it was quite costly and interfered with market signals, largely because it used long-term average prices in establishing the guarantee. Therefore, after 1995 the programme was integrated into an income stabilization programme.[12] Based on this Canadian experience, all US revenue insurance products use an intra-year futures-based price in establishing guarantee, rather than a guarantee based on long-term average prices (Harwood *et al.*1999).

In the United States, revenue insurance products, *Crop Revenue Coverage* (CRC) and *Income Protection* (IP), first became available for new crops in selected areas in the 1996 crop year. *Revenue Assurance* (RA) was added in the 1997 crop year, and *Group Risk Income Protection* (GRIP) and *Adjusted Gross Revenue* (AGR) were added in the 1999 crop year. GRIP is also index-based insurance while AGR is also whole-farm insurance. These two products will be discussed under separate sections.

Operation of products[13]

[11] References to the evolution of revenue insurance products are based on Skees *et al.* (1998), Harwood *et al.* (1999) and Turvey (1992).
[12] Since the Canadian GRIP paid indemnities based on a 15-year moving average of crop revenue, it ran into early problems because the guarantee was based on a long-run guarantee that reflected higher prices in early years. Because international commodity prices were low when GRIP was introduced, the revenue guarantee was too high to sustain. The programme was more of an income-enhancement programme than an insurance programme. This points out a significant problem in providing guarantees for long-term incomes (Skees *et al.* 1998).
[13] The following details on the revenue insurance products being operated in the United States are taken from Harwood *et al.* (1999), Dismurke (1999 and 2002) and RMA, USDA website: www.rma.usda.gov.

The first three plans introduced in the United States have many similar features, while they are also unique in many ways.

(i) Similarities between CRC, IP and RA

Indemnities are due when any combination of yield and price result in revenue below the revenue guarantee. All use the basic policy terms and conditions of the traditional individual-farm yield insurance, the Actual Production History (APH) plan of Multiple Peril Crop Insurance (MPCI).[14] APH provides the yield value used to calculate the revenue guarantee by using the insured's historical yield records. APH is the documentation process to measure the yield for the insurance period.

Revenue protection for all products is provided by extending traditional APH protection to include price variability measured by the prices discovered in the commodity futures market. Price discovery occurs twice in all three plans: first, before the insurance period (Base price for CRC, Projected price for IP, Projected Harvest price for RA) to establish the guarantee and premium; then, at harvest time (Harvest price for CRC and IP; Fall Harvest price for RA).

All of these revenue insurance plans pay the insured producer an indemnity when any combination of harvested and appraised yield times the harvest price results in insurance revenue that is less than the revenue guarantee.

All revenue product contract prices are the average of the daily settlement prices for the commodity futures exchange, contract, and period listed in the insurance contract. Before insurance begins, the guarantee price (Base, Projected, or Projected Harvest price) is calculated using the average of the daily settlement prices at the commodity futures exchange during the month designated in the insurance contract. Near the end of the insurance period, the Harvest price (Harvest or Fall Harvest price) is calculated using the average of the daily settlement prices at the commodity futures exchange during the month designated in the insurance contract. These prices are available on the RMA website shortly after the close of each discovery period.

(ii) Uniqueness of each product

The uniqueness of each product as described below is found in the specifications of the guarantee and the producer's ability to subdivide acreage into individual parcels. More details on the three products will be elaborated below.

Crop Revenue Coverage **(CRC)** uses two prices to measure price fluctuation during the insurance period. Base price establishes the revenue guarantee. Harvest price establishes the crop value to count against the revenue guarantee, and is also used to recompute the revenue guarantee when it is higher than the Base price. Price fluctuations are measured by the difference between the average commodity price before insurance begins, "the Base price", and the price at harvest time, "the Harvest price". Price fluctuations between the "Harvest" and "Base price" are limited to US$1.50 for corn, US$0.70 for cotton, US$1.50 for grain sorghum, US$0.05 for rice, US$3.00 for soybeans and US$2.00 for

---

[14] APH-MPCI, which still accounts for the bulk of the Federal crop insurance business, insures producers against yield losses due to natural causes such as drought, excessive moisture, hail, wind, frost, insects and disease. The farmer selects the unit guarantee level, from 50 to 75 percent (in some areas to 85 percent). The unit guarantee is calculated as a four-to ten-year simple average of the producer's actual production history (APH) yield on the insured parcel of land. If a producer does not have records of actual yields, the series is filled in with a "transitional yield" based on county average yields. The farmer also selects the percentage of the predicted price that he or she wants to insure, which is between 55 and 100 percent of the crop price established annually by RMA. If the harvest is less than the yield insured, the farmer is paid an indemnity based on the difference. Indemnities are calculated by multiplying this difference by the insured percentage of the established price selected when crop insurance was purchased.

wheat. Any indemnity payments will be paid after the Harvest price and actual production are determined.

CRC policyholders can select any county/crop combination, but must insure all acreage of the insured crop in the county in which they have an interest. Insurance is offered by units that describe acreage and location. Basic units are determined by ownership, owner-operator and cash rent, or each sharing entity. Basic units can be subdivided into Optional units that are determined by location and/or production practice. Each proposed Optional unit must be supported by the producer's historic records of planted acreage and harvested production. The revenue guarantee applies individually to each Basic or Optional unit. Producers may choose to create an Enterprise unit – defined as the entire acreage of the insured crop in the county in which the insured has a share – from several Basic or Optional units and receive a premium discount.

Producers choose the amount of revenue protection that meets their risk management needs by selecting a coverage level between 50 and 75 percent (85 percent coverage level is available for selected crops and counties). The CRC revenue guarantee is calculated by multiplying the APH yield times the insured's chosen coverage level times *the higher of the Base price, or the Harvest price*. Therefore, CRC coverage can increase when the Harvest price is greater than the Base price. CRC policyholders are due an indemnity when the harvested and appraised yield times the Harvest price is less than the revenue guarantee.

The CRC policy provides insurance protection for unavoidable loss of revenue due to insured causes of loss, including market prices. Exclusions are the same as in the MPCI policy.[15]

Income Protection (IP) uses two prices to measure price fluctuation during the insurance period. Projected price establishes the revenue guarantee. Harvest price establishes the crop value to count against the revenue guarantee. Price fluctuations are measured by the difference between the average commodity price before insurance begins, "Projected price", and the price at harvest time, "Harvest price". Indemnity will be paid when the appraised production and the Harvest price are determined.

Producers must insure all of their crop acreage in the county as a single parcel, an "Enterprise unit", as referred to in the CRC. Producers choose the amount of revenue protection that meets their risk management needs by selecting either catastrophic coverage (CAT)[16] or a coverage level between 50 and 75 percent (85 percent coverage is available for selected crops and counties). The IP revenue guarantee is the insured's selected coverage level times the APH yield times the Projected price. IP policyholders are due an indemnity when the harvested and appraised yield times the Harvest price is less than the guarantee. If producers select the CAT level of protection and pay the administrative fee, no premium is due.

Beginning with the 1999 crop year, the Indexed IP (IIP) pilot programme is available for selected crops and counties. IIP is identical to regular IP except in how the APH approved yield is calculated. This pilot programme makes a higher yield guarantee available in areas that have experienced unusually low yields in recent years and the traditional APH approved yields may not reflect the insured crop's expected yield. Indexing producer yields alleviates this problem.

The indexing process uses county data to minimize the effect of unusually low yields. The approved APH yield for the Indexed IP policy is calculated by subtracting the average of producer's reported yields at the enterprise unit level from the county average yields for the same years, then subtracting that difference from the county's expected yield for the current crop year. The IP policy provides

[15] See footnote 4.

[16] Catastrophic Coverage (CAT) is crop insurance coverage at the lowest level. Coverage is set at the 50/55 level, meaning that yield must fall below 50 percent of average yield before a loss is paid, and such losses are paid at a rate of 55 percent of the highest price election. The premium on CAT coverage is paid by the government; however, producers must pay only a fixed administrative fee for each crop insured in each county.

insurance protection for unavoidable loss of revenue due to insured causes of loss, including low market prices. Exclusions are the same as in the MCPI policy.

Revenue Assurance **(RA)** also uses two prices to measure price fluctuation during the insurance period. Projected Harvest price establishes the revenue guarantee. The Fall Harvest price establishes the crop value to count against the revenue guarantee. Price fluctuations are measured by the difference between the average commodity price before insurance begins, "Projected Harvest price", and the price at harvest time, "Fall Harvest price". The Fall Harvest price is used to recompute the revenue guarantee when the Fall Harvest price option is elected and the Fall Harvest price is higher than the Projected Harvest price. Indemnity payments will be paid when the harvest price and appraised production and Harvest price are determined.

RA policyholders must insure all the acreage of the insured crop in the county in which they have an interest. However, they may select from several unit organizations: basic, optional, enterprise, or whole farm. Basic units are determined by ownership, owner-operator and cash rent, or each sharing entity. Basic units can be subdivided into Optional units that are determined by location and/or production practice, each proposed Optional unit must be supported by historic records of planted acreage and yield.

RA provides a premium discount if the insured elects an Enterprise unit. An additional premium discount is available when the insured elects the Whole farm unit, which is the entire acreage of the insured crop in the county in which the insured has a share. In these cases, the premium discount is justified by a higher degree of self-insurance.

The RA unit revenue guarantee is the insured's selected coverage level (from 65 percent with 5 percent increments to 85 percent) times the APH yield for the unit times the Projected Harvest price. RA indemnities are paid if the harvested and appraised yield times the Harvest price is less than the per-acre revenue guarantee times the number of acres.

Table 4 shows a side-by-side comparison outlining the major features of the above three revenue insurance products.

Growing participation in revenue insurance

According to Dismurke, in the United States, revenue insurance participation has grown steadily since its introduction, reaching 43 percent of all acres insured in the crop insurance programme in 2001. Around 60 percent of the insured acres of corn and wheat and 37 percent of the acres of soybeans were covered by revenue insurance. The following are ascribed to this growing participation (Dismurke 2002):

(i) Farmers are ultimately interested in dollars, not in bushels, and revenue coverage guarantees a specific revenue, regardless of whether low revenue results from low yields or from low prices.

(ii) CRC, by far the most widely available and most popular form of revenue insurance, offers a feature that increases the revenue guarantee if the crop price at harvest is higher than the price used to establish coverage prior to planting. Farmers who believe prices are likely to rise in years when they have yield losses may find this feature appealing. RA with a "harvest price option" provides similar coverage. IP does not have this feature.

(iii) The price used to establish the coverage level of CRC has often been slightly higher than that used to establish the value of a crop under MPCI yield insurance. CRC, RA and IP establish their coverage using futures market prices, which have in many cases been higher than the maximum prices used for yield insurance indemnities.

(iv) Revenue insurance products provide protection against declines in price during the crop growing season and not against declines that occur between growing seasons or over several seasons. Prices of revenue coverage are determined when insurance guarantees are set at planting based on prices of futures contracts with delivery dates near harvest time. This procedure keeps the value of insurance consistent with the expected value of the crop.

Table 4
Comparison of the three revenue insurance products

Feature	*CRC*	*IP*	*RA*
Unit organization	Basic, optional, or enterprise units	Enterprise unit (all acreage of the insured crop in the county in which the insured has interest)	Basic, optional, enterprise, or Whole farm units (all RA insurable crop acreage in the county in which the insured has an interest)
Basis for insurance guarantee	Higher of 1) APH yield × Base price; or 2) APH yield × Harvest price Insurance guarantee increases when the Harvest price exceeds the Base price	APH yield × Projected price	APH yield × Projected Harvest price Harvest price option increases the guarantee when the Harvest price exceeds the Projected Harvest price
Maximum protection unit price increase	corn US$1.50 cotton US$0.70 grain sorghum US$1.50 rice US$0.05 soybeans US$3.00 wheat US$2.00	Not applicable	Not applicable
Reference commodity price	For corn, cotton, rice, soybeans and wheat, 100% of the selected commodity contract traded on a commodity futures exchange Grain sorghum is 95% of the corn futures	For corn, cotton, soybeans, and wheat, 100% of selected commodity contract traded on a commodity futures exchange Grain sorghum is 90% of the corn futures Barley is 85% of the corn futures	100% of selected commodity contract traded on a commodity futures exchange
Eligibility for high-risk land	High-risk land is eligible for coverage if elected by insured	High-risk land is not eligible for coverage	High-risk land is eligible for coverage if elected by insured
Coverage levels	50-75% in 5% increments, except 50-85% where 85% APH is available CAT is not available	50-75%, except 50-85% where 85% APH is available CAT is 27.5%	65-75%, except 65-85% for Whole farm and Enterprise units CAT is not available
Hail and fire exclusion	Not available	Not available	Not available
Insured crops	Corn, cotton, grain sorghum, rice, soybeans and wheat	Barley, corn, cotton, grain sorghum, soybeans and wheat	Corn, feed barley, canola/rapeseed, soybeans, sunflowers and spring wheat
Premium rating	APH base rate plus low price factor plus high price factor plus CRC factor	New rating model incorporating yield and price variability	New rating model incorporating yield and price variability and yield and price correlation

Source: RMA, USDA website: www.rma.usda.gov

(2) Whole farm insurance

This insurance product offers coverage on a whole-farm basis rather than on a crop-by-crop basis. The whole farm insurance product was first introduced in 1999 in the United States as *Adjusted Gross Revenue* (AGR), an expansion of revenue insurance.[17]

AGR provides protection against low revenue due to unavoidable natural disasters and market fluctuations that occur during the insurance year. Under this programme, a producer can insure gross revenue from all farm commodities, including incidental amounts of income from animals, animal products and aquaculture reared in a controlled environment.

AGR bases insurance coverage on income from agricultural commodities reported on a producer's Schedule F tax form[18] to calculate the policy revenue guarantee. AGR provides insurance coverage for multiple agricultural commodities in one insurance product, therefore targeting crop producers – particularly specialty crops – for which individual crop insurance programmes are not presently available.

AGR liability (protection) is calculated by multiplying the approved adjusted gross revenue by the coverage level (65 percent, 75 percent and 80 percent) selected by the producer. Coverage levels and payment rates can vary with the number of crops produced and are selected by the producer from the county actuarial document. A producer selects one amount of coverage.

Loss payments are triggered when the adjusted income for the insured year is less than the AGR liability. Once a revenue loss is triggered, the insured is paid based on the payment rate selected, either 75 percent or 90 percent of each dollar lost.

For example, if a farm with approved AGR of US$94 900 bought an AGR insurance policy of an 80 percent coverage level and a 90 percent payment rate, the farm's AGR liability (protection guarantee) would be US$75 920 (= US$94 900 × 80 percent). If the farm earned its adjusted gross income of US$21 000 for the insured year, its loss of revenue would be US$54 920 (= US$75 920 – US$21 000) and its due indemnity would be US$49 428 (= US$54 920 × 90 percent).

Whole-farm insurance is less likely to distort markets because it is less likely to influence farmers' planting and other management decisions than some other insurance plans. By using coverage levels based on gross sales receipts reported on the Schedule F tax form, the costs of administration and delivery of the insurance programmes could be greatly reduced (Makki 2002).

(3) Price insurance

Price insurance products are designed to provide price protection only. Unlike crop farmer's income, livestock producer's income is affected more by market price changes than production volatility. Two price insurance products have been available for livestock producers in the United States.[19]

(i) Livestock Risk Protection (LRP)

LRP protects against decreases in the market value of insured cattle and swine. LRP protects producers of swine, feeder cattle and fed cattle against a decline in market prices below the established

[17] The following details on AGR are taken from the RMA, USDA website: www.rma.usda.gov.
[18] In the United States, farmers must report annually to the Internal Revenue Service (IRS) to declare their taxable income from trade or business of farming by completing and filing a Schedule F form.
[19] The following details on LRP and LGM are taken from the RMA, USDA website: www.rma.usda.gov.

coverage price. Coverage prices are based on the Chicago Mercantile Exchange's (CME's) Feeder Cattle Contract, which is settled to the CME Index. Producers may select from a variety of coverage levels ranging from 70 to 95 percent and periods of insurance to correspond with the time their hogs or cattle would normally be marketed. LRP may be purchased continuously throughout the year.

For an illustration of indemnity calculation, let us observe an operation with 100 head of feeder cattle, a target weight of 7.5 cwt[20] each and a coverage price of US$75 live cwt. If the actual ending value is US$70 per live cwt, an indemnity is due, since US$70 is less than the coverage price of US$75.

1. 100 head times the 7.5 cwt target weight equals the target weight of 750 cwt;
2. subtracting the actual ending value of US$70 from the coverage price of US$75 equals $5/cwt;
3. multiplying 750 cwt by US$5/cwt equals an indemnity payment of US$3 750.

Sales for LRP Feeder Cattle and Fed Cattle were suspended on 23 December 2003 when bovine spongiform encephalopathy (BSE) was detected in the State of Washington. In order to address these and other abnormal occurrences, changes were submitted by the product developer. On 29 July 2004, the Federal Crop Insurance Corporation (FCIC) Board of Directors approved the resumption of sales and expansion of the LRP programme for fed and feeder cattle and swine pending final policy revisions and the determination of a sales date by RMA.

Until July 2004 when the resumption of sales was approved, several regulations were modified. The modified regulations stipulate for long-term suspension and resumption of sales in cases of catastrophic events or highly volatile futures market prices. A new daily limit of premium by class of livestock was also included. Provisions were added to suspend sales for any endorsement period that involves rating based on a futures contract that is above or below the limit allowed by the CME.

(ii) Livestock Gross Margin (LGM)

Livestock Gross Margin (LGM), available only for swine, protects against decreases in the margin between the market value of the animal and the cost of feed inputs. Approved together with LRP as another pilot insurance programme on hog prices in November 2001, LGM provides protection against the loss of gross margin (market value of livestock minus feed costs) on the swine. LGM does not insure against death loss or any other loss or damage to the producer's hogs.

The indemnity at the end of the six-month insurance period is the difference, if positive, between the gross margin guarantee and the actual gross margin. LGM uses simple averages of futures contract daily settlement prices to determine the Expected Gross Margin and the Actual Gross Margin. The price the producer receives at the local market is not used in these calculations.

LGM is sold on the last business day of each month, so producers can sign up for LGM twelve times per year and insure all of the hogs they expect to market over a rolling six month insurance period.

(4) Index-based insurance

Index-based insurance products pay indemnities based on changes in the value of an index rather than on actual losses incurred by the farmer. Various events can be used as indices: weather variables (rainfall, temperature, wind speed, etc.), area yield, price and even mortality rate of livestock.

[20] Cwt is a unit of weight in the US Customary System equal to 100 pounds (45.36 kg).

Advantages

Index insurance products have several advantages relative to traditional insurance products.[21]

Index insurance products are not susceptible to common insurance problems of moral hazard and adverse selection. Both of these problems are caused by the fact that relevant information is asymmetrically distributed – that is, policyholders (or potential policyholders) typically have better information about their risk exposure than does the insurer. In the long run, both of these problems can cause insurers to increase premium rates, driving lower-risk insurance purchasers out of the market.

Index insurance products, however, eliminate the problem of moral hazard because indemnities are based on an index over which the policyholder has no control, and avoid adverse selection problems since there is no information asymmetry between the insurer and the insured. In other words, the policy-holder likely has no better information than the insurer about the potential realized values of the index (and hence, the probability of an indemnity occurring or potential magnitude of an indemnity).[22]

They have less potential for error and lower transaction costs because they do not require individual contracts and on-field inspections or loss adjustment.

It is very difficult to make accurate estimates of farm-level expected yields and to verify the accuracy of the documentation provided. However, index insurance products require no such historic or actual farm-level yield data. The only data required are historical values of the index. These data are generally available for much longer periods of time than the farm-level yield data required for farm-level yield and revenue insurance products. In addition, the data are typically easily accessible, transparent, and verifiable. A reason for less error comes from the fact that they require no farm-level loss adjustment, which even with careful adjustment procedures simply cannot avoid errors in calculating the true realized value for yields. In contrast, there should be far less error in calculating the true realized value for most index insurance products.

The transaction cost savings occur primarily in two areas – the establishment of the insurance trigger and loss adjustment:

- With index insurance products, the purchasers need not provide historic farm-level yield data to establish a yield guarantee, because trigger is based on the expected value of the index rather than individual historic yields. This is particularly beneficial to new farmers, in addition to those farming new parcels of land, those who do not maintain historic yield documentation, or those who simply prefer not to disclose their historic yield data required for traditional insurance products. Even growers who have been farming the same parcels for many years may find it time-consuming to locate the documents needed to verify historical yield records. Whatever the reason, index insurance products are of benefit to growers who cannot or do not wish to provide farm-level yield data. Similarly, sales agents benefit because they are not required to collect and document grower-provided yield records.

- Loss adjustment is also less costly for index insurance than for traditional insurance products. Once the realized value of the index has been established (e.g. agricultural statistics authorities and weather station in the case of area-based index and weather-based index insurance,

[21] Barnett (2004), Skees, Hazell and Miranda (1999), and Hess, Richter and Stoppa (2002) were used as references for discussions on advantages and limitations.

[22] Taking the example of area-based yield insurance as shown below, policies are sold only in regions with sufficient acreage so that no individual grower's yield will significantly affect the realized region average yield (i.e. the index). Thus, unlike traditional insurance products, indemnities are based on an index over which the policyholder has no control. Further, there is no reason to believe that growers have any better information about expected region average yields than does the insurer. Since there is no information asymmetry, there should be no problems with moral hazard or adverse selection (Barnett 2004).

respectively), a simple mathematical calculation is used to determine the amount of indemnity, if any, due each policy holder. Since index insurance requires no farm-level loss adjustment, transaction costs, for both growers and insurers, are less than with traditional insurance products.

Further, with index insurance, vulnerability to political interference and manipulation of farm losses is reduced, because triggers can be verified independently. It is also practical to implement and has low administrative and transaction costs, so the private sector can provide it with little or no government subsidies (World Bank 2004).

Finally, 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 and 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 (Skees 2003b). Also, since they are standardized and transparent, index insurance policies can easily be traded in secondary markets. This will result in transferring the systemic portion of the risk outside the region or country and tapping capital market, which would create liquidity and allow policies to flow where they are most highly valued.

Opposing the widening of the extent of risk pooling, however, it may be argued that since indemnities are not based on farm-level losses, an individual could theoretically purchase agricultural index insurance products without even producing the agricultural commodity that the insurance product is intended to protect, that is, individuals could speculate on agricultural index insurance. Therefore, even with index insurance products, insurance sales agents must verify that the producer is actually producing the commodity that is being insured (Barnett 2004). Other authorities see that this broadening of the market does not fundamentally affect the business (Skees 2003b and Roberts 2005).

Limitations

Index insurance products have also several limitations or challenges, an extremely important one being "basis risk".[23] Basis risk occurs in insurance when an insured who has a loss does not receive an insurance payment sufficient to cover the loss, or does not have any indemnity. Similarly, it occurs when an insured receives a payment even when farm-level losses do not occur or receives a payment that exceeds the amount of loss. The effectiveness of index insurance as a risk management tool depends on how positively the insured's losses are correlated with the underlying index (Skees 2003b).[24]

---

[23] The phrase "basis" has been most commonly used in reference to commodity futures markets to indicate the difference between the futures market price for the commodity and the cash market price in a given location. Basis risk is the variability in basis due to changes in transportation costs and/or local supply and demand conditions. With index insurance products, basis is the difference between the level of the index (e.g. county yield for GRP and GRIP, examples of the area-based yield insurance product as shown below) and the farm-level yield or revenue (Barnett 2004).

[24] Basis risk does not occur only in index insurance products. Farm-level MPCI has basis risk as well. First, a very small sample size is used to develop estimates of the central tendency in yields. Given simple statistics on errors of estimates with small samples, it can easily be demonstrated that significant errors are made on estimating central tendency. Such significant errors make 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. 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- or over-payments. Between the two sources of error, measuring expected yields and measuring realized yields, farm-level crop insurance programmes also have significant basis risk (Skees 2003b).

If the farm-level yield or revenue is sufficiently correlated with the index, the basis risk will occur only rarely. If this is not so, however, the basis risk will be so large that the index insurance product will not provide the grower with adequate risk protection. To minimize basis risk, careful design and structuring of index insurance policy parameters (coverage period, trigger, etc.) are devised, as discussed in the section below on "weather-based index insurance".

Next, the viability of index insurance critically depends on the underlying index being objectively and accurately measured. The index measurements must then be made widely available in a timely manner and be secure from tampering, whether provided by governments or other third party sources.

(a) Area-based yield insurance

Area-based yield contracts offer payouts when average area yield in a pre-specified area falls below a certain level. This area is usually at a county level or at a level large enough to avoid collusion and small enough to represent the physical and market conditions of any given individual farmer.

In area-based yield insurance, therefore, the indemnity does not depend on the insured's individual farm-level yield, which not only avoids problems of moral hazard, adverse selection and high transaction costs, but also creates the incentives for improving productivity at higher levels than the average area (county) yield in order to benefit further from any payout by the insurance (Wenner and Arias 2003).

Since the contracts are based on the yield at a specified area rather than individual yield, such contracts foster competition among producers and encourage them to take measures so that their individual farm-level yield may be above the average county-level yield. In the case of the county-level yield falling below a certain level and triggering indemnity payouts, farmers that had higher than average farm-level yields would not only benefit from the payouts, but also from the relative higher revenues from higher than average yields.

(i) Group Risk Plan (GRP)

An area-based yield contract was first introduced in the United States in 1995 and was known as the *Group Risk Plan* (GRP).[25] According to RMA, USDA, this Plan is a "dramatic departure from traditional approach to crop insurance protection," with less paperwork and generally less cost than MCPI.[26] The policy was developed on the basis that when an entire county's crop yield is low, most farmers in that county will also have low yields.

GRP bases coverage on the overall yield in a farmer's county rather than on that of the individual farmer's loss records, using a county index as the basis for determining a loss. Individual crop losses may not be covered if the county yield does not suffer a similar level of loss. This type of insurance is therefore most often selected by farmers whose crop losses typically follow the county pattern.

Producers must choose one coverage level for each crop and county combination. The grower selects the dollar amount of protection per acre and one of the five coverage levels (70, 75, 80, 85 or 90 percent) of the FCIC expected county yield. The expected county yield used for GRP is calculated using many years of county data from the National Agricultural Statistics Service (NASS) with an adjustment for the yield trend. Indemnities are paid when the NASS county yield for the insured crop

---

[25] The following details on the GRP are taken from the Risk Management Agency, USDA website: www.rma.usda.gov.

[26] The loss rate of the GRP (indemnities divided by premiums) since its introduction has been around 90 percent (Skees 2003b).

falls below the trigger level chosen by the farmer. Indemnity payments are made around six months after harvest of the crop.

GRP liability is calculated as:
Liability = Expected county yield × Indemnity price × Farmer's planted acreage

For example, if the corn yield forecast for the county yield is 100 bushels and a farmer chooses 90 percent coverage level, he or she can obtain a contract that will pay whenever the actual estimate of the county yield is below 90 bushels (the trigger = 90 bushels). Assume that the expected price on corn is US$2.00 per bushel. The GRP liability for the farmer with 100 acres is US$20 000 (= 100 × US$2 × 100). If the realized estimate of county yields is 60 bushels, the indemnity payment is calculated as US$20 000 × (90 – 60)/90 = US$6 666.

(ii) Group Risk Income Protection (GRIP)

Group Risk Income Protection (GRIP) adds a revenue component to GRP in order to expand revenue insurance choices. Coverage is based on county-level revenue, calculated as the product of the county yield and the harvest-time futures market price. GRIP makes indemnity payments in the event the county average per-acre revenue falls below the revenue chosen by the farmer ("trigger revenue").

Since GRIP is a GRP policy with a price component used to provide revenue protection, it differs from IP, CRC and RA in that it is designed to protect against widespread loss of revenue due to low county yields or crop prices based on a group or area concept. It does not protect individual producer revenue. The coverage levels for GRIP are 70 to 90 percent in 5 percent increments. GRIP is available only for corn and soybeans in the counties of selected States where GRP is offered.

As in other revenue insurance plans, GRIP uses two prices to measure price fluctuation during the insurance period. The *Expected price* is defined as the simple average of the final closing daily settlement prices for the five trading days prior to the sales closing date on the nearby Chicago Board of Trade (CBOT) December corn futures contract and the nearby CBOT November soybean futures contract for the current crop year. The *Harvest price* is defined as the simple average of the final closing daily settlement prices in November on the CBOT nearby December corn futures contract and in October on the CBOT nearby November soybean futures contract for the current crop year.

A GRIP indemnity payment will occur if the county revenue is less than the producer's trigger revenue based on the selected coverage level. For example, if a farmer selects US$244 protection per acre on 200 acres, the policy protection is US$48 800 (US$244 × 200 acres). Consider the following example: expected county revenue is US$271 and the insured buys 85 percent coverage, the insured's trigger revenue will be US$230 (85 percent of $271). If Federal Crop Insurance Corporation (FCIC) issues county revenue of US$225, the indemnity payment will be calculated as US$48 800 × (US$230-225)/230) = US$1 061.

(b) Weather-based index insurance

The virtues of weather-based index insurance are the same as in the area-yield index insurance. Its essential principle is that contracts are written against specific weather events or outcomes that are outside the control of either farmers or insurance companies.

The key innovation of such contracts is that insurance is linked to the underlying systemic risk defined as an index and recorded at a regional level (local weather station), rather than to the extent of loss (the resulting reduction in crop yields). In other words, the economic incentive for a farmer to manage so as to maximize production is unaffected by the weather-based index insurance, thus moral hazard can be avoided. Adverse selection is minimized as premiums are fixed without taking into account the composition of the risk pool of farmers in the insurance scheme. At the same time, as long as weather parameters correlate sufficiently with yields, it will result in a substantial reduction in a farmer's risk exposure (Hess, Richter and Stoppa 2002).

Index structuring

Weather-based index insurance compares a measurable, objective, correlated risk (e.g. rainfall, temperature, wind speed, etc.) to yields. For weather parameters to correlate sufficiently with yields, a weather (rainfall) index should be carefully designed to give greater weight to the more important periods for rainfall in the crop cycle more than those periods where rainfall is not as important to production (Bryla *et al*. 2003). An example of such index structuring will be shown later in the Moroccan case.

Contract design

The rainfall outcomes should be highly correlated with the value of regional agricultural production or income. In order of complexity, there are three basic alternatives: (i) a zero-one contract; (ii) a layered contract; (iii) a percentage contract. While the simple contracts may be more attractive as they are easier to understand, the more complex contracts are more likely to offer the best risk protection (Skees 2000).

(i) Zero-one contract

This contract would simply pay all liability (full face value) when cumulative rainfall is at or below the strike (the level of rainfall where payments begin) in a specific location. In other words, in years when the insured event occurs, all the people who purchased the insurance receive the same payment per unit of insurance. In all other years, no payments are made.

For example, if the most critical period for rainfall is the first two months after planting, one could design a policy that would pay the full face value of the contract when rainfall is below a specific percentage of average rainfall during that period. If an individual purchases a US$100 contract that pays if rainfall drops below 50 percent of the 500 mm average rainfall for the two-month period, the strike is 250 mm and all of the US$100 liability would be paid for the rainfall at or below 250 mm. In this case, the pure premium rate will be set at the liability multiplied by frequency percentage of the strike event. If such an event occurs 8.3 percent of the time according to the weather station records, the insured would pay US$8.30 as pure premium rate.

The simplicity of the zero-one design is attractive. However, the major shortcoming is that premium rates would have to be very high.[27] The policy may therefore have to be written for very low and infrequent events, such as once in 20 years or a 5 percent chance.

(ii) Layered contract

This contract with multiple strikes would pay a fixed additional amount when each layer is penetrated. A policy may be designed that would pay one-third of the face value for three levels of rainfall. For example, if rainfall is between 40 and 60 percent of the normal level, the insured might get a payment equal to 1/3; the next 1/3 would come if rainfall equaled 20 to 40 percent of normal; a full payment

[27] In addition, when clients know that the rainfall is close to triggering a full payment contract (the strike), they have more incentives to attempt to tamper with rainfall measures since a fraction of a centimeter of rain can make the difference between paying all or nothing (Skees, Hazell and Miranda 1999; Skees 2000).

would come for rainfall below the 20 percent of normal level. For a policy of US$100, the following payment schedule may be considered, which starts paying for rain below 60 percent of the average level:

Table 5 An example of a layered contract payment schedule

Rainfall	Payment	Odds (frequency)	Frequency × payout
200< R ≤300	US$33.33	15.8% (of rain below 300 mm)	0.158×US$33.33=US$5.3
100< R ≤200	US$66.66	3.0% (of rain below 200 mm)	0.030×US$33.33=US$1.0
R ≤100	US$100	0.0% (of rain below 100 mm)	0.000×US$33.33=US$0

The total pure premium will be set at US$6.3, the sum of each layer premium rate.

(iii) Percentage contract

This contract develops payouts as a function of rain below a set strike level. Payments would be calculated on the basis of percentage below a strike level rainfall. The percentage would be multiplied by the liability purchased. Using the same strike rainfall level of 300 mm, one would pay as follows:

Payment= [(300-actual rain)]/300] × liability

Case examples

(i) Morocco[28]

In order to evaluate the possibility of developing an insurance programme directly related to weather events, in 2001 the World Bank helped the Moroccan government launch an on-field international research project. The research team concluded that Moroccan agriculture could significantly benefit from a rainfall insurance programme and recommended the adoption of a pilot area-based rainfall insurance scheme.

To help the local insurance industry design the practical details of such a programme and facilitate access to international weather risk markets, the IFC, assisted by the Italian Government, sponsored a project to help structure the weather contracts and set up a company that would launch and manage such products.

Statistical correlation between rainfall and cereal revenue appears to be sufficiently strong in the 17 provinces in three climatic zones to support the weather-based index insurance. Using the historical data, the trigger or strike rainfall level was determined for each province. Proportional contracts were recommended from among the alternative contract types (See [iii] percentage contract in the above section "Contract design"). This type of contract pays in terms of percentage for levels of rainfall below a well-specified strike or threshold. For example, if the median rainfall in a given province is 300 mm from November to March and the strike rainfall is 250 mm, one might begin payments anytime rainfall is below 250 mm. The percentage would be calculated as (250-actual rain)/250.

For example, if the rainfall is 200 mm, the percentage would be 50/250 or 20 percent. Those at risk (farmers, agribusinesses, farmer organizations, banks, etc.) would purchase contracts at some specific

[28] The Moroccan case was taken from Hess, Richter and Stoppa (2002); Bryla *et al*. (2003); and Skees *et al.* (2001).

value, say, 1 000 MAD.[29] If the insured purchased 10 units of the 1 000 MAD unit, the actual payment would equal 0.20 x 10 x 1 000 = 2 000 MAD.

(ii) Forage rainfall plan in Ontario, Canada[30]

In the spring of 2000, Agricorp, the crown corporation charged with providing crop insurance to Ontario farmers, initiated a pilot project for a forage rainfall plan. Under this plan which offers protection against drought, insured customers receive a claim payment if the measured rainfall during the period from May through August is less than 80 percent of the long-term average for their area. Claim payments are made in September when final rainfall values are collected.

Rainfall is collected at predetermined sites using Agricorp's rain gauge network. The insured can choose the rainfall collection site that best represents the rainfall on their farm. Rainfall collection stations are located 15-km intervals throughout participating areas. The Customer premium rate is 3.56 percent of the policy value, of which 60 percent is paid by the government.

For example, a customer enrolled in the plan has a forage crop valued at US$22 000. The historical rainfall for this rainfall station for the months of May, June, July, and August is 72 mm, 81 mm, 82 mm, and 84 mm, respectively, for a seasonal total of 319 mm. Actual rainfall recorded for these months is 102 mm, 40 mm, 58 mm, and 62 mm, respectively. To limit the amount of offsetting, rainfall for May is capped at 125 percent of the historical level of 72 mm, or 90 mm. Overall, the recorded seasonal rainfall was 250 mm, which is only 78.37 percent of the historical average of 319 mm. As per the plan the customer is guaranteed 80 percent of his area's historical rainfall, the shortfall of 1.63 percent is multiplied by the policy value of US$22 000 to calculate a claim amount of US$358.60. This amount is doubled to reflect transportation costs associated with purchasing replacement forage. The total claim payment is US$717.20.

(c) Other types of index-based insurance

(i) Livestock mortality rate index insurance[31]

As part of the Mongolia Sustainable Livelihoods project (2003-2007), livestock mortality rate index insurance (herein called "mortality index insurance") was developed by the World Bank. The mortality rate is the ratio of total losses of adult animals divided by the number of animals reported at the end of the previous year census. The census of animals is undertaken every year. All data on animal numbers at the beginning of year and animal losses are collected from the Central Statistics Board of Mongolia.

The livestock mortality rate index insurance pays whenever the mortality rate 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. Here is an example of how sheep mortality index insurance works in a given region:

> The insurance would pay the purchaser when the mortality rate exceeds a rate of 6.5 percent. Assuming the value of average sheep to be around Tg 22 000,[32] a herder may purchase any value of insurance between Tg 4 400 and Tg 44 000 per animal reported. The premium would be the rate of 4 percent times the value of insurance chosen. The payment for losses (indemnity) would be the

[29] The Moroccan dirham (MAD) is the monetary unit of Morocco (US$1: 9.26 MAD as of May 2003).
[30] The Canadian case was taken from the Agricorp website: www.agricorp.com.
[31] This Mongolian case was based on Enkh-Amgalan and Skees (2002).
[32] The Togrog (Tg) is the monetary unit of Mongolia (US$1: 1 130 Tg as of May 2003).

purchaser's mortality rate times the value of insurance chosen. For example, if a herder had 500 sheep and chose Tg 20 000 per animal, he would purchase the insurance value of Tg 10 000 000 and pay 400 000 as premium. If the mortality rate of that region was 10 percent, he would receive a payment of Tg 1 000 000.

Since this insurance would pay all insured herders in the same region at the same rate regardless of the mortality rate for the policy holder, the incentives for individual herders to mitigate livestock losses not only remain strong, but would also be reinforced by competition among herders to survive the severe weather with a lower-than-average livestock mortality rate.

An alternative payout structure

One concern with the contract designed above is that once the mortality numbers are close to the trigger mortality rates, the officials developing the statistics for mortality rates may "create losses" by ensuring that the values will trigger a payment. This incentive might be stronger given the fact that levels of payment are high once the trigger is crossed.

An alternative to reducing these incentives would be to scale the payments once the trigger is crossed. For example, if the trigger were set at a 10 percent mortality rate, each percentage point above that level could be considered a "tick" and a certain level of payment could be tied to each "tick".

With a tick system, payout would only begin when the mortality rate is equal to 11percent and would be made gradually. For example, if the corresponding value at risk for cattle is 10 000 Tg, and a herder has 100 cattle, he would want insurance values of 10 000 000 Tg. If we consider that the maximum mortality rate in a given region may be 60 percent, then we have 50 ticks between the trigger value of 10 percent and 60 percent. We can divide the 10 000 000 Tg by 50 ticks to get a value per tick of 2 000 000 Tg. Thus, at 11 percent mortality the herder would receive 2 000 000 Tg. If the mortality is 12 percent, the payment would be 4 000 000 Tg, and so on.

Payment = (Mortality rate – Trigger) x Tick value = (12 percent - 10 percent) x 2 000 000

This system may also be more easily explained to a herder. The explanation is simple – for each point above the trigger, you will receive a payment of 2 million Tg. Premium rates and all other considerations could be recalculated using with the new payout rules.

(ii) Livestock Price Insurance

Both Livestock Risk Protection (LRP) and Livestock Gross Margin (LGM) mentioned in section (3) under "Price insurance" can also be classified as index-based insurance because indemnities are based not on actual prices received and/or paid by the producer, but rather on changes in the futures market prices (the index) for the animal (in the case of LRP) or the animal and feed inputs (in the case of LGM) during the life of the insurance policy.

Advantages of LRP and LGM as index-based insurance

In contrast to a hypothetical insurance product that pays indemnities whenever the actual price received by livestock producers falls below a specified trigger price, this index-based livestock price insurance has an evident advantage. If prevailing market prices fall below the trigger prices, insured producers have little incentive to aggressively market their livestock in order to attain the highest price possible. After all, the insurance will make up for any difference between the trigger price and actual price received. In other words, basing livestock price insurance on actual prices received would create severe moral hazard problems. Individual livestock producers, however, cannot significantly affect futures market prices. Therefore, as with GRP and GRIP, basing indemnities on an index rather than on actual farm experience would greatly reduce the potential for moral hazard.

Next, price risk (for livestock and major crops) tends to be much more systemic than crop production risk. Crop production shortfalls in one region do not necessarily imply the same in other regions. In contrast, price increases or decreases are much more likely to affect all producers, regardless of where their farm is located. This means that, in general, one would expect less basis risk for index insurance products such as LRP and LGM that provide price risk protection, compared to products like GRP or GRIP that protect against yield (revenue) risk (Barnett 2004).

IV. Further innovative risk management tools – alternatives to insurance

(1) Self-insurance through preferential savings

By depositing income into accounts during years of high net farm income, farmers could build a fund to draw on during low-income years. In this process, the government contributes to reserve building through either direct payment or tax exemption. The cases in operation in Canada, the United States, and France will be examined below.

(i) The Canadian Agricultural Income Stabilization (CAIS) programme[33]

To help producers protect their farming operations from both small and large drops in income, the Canadian Agricultural Income Stabilization (CAIS) programme was launched in the 2003 production year, replacing two programmes –one of income stabilization (the former Net Income Stabilization Account [NISA]) and one of disaster assistance (the Canadian Farm Income Programme [CFIP])**.** The CAIS programme is a long-term whole-farm risk-management tool available to eligible farmers regardless of the commodities they produce.

Producers select a protection level (between 70 percent at minimum and 92 percent at maximum) and then make the deposit required for the selected protection level at participating financial institutions. The level of protection indicates that if the margin drops to zero, the producer will receive a payment equal to the protection level times his reference margin. If there is a smaller decline in income, the producer may receive a payment equal to 100 percent of his reference margin.

Programme payments are triggered when his current year production margin (deduction of direct production expenses from farm sales) falls below his reference margin. A producer's reference margin is calculated as an average production margin over the previous five-year period, where the years with the highest and lowest margin are dropped. This represents the average historic margin and forms the basis of the producer's protection under the programme.

CAIS is based on the philosophy that producers and governments (federal and provincial) share the cost of replacing lost income. The government contribution increases as the loss deepens. At margin declines of up to 15 percent, each producer dollar is matched by one dollar from the government (50:50). At margin declines between 15 percent and 30 percent, each producer dollar is matched by $2.33 from the government (30:70). At margin declines greater than 30 percent, each producer dollar is matched by $4.00 from the government (20:80). (See Figure 1)

For example, if a producer who had a reference margin of $250 000 selected an 80 percent protection level against full margin decline, and realized his current year margin at $125 000, his margin decline would be $125 000 and his due programme payment would be calculated as in Table 6.

The deposit is not premium. It is owned by the producer and earns interest. A producer receives a government payment and a withdrawal from his account to cover the margin decline experienced in that year. Any funds left in his account roll forward, thereby reducing the producer's deposit to secure coverage in the next programme year.

---

[33] The following details on the CAIS Programme are taken from the Canadian Federal Ministry of Agriculture and Agri-Food website: www.agr.gc.ca.

Figure 1 Producer-government cost-sharing in CAIS Programme

Tier	Producer	Government	Reference Margin
1	50%($1)	50%($1)	0-15%
2	30%($1)	70%($2.33)	15-30%
3	20%($1)	80%($4)	30-100%

Source: Canadian Federal Ministry of Agriculture and Agri-Food website

Table 6 Calculation example of CAIS programme payment

Tier (producer/government ratio)	Portion of $65 000 decline	Producer funds	Government funds	Total payment
Tier 1 (50/50) ($1/$1)	$37 500 (15% of $125 000)	$18 750	$18 750	$37 500
Tier 2 (30/70) ($1/$2.33)	$37 500 (15% of $125 000)	$11 250	$26 250	$37 500
Tier 3 (20/80) ($1/4$)	$50 000 ($125 000 - $75 000)	$10 000	$40 000	$50 000
Total		$40 000	$85 000	$125 000

(ii) Tax-deferred savings accounts for farmers in the United States and France

Since 1998, as the US Congress sought to expand the farm safety net and ease stress from low prices and regional disasters, it has been taking into consideration the Farm and Ranch Risk Management (FARRM) programme of tax-deferred savings accounts for farmers to help them manage year-to-year income variability (Durst and Monke 2001; Monke and Durst 1999).

Farmers can obtain a federal income tax deduction for a FARRM deposit of up to 20 percent of eligible farm income. Eligible farm income is defined as taxable net farm income plus net capital gains from the sale of farm assets including livestock but not land. Deposits would be made to interest-bearing accounts at approved financial institutions, and earnings would be distributed and taxable to the farmer annually.

Withdrawals from principal would be at the farmer's discretion (no price or income triggers for withdrawal) and taxable in the year withdrawn. Deposits may stay in the account for up to five years, with new accounts added on a first-in-first-out basis. Deposits not withdrawn after five years would incur a 10 percent penalty. FARRM funds would also have to be withdrawn if the participant stops farming for two consecutive years.

In France, a similar programme of tax-deferred savings has been operating since 2002. Farmers may deduct a portion of their taxable profit each year on condition that it will be deposited to the precautionary individual professional saving account (*une épargne de précaution à vocation professionnelle*), which is to be used in the event of natural, economic or family hazards. This saving would be regarded as a farming expense; therefore income tax for that portion is deferred until it is withdrawn (Babusiaux 2000; Boyer 2002).

While a programme of tax-deferred risk management accounts have the potential to encourage farmers to provide their own safety net by saving money from high-income years to withdraw during low-income years, it has potential limitations. Many farmers, particularly those most in need of risk management tools such as limited resource, including beginning farmers, have low levels of taxable income for building meaningful account balances, and programme benefits are likely to be concentrated among operators with large farms and relatively high off-farm income (Monke and Durst 1999).

(2) Market-based commodity price risk management instruments

Commodity price volatility is a major source of instability and uncertainty in commodity-dependent developing countries, affecting governments, producers (farmers), traders, processors, and financial institutions.[34] Over the past half century, attempts to deal with commodity price volatility relied on physical buffer stocks, stabilization funds, government intervention in commodity markets, and international commodity agreements to stabilize prices. These schemes have proven largely unsuccessful, sometimes spectacularly so (Yabuki, Varangis and Larson 1998).

As the poor performance of stabilization schemes became more evident, academics and policy-makers began to advocate market-based commodity risk management instruments. The rise of these instruments was aided by the globalization of commodity markets, market liberalization and lower trade and capital control barriers (International Task Force on Commodity Risk Management 1999). Market-based systems are most relevant for standardized commodities traded internationally in large volumes, mainly coffee, cocoa, rubber, cotton, grains, sugar, and oilseeds (and some livestock products).

There are three basic types of risk management tools (generally referred to as "derivatives"[35] or hedging instruments):

- Forward contracts

  A forward contract is an agreement between two parties to undertake an exchange at an agreed future date at a price now. Unlike a futures contract, a forward contract is not usually transferable and its terms are not standardized. It is a bilateral agreement between the buyer and seller, and therefore both parties take on counterparty risk. As such, it may be for any amount and period and have terms and conditions specific to those parties (Moles and Terry, 1997).

- Futures contracts

  A futures contract is similar to a forward contract: an agreement between two parties to undertake a transaction at an agreed price on a specified future date. Nevertheless, futures contracts differ significantly from forward contracts in four technical respects:

  (i) Contract terms (amounts, grades, delivery dates, etc.) are generally standardized.

[34] During 1983-1998, prices of many commodities fluctuated from below 50 percent to above 150 percent of their average prices. More than 50 developing countries depend on three or fewer commodities for more than half of their export earnings (International Task Force on Commodity Risk Management 1999).

[35] Derivatives are contracts that give the right, and sometimes the obligation, to buy or sell a quantity of the underlying assets (usually referred to simply as the "underlying"), or benefit in another way from a rise or fall in the value of the underlying. There are four principal classes: forwards; futures; swaps and options. They are called derivatives because their price behaviour comes from the underlying asset's price movements (Arnold, 2004, 128 and 158; Moles and Terry 1997, 128).

(ii) Transactions are handled only by organized exchanges through a clearinghouse system.
(iii) Profits and losses in trades are settled daily.
(iv) Futures contracts require depositing a certain amount of margin money in exchange as collateral.
(v) While forward contracts involve physical delivery at maturity, futures contracts are usually closed before or at maturity (Varangis and Larson 1996). It is a type of forward contract traded through a futures exchange, normally for delivery of a fixed quantity of an underlying assets or instrument at a fixed price (Moles and Terry 1997).

In contrast to buying options, which gives the buyer the choice to walk away from the deal, in the case of futures the buyer is committed and is unable to back away. This is a very important difference. In purchasing an option the minimum the purchaser can lose is the premium paid, whereas the purchaser can lose multiples of the amounts he or she employs in taking a futures position.

- Options contracts

An option contract gives one party the right but not the obligation to buy or sell a specified financial instrument, commodity or some other underlying asset at a given price at or before a specified date. The purchaser of the option can either exercise the right or let it lapse – the choice is his or hers. Exchange-traded[36] options, such as futures contracts, are standardized. There are also so-called "over-the-counter options"[37] offered by banks and commodity brokers, which can be customized. The purchase of an option is equivalent to price insurance; therefore, there is a price to be paid just like an insurance premium,.

Options are either *call options* or *put options.* A call option gives the holder the right but not the obligation to buy the underlying futures at a specific price during a given period of time. Call options are usually purchased as an insurance against price increases. A put option gives the holder the right but not the obligation to sell the underlying futures at a specific price during a given period of time. Put options are usually purchased as an insurance against price declines.

How the instruments work

On behalf of their producers, producers' organizations, local banks, or exporters can purchase derivatives that are traded on international exchange (or based off these exchanges). In most cases, they are simple put options. In order to purchase the put option, producers must pay a market-related fee or a premium. When the price rises during the option contract period, the producer receives no payout from the contract, but can still sell his physical product for the market price in order to benefit from the rising prices. However, when the price falls during this period, the producer receives a payout equal to the difference between the price that the producer chose to insure with the price risk management contract, and the international market price on the last date of the option coverage (Bryla *et al.* 2003).

Case examples

[36] securities or derivatives that are traded on organized and regulated exchanges (cf. over the counter)

[37] securities or derivatives that are traded on organized exchanges outside organized and regulated exchanges by dealers trading directly with one another, or their counterparties, by telephone or screen, allowing tailor-made transactions (Arnold 2004)

(i) Mexico: Cotton price support scheme[38]

Since Mexico joined the North America Free Trade Agreement (NAFTA), the government has moved to liberalize its agricultural sector and make it more competitive worldwide. As an alternative to long-standing policies of guaranteed minimum prices, the government designed a sustainable programme to transfer the risks from growers to international markets.

The Support Services for Agricultural Marketing Agency (ASERCA), a decentralized administrative body providing commercial support to farmers, offers them the chance to participate in a programme guaranteeing a minimum cotton price for a fixed fee. The minimum price is fixed using the New York cotton futures exchange. For a fee, ASERCA offers a guaranteed price (in US dollars) and hedges its own risk by using the fee to purchase a put option on the exchange for future delivery at harvest time.

The put option gives ASERCA the right to sell cotton on a specific future date at a pre-specified price, known as the strike price. Should prices subsequently fall, ASERCA pays farmers the difference between the New York price at harvest and the minimum price. This difference is exactly equal the payoff value of the put option. If prices rise instead, ASERCA makes no payment to farmers. By paying a fee and participating in the programme, a farmer in effect purchases insurance against a drop in prices below a certain level. In fact, the programme refers to the fee as a "premium".

In summary, ASERCA functions as an intermediary and facilitator between the producers and the commodity broker. After the producer has deposited his or her portion of the premium in an ASERCA account at a local bank, the producer places the order for an option and ASERCA buys the option through the U.S. broker directly. The Mexican banking sector is more aware of the benefits of price risk management. Many banks now require participation in ASERCA programme to obtain loans.

The Mexican government, through ASERCA, subsidized 100 percent of premium payments in 1994, but since then the subsidy has been reduced to 50 percent. However, if the market conditions are favourable and the producer benefits from the option, then ASERCA is reimbursed when the option is exercised. Actually, strongly influenced by the market conditions prevailing in 1997, ASERCA was reimbursed for 80 percent of its subsidies.

(ii) Guatemala: the hedged coffee loan programme[39]

The coffee sector in Guatemala provides jobs to 30 percent of the population, and accounts for around 30 percent of the country's total export in a normal year. Asociación Nacional de la Industria del Café (The National Association of Coffee) (ANACAFE) – a non-profit and private organization including around 60 000 coffee producers from all over the country – introduced a hedged coffee loan programme in 1994. This aims at improving the access of coffee producers to commercial bank financing. Hedging is required under the programme in order to reduce the risk to the bank, which then provides credits to coffee farmers at lower interest rates.

ANACAFE verifies the production potential of the farm and provides a list of banks with which it has agreements from which the farmer chooses. The bank approves the loan which is conditioned upon the farmer's obtaining a hedge (for example, selling forward or purchasing options) from an exporter. The hedge provides protection against the drop in market prices, thus guaranteeing that they will be able to cover the loan payments.

[38] The Mexico case is based on Varangis and Larson (1996), Yabuki, Varangis and Larson (1998) and the International Task Force on Commodity Risk Management (1999).

[39] The Guatemala case is based on information from the International Task Force on Commodity Risk Management (1999).

To hedge prices, producers usually contact an exporter with whom they fix a price for future delivery of the crop purchased. Subsequently, exporters sell futures or purchase options in the New York Coffee, Sugar and Cocoa Exchange (CSCE) to hedge their assumed exposure. In the case of options, exporters pay the premium in advance and deduct from the price they pay producers upon delivery.

Moreover, if the producer fails to deliver and prices increase, exporters could incur significant financial losses. For this reason, ANACAFE assists in providing estimates of the expected crop so that producers will not over- or under-hedge their exposure. Most of the hedging operations involve future/forward contracts; however, there is an increase in the use of option strategies such as purchase of puts or sale of calls.

Under the hedged coffee loan programme, ANACAFE is a facilitator, not a director, creditor or hedger. The government does not incur any cost nor provide any type of subsidies. While there is no formal system to enforce hedging contracts, ANACAFE is trying to play the role of arbiter so that producers and exporters comply with their obligations.

(3) Weather derivatives

Weather has always been a source of risk for many economic activities, but it was not until the late 1990s that firms explored the possibility of hedging against weather-related variability through weather derivatives (WDs) (Stoppa and Hess, 2003). The impetus for developing weather markets was given by the large deregulation of the U.S. energy sector in 1997. Since energy prices were no longer controlled, energy traders started to think of financial solutions for trading their exposure to weather risks within their own industry.

WDs are contingent securities that promise payment to the holder based on the difference between an underling weather index – accumulated snowfall, rainfall or temperatures over a specified period – and an agreed strike value (Richards, Manfredo and Sanders, 2004).[40] WDs exist as either futures or options and are traded either on formal exchanges (e.g. the CME) or over the counter. Although some initial thought has been given to using various weather events as the underlying, most of the weather hedges realized to date refer to just one facet of the weather, i.e. the temperature.

Temperature-based WDs are based on so-called accumulated "heating degree days" (HDDs) and "cooling degree days" (CDDs) over a defined period.[41] As a rule, HDDs measure the average temperature for the winter half-year, while CDDs usually measure average temperature for the summer half-year. HDD options can be used to obtain protection against excessively warm winters, whereas CDD options provide a safeguard against excessively cool summers. The option strategies available in this context are HDD/CDD calls and puts. The system for HDD/CDD calls and puts, for example, is as follows:

[40] WDs differ from conventional derivatives in that there is no original, negotiable underlying asset or instrument that normally forms the basis of any derivative. For example, financial derivatives are based on shares, share index, bonds, exchange rates or currencies, all of which are negotiable objects, something that cannot be said of the weather in view of its numerous facets. The underlying of WDs is based on data, such as temperature, which influence the trading volume or production of goods and services. (Müller and Grandi 2000).

[41] The idea of structuring a HDD/CDD index came about in order to correlate revenue fluctuations and temperature. Analysis of the relationships between temperature and demand for heating in the United States showed that the threshold of 65º F, or 18º C, was the turning point for increase in energy demand for heating. Based on such a threshold, the number of heating or cooling degrees per day is given by HDD = max [0; 65º-T] or CDD = max [T-65º;0], where T is the average temperature on a particular day. For example, if T is 45º F, the number of HDD is 20. A HDD is defined as the amount by which the average temperature on a given day falls below 65º F. A CDD, on the other hand, is the amount by which the average daily temperature exceeds 65º F (Stoppa and Hess 2003; Richards, Manfredo and Sanders 2004).

Table 7 System for temperature options

Option type	Protection against ...	Exercised* when	Payout
HDD call	overly cold winters	HDD> strike value	Tick size**×(HDD-strike value)
HDD put	overly warm winters	HDD< strike value	Tick size×(strike value-HDD)
CDD call	overly hot summers	CDD> strike value	Tick size×(CDD-strike value)
CDD put	overly cool summers	CDD< strike value	Tick size×(strike value-CDD)

* To exercise a call/put is to elect to buy/sell the underlying instrument at the price specified in the option contract, but here this means that the conditions for payout are met.
** Tick size is defined as money value per unit of index.
Source: Müller and Grandi (2000).

Using a CDD call as an example,[42] the option will acquire value when the accumulative CDD index rises above an agreed strike level (strike value in Table 7). At the agreed expiry date, the holder receives a payment if the CDD index rises above the strike level. The amount of the payment is equal to the CDD index less the strike level, multiplied by some notional money value per unit of the index (stick size in Table 6). Ideally, the buyer of the derivative is thus compensated by the underwriter for an amount that offsets the real business losses from adverse weather. For example, an amusement park owner would buy a CDD put that pays out if there is a string of unusually cold days. The value accumulated with the long put position will help offset the lost revenue from customers who have stayed away during the cool weather period. If, on the other hand, the intervening period is unusually hot so that the CDD index rises well above the strike level, then the put expires worthless. A farmer's interest in WDs is analogous to the amusement park owner example. A fruit grower, for example, would likely buy a CDD call so that he or she is compensated if sustained, unusually hot weather during the critical growing period reduces yield.

WDs in agriculture[43]

In order to develop WDs for agriculture, the weather variable must be measurable, historical records must be adequate and available, and all parties involved in the transaction must consider such measures objective and reliable. In addition, the existence of a complex relationship between the product and the weather factor must be carefully explored.[44] For agricultural production, however, the relationship is not always straightforward since differences in products, crop growth phases and soil textures, among others have different responses to the same weather factor. Also, the more skilled and advanced the cultivating techniques, the greater the entrepreneurial influence on yields and the smaller the portion of variability generated by the specific weather elements.

(4) Insurance securitization[45]

Securitization of catastrophic risks is an emerging trend that attempts to bring together insurance and capital markets to address the limits of reinsurance. One characteristic of catastrophe insurance is that

[42] The examples below were taken from Richards, Manfredo and Sanders (2004).
[43] This section is based on Stoppa and Hess (2003).
[44] In this connection, Turvey examined daily rainfall and temperature data from 1935 to 1996 at Woodstock, Ontario, Canada. Cumulative rainfall and cumulative degree-days above 50º F were correlated with average county yields. Using a Cobb-Douglas production function, it was shown that corn and soybeans were more sensitive to low temperatures, while hay was more sensitive to low rainfall. The results indicate that specific-event weather conditions can contribute significantly to crop yield risk and thus weather insurance/derivatives can play a significant role in managing agricultural production risks (Turvey 2001).
[45] See Enz *et al*., (2004); Laster and Raturi (2001); Miranda and Vedenov (2001); Torre-Enciso and Laye (2001) and Skees (1999 and 2003b).

certain loss potentials exceed the total capacity of even the global insurance industry.[46] For example, reinsurance was in very short supply in the wake of Hurricane Andrew (1992) and the Northbridge Earthquake (1994), causing premium rates to more than double between 1991 and 1994. These events drove industry efforts to find alternative sources of reinsurance capacity – one of the new mechanisms is securitization.[47]

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. Two principal forms of securitization are catastrophe bonds and exchange-traded catastrophe options.

(i) Catastrophe bonds

Catastrophe or "Cat" bonds, just like corporate bonds, are debt instruments providing capital contingent upon the triggering of a certain event. In exchange for taking risk, those investors receive a relatively high rate of return if no loss event occurs. If, however, a pre-defined catastrophic event occurs or actual catastrophe losses exceed a specified amount, investors suffer a loss of interest, principal, or both. These funds are transferred to the insurer, in fulfillment of the reinsurance contract.[48] Since catastrophes should be independent of the general economic trends, fund managers are attracted to Cat bonds to diversify their portfolios with an instrument that has zero correlation with traditional equity markets.[49]

(ii) Exchange-traded catastrophe (call) options[50]

Exchange-traded catastrophe (Cat) options are standardized contracts that give the purchaser the right to a cash payment if a specified index of catastrophe losses for a specific period reaches a specified level, known as the *strike price*. If the catastrophe index remains below the strike price for the pre-specified time period, the options expire worthless and the seller keeps the premium. If, however, the catastrophe loss index exceeds the strike price, the purchaser of the options receives – and the seller provides – cash payment equal to the difference between the catastrophe index and the strike price. An insurer or reinsurer that wants to use this form of securitization to hedge catastrophe risk can buy Catcall options from investors.

The Property Claim Services (PCS) Cat options that trade on the Chicago Board of Trade (CBOT) are the first exchange-traded Cat options (Skees 2003b). 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 indexes (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.

---

[46] "The primary insurance and reinsurance industries in the United States, only have approximately U$245 billion of capital that must service a country that has U$25 to U$30 trillion worth of property. If a US$50 billion catastrophe were to occur in the United States, approximately 20 percent of the capital of the primary and reinsurance industries would be wiped out" (Martínez Torre-Enciso and Laye 2001).

[47] Since its inception, the market for risk-linked securities (RLS) has witnessed worldwide issuance in excess of U$9.5 billion. Catastrophe bonds, a major segment of the RLS market, of approximately U$7.5 billion have been issued since 1996 (Enz, *et al.* 2004).

[48] In 2003, over U$2 billion worth of Cat bonds were issued doubling the 2002 volume of issuance. The market ended the year with over U$4.3 billion outstanding, an increase of approximately 53 percent from year-end 2002. It is foreseen that annual securitizations may grow to US$10 billion by 2010. This is just the beginning. (ibid).

[49] Skees and Barnett (1999) and Skees (2003b)

[50] Concerning "exchange-traded" and "call options", refer to section (2) above, "Market-based commodity price risk management instruments."

(5) Area-yield reinsurance and options[51]

(i) Area-yield reinsurance

Like insurance securitization serving as another type of reinsurance against systemic risks, area-yield reinsurance is proposed as a mechanism for strengthening the affordability of reinsurance, particularly in the case of government reinsurer. Area-yield reinsurance contracts would indemnify the owner (direct insurer) based on shortfalls in regional yields, offering crop insurers protection against catastrophic losses arising from widespread natural disasters. An area-yield reinsurance contract would be written for a specified region, crop and yield guarantee, and would be settled on final regional crop yield estimates of the central statistics authorities.

For the United States example, in the case of a US$10 000 Iowa corn reinsurance contract with a yield guarantee of 120 bushels per acre, a final USDA Iowa corn yield estimate of, for instance, 90 bushels per acre would imply a 25 percent yield loss. The indemnity paid on the reinsurance contract would be proportional to the contract size and the percentage yield shortfall, in this case 25 percent of US$10 000, or US$2 500. If the final Iowa corn yield estimate exceeded the yield guarantee, then the area-yield reinsurance contract would pay no indemnity.

In a simulated scenario, researchers have demonstrated that there was significant risk reduction to the insurer when area-yield reinsurance was available at the state level. More importantly, their results show that state area-yield reinsurance contracts would allow crop insurers to reduce their portfolio risk to levels comparable to those enjoyed by automobile and health insurers.

Area-yield reinsurance could be sold either by a reinsurance company or by the government at a low cost. Area yield cannot be manipulated by crop insurers, thus it could substantially reduce the moral hazard and adverse selection problems that have existed between the reinsurer and the insurer or between the government and the insurer.

(ii) Area-yield options

Commodity exchanges could make a market in area-yield options contracts the structure of which would be the same as area-yield reinsurance contracts. The writer of the option, like the writer of the reinsurance contract, would pay the bearer of the contract the value of the shortfall in the regional yield. Area-yield options contracts would differ from area-yield reinsurance contracts only in who writes the contracts and how the premiums are set. Area-yield reinsurance contracts would set premiums based on actuarial considerations, but area-yield options would be written by profit-driven futures markets participants, and premium rates would be set by an open market process.

Area-yield options contracts would be efficiently priced on a competitive market and would offer open public discovery of aggregate yield expectations. Option premiums would ultimately reflect the full spectrum of private information available as to how prevailing weather patterns are affecting regional yield expectations. By contrast, the actuarial fairness of a government or private reinsurance agreement is limited by the available information, and errors in ratemaking, whether deliberate or accidental, could induce adverse selection. Another benefit from area-yield options is that they would be available to anyone whose income varies with aggregate agricultural production. These include insurers, farmers, grain elevators, barge operators, food processors, rural banks and farm implement dealers.

[51] This section relied upon Miranda and Glauber (1997) and Makki (2002).

In June 1995, the Chicago Board of Trade (CBOT) launched trade in Iowa Area-Yield futures and options contracts and then expanded trading in 1996 to introduce corn yield contracts for Nebraska, Illinois, Indiana, Ohio, and the entire United States.

V. Summary and conclusion

When drawing up new solutions for managing market risks and climate-driven production risks, various insurance mechanisms are preferable to *ad hoc* disaster aids, which are now known to have severe drawbacks compared with insurance.[52] Disaster aid has counter-productive effects since it encourages farmers to neglect their responsibility for managing their own business risk. It tends to encourage production in marginal situations by indiscriminately covering crop losses – e.g. in fragile, arid countryside or flood-prone wetlands. In contrast, crop insurance actively reduces risk exposure by promoting public and private risk management (Ortloff 1998). Moreover, an important aspect to consider in drafting insurance solutions for the agricultural sector is that the government measures for assistance in crop insurance schemes are still permissible within the WTO framework.

With these issues in mind, this paper examines the development of agricultural insurance products and schemes, and explores innovative ideas to reform existing programmes.

Single-peril (e.g. hail) crop insurance has a long history of private sector involvement because the losses are comparatively independent, hence insurable. As agriculture becomes more sophisticated, however, producers have demanded insurance that covers a greater number of agricultural risks from natural hazards, including pests and diseases, to price fluctuations. Since multi-peril schemes allow traditionally uninsurable risks to be included alongside insurable risks, state involvement becomes inevitable to maintain the schemes, either by paying part of the farmers' insurance premium and reimbursing the private insurers' expenses (state subsidies), or by covering private insurers' overall retention in the pools against excessive losses (state reinsurance).

Unfortunately, government support programmes often come at a high social cost, as seen in Chapter II. Moreover, sustained government involvement in agricultural risk insurance may have had several unintended consequences,[53] although intended to provide economic stability to agriculture in an efficient manner. As a public programme, crop insurance may never attain the economic efficiency of a market-based private insurance (Makki 2002).

Some innovative ideas discussed in this paper include coping with the inherent problems associated with traditional crop insurance and facilitating more efficient and less market- distorting allocation of resources by market-based approaches. They can all be said to be directed at:

(i) satisfying the growing needs of farmers to expand the insured perils (e.g. revenue insurance, whole farm insurance);

---

[52] In the U.S., the Agricultural Risk Protection Act of 2000 increased premium subsidies for all coverage levels in an attempt to bring more farmers into the crop insurance programme and lessen the need for ad hoc disaster assistance (Makki 2002).

[53] In addition to the high social cost due to high loss ratios, Makki (2002) points out acreage response, changes in production practice, and increased land values, as substantiated by relevant studies:

(i) High loss ratios imply that riskier crops and regions benefit more from crop insurance. This leads to the argument that the subsidized crop insurance programme distorts production patterns and allocation of resources in agriculture;

(ii) Effects of increased premium subsidy levels on acreage response is fairly modest;

(iii) Even though the aggregate response seems to be moderate, there are concerns that the subsidized crop insurance programme may cause cropping to be extended to environmentally fragile lands, including pasture and marginal areas. As a result, output will exceed economically efficient levels and suppress prices for all producers. In other words, such a response would increase both production and price risks to producers, undermining the very purpose of the programme;

(iv) Like any other government commodity programmes, subsidized crop insurance also has the potential to land values in the long run. That can increase debt service cost and the unit cost of production. High land values can create barriers to entry for new farmers – the very thing that government wants to prevent.

(ii) minimizing or eliminating the moral hazard and adverse selection associated with traditional yield risk covering insurance (e.g. index-based insurance, weather derivatives, area-yield options);

(iii) diversifying alternatives to insurance (e.g. self-insurance through preferential savings);

(iv) approaching a market-based solution (e.g. market-based commodity price risk management instruments, weather derivatives);

(v) strengthening the capacity of reinsurance market against systemic risk arising from natural catastrophes (e.g. insurance securitization, area-yield reinsurance).

Noteworthy among these innovative ideas are index-based and market-based approaches in the context of developing countries, where governments cannot afford direct support for producers. Such approaches offer positive advantages:

- In addition to not being susceptible to moral hazard and adverse selection, the index-based approach involves lower transaction costs since it does not need farm-level yield data and loss adjustment relative to traditional insurance products, and in the case of rainfall insurance, has a market open to everyone. This would therefore enable the development of independent private insurance markets.
- It would be possible to transfer the systemic portion of the country's risk to the global market.[54]
- Commodity price risk management instruments, such as forward contracts, futures and options, provide farmers with opportunity to protect their short-term commodity revenues from declines in world commodity prices.[55]
- These instruments also enable access to credit, an important issue given the financing problems that farmers face in several developing countries.[56]

Governments would need to provide the requisite technical and institutional assistance to facilitate such approaches, possibly with the support of international financial institutions and expert organizations. Such assistance would make sure that the index measurement systems are reliable and

[54] When the Government of Nicaragua initiated index-based rainfall insurance in late 1990s, it formed a partnership with several international reinsurance companies or financial institutions (e.g. Swiss Re, Munich Re, Merrill Lynch, Aon, etc.) and established a special purpose vehicle, such as an off-shore reinsurance company, with the sole purpose of providing reinsurance for the government of Nicaragua. The newly created company would then issue contingency securities (catastrophe bonds, etc.) to be offered at exchanges or over the counter (OTC) trading. The recognizable names of financial institutions behind the issue would serve as an additional guarantee. Since the correlation between rainfall in Nicaragua and variations in the international financial market is practically non-existent, the rainfall insurance contract should provide an ideal diversification instrument for investor portfolios. The government of Nicaragua, on the other hand, gets access to funds that can be used for disaster relief and reinsurance of domestic agricultural insurance, etc. (Miranda and Vedenov 2001).

[55] These instruments cannot stop the overall downward trend in prices. However, they can protect against the negative effects of world price volatility within a crop year. This allows farmers to manage their farms more efficiently in terms of allocating inputs and labour. Using risk management instruments, farmers have more time to adjust to long-term downward price falls. In addition, farmers can use price risk management instruments to improve the timing of sales and potentially achieve a better price (World Bank 2003).

[56] Sharp declines in commodity prices often seriously affect the functioning and viability of much of the formal and informal credit sectors, particularly if these commodities are important to the agriculture sector. This makes it increasingly likely that any future lending from banks to the agricultural sector will require increased collateral and guarantees as a necessary condition for credit. Price risk management instruments may allow banks to extend greater amounts of lending at better rates with the knowledge that their clientele can secure a minimum price for their commodities (World Bank 2003).

free from any possible tampering, create the exchange markets and provide the necessary training for farmers in order to equip them or their organizations to conclude transactions with private sector providers.

References

Arnold, G. 2004. *The Financial Times' Guide to Investing*: a definitive introduction to investment and the financial markets. Harlow, UK, FT/Prentice Hall.

Babusiaux, C. 2000. *L'assurance récolte et la protection contre les risques en agriculture*. Report to the Parliament, October. Ottawa, Canada.

Barnett, B. 2004. *Agricultural index insurance products: strengths and limitations*. Presented at Agricultural Outlook Forum, 19 February, Washington, USA, USDA.

Berg, E. 2002. *Das system der ernte- und einkommensversicherungen in den USA – ein modell für Europa?* In *Berichte über Landwirtschaft*, Band 80 (1), March.

Berliner, B. 1982. *Limits of insurability of risks*. Englewood Cliffs, NJ, USA, Prentice-Hall.

Boyer, P. 2002. *The French system of protection against the risks of farm production and its recent evolution.* Presented at the International Conference: Agricultural Insurance and Income Guarantees, May 13-14, Madrid, Spain

Bryla, E., Dana, J., Hess, U. & Varangis, P. 2003. *The use of price and weather risk management instruments*. Presented at the International Conference: *Paving the Way Forward for Rural Finance*, June 2-4, Washington DC, USA.

Dismurke, R. 1999. Recent developments in crop yield and revenue insurance. *Agricultural Outlook*, May. Economic Research Service, USDA.

Dismurke, R. 2002. *Crop insurance in the United States*. Presented at the International Conference: Agricultural Insurance and Income Guarantees, May 13-14, Madrid, Spain.

Durst, R. & Monke, J. 2001. Federal tax policy and the farm factor. *Agricultural Outlook Forum*, February. Available at USDA website (see below).

Enkh-Amgalan, A. & Skees, J. *2002. Examining the feasibility of livestock insurance in Mongolia*. Working Paper, No. 2886, September. Washington, D.C., USA, World Bank.

Enz, R., Heck, P., Green, J., & Suter, S. 2004. *Natural catastrophes and man-made disasters in 2003: many fatalities, comparatively moderate insured losses*. *Sigma* (No.1). Economic Research & Consulting, Swiss Reinsurance Company. Available at Swiss Re website (see below).

FAO. 1991. *Crop Insurance Compendium*. Rome.

Goodwin, B.K. 2001. Problems with market insurance in agriculture. *American Journal of Agricultural Economics* Vol.83 (No.3) August.

Gudger, M. 1991. *Crop insurance: failure of the public sector and the rise of the private sector alternative*. In Holden, D., Hazell, P. & Pritchard, eds. *Risk in agriculture*. Proceedings of the tenth Agriculture Sector Symposium, Washington, D.C., USA., World Bank.

Hardaker, J.B., Ruud, R.B.M. & Anderson, J.R. 1997. *Coping with risk in agriculture*. Wallingford, Oxfordshire, UK, CABI International.

Harwood, J., Heifner, R., Coble, K., Perry, J. & Agapi Somwaru, A. 1999. Managing risk in farming: concepts, research and analysis. In *Agricultural Economics Report,* No. 774 (March). Available at RMA, USDA website (see below).

Hazell, P. 2001. *Potential role for insurance in managing catastrophic risks in developing countries*. Available at International Food Policy Research Institute website (see below).

Hazell, P., Bassoco, L.M. & Arcia, G. 1986. *A model for evaluating farmers' demand for insurance: applications in Mexico and Panama*. In Hazell, P., Pomareda, C. & Valdes, A., eds. 1986. *Crop insurance for agricultural development – issues and experience*. Baltimore, USA, Johns Hopkins University Press.

Hazell, P., Pomareda, C. & Valdés, A., eds. 1986. *Crop insurance for agricultural development – issues and experience*. Baltimore, USA., Johns Hopkins University Press.

Hess, U., Richter, K. & Stoppa, A. 2002. *Weather risk management for agriculture and agri-business in developing countries*. In Dischel, ed. *Climate risk and the weather market, financial risk management with weather hedges*. London, England, Risk Books.

Hueth, D.L. & Furtan, W.H., eds. 1994. *Economics of agricultural crop insurance: theory and evidence*. London, England, Kluwer Academic Publishers.

International Task Force on Commodity Risk Management. 1999. *Dealing with commodity price risk volatility in developing countries: a proposal for a market-based approach*. Discussion Paper for the Roundtable on Commodity Risk Management in Developing Countries. September. 1999. Available at the International Task Force on Commodity Risk Management in Developing Countries website (see below).

Knight, T.O. & Coble, K.H. 1997. Survey of U.S. multiple peril crop insurance literature since 1980. *Review of Agricultural Economics,* Vol.19 (Spring/Summer).

Laster, D.S: & Raturi, M. 2001. Capital market innovation in the insurance industry. *Sigma* (No.3), Economic Research & Consulting. Zurich, Switzerland, Swiss Re. Available at Swiss Reinsurance Company website (see below).

Makki, S.S. 2002. *Crop insurance: inherent problems and innovative solutions*. In Luther Tweeten, L. & Thompson, S.R. eds. *Agricultural policy for the 21st century.* Iowa State University Press, Ohio, USA.

Martínez Torre-Enciso, I. & John E, Laye, J.E. 2001. Financing catastrophe risk in the capital markets. *International Journal of Emergency Management,* Vol.1 (No.1).

Meyer, C. 2002. *Agricultural insurances: future development*. Presented at the International Conference: *Agricultural Insurance and Income Guarantees*, May 13-14, Madrid, Spain.

Miranda, M. & Glauber, J.W.1997. Systemic risk, reinsurance, and the failure of crop insurance markets. *American Journal of Agricultural Economics,* Vol.79 February.

Miranda, M. & Vedenov, DV. 2001. Innovation in agricultural and natural disaster insurance. *American Journal of Agricultural Economics* Vol.83 (No.3) August.

Moles, P. & Terry, N.1997. *The Handbook of International Financial Terms*. Oxford University Press, Oxford, England.

Monke, J. & Durst, R. 1999. Tax-deferred savings accounts for farmers: a potential risk management tool. *Agricultural Outlook*. Economic Research Service, USDA.

Müller, A. & Grandi, M. 2000. *Weather derivatives for protection against weather risks*. Munich Re ART Solutions Series. Available at Münich Re Group website (see below).

Ortloff, W. 1998. *Approaches to a changing risk profile*. Available at Swiss Reinsurance Company website (see below).

Quiggin, J. 1994. *The optimal design of crop insurance*. In Hueth, D.L. & Furtan, W.H.,eds. *Economics of agricultural crop insurance: theory and evidence*. London, England, Kluwer Academic Publishers.

Richards, T.J., Manfredo, M.R. & Sanders, D.R. 2004. Pricing weather derivatives. *American Journal of Agricultural Economics* Vol.86 (No.4) November.

Roberts, R.A.J. 2005. *Insurance of crops and forests in developing countries*. Rome, FAO (in print).

Siamwalla, A. & Valdés, A. 1986. *Should crop insurance be subsidized?* In Hazell, P., Pomareda, C. & Valdés, A., eds. *Crop insurance for agricultural fevelopment – issues and experience*. Baltimore, USA, Johns Hopkins University Press.

Skees, J. 1999. Opportunities for improved efficiency in risk sharing using capital markets. *American Journal of Agricultural Economics* Vol.81 (No.5)

Skees, J. 2000. A role for capital markets in natural disasters; A piece of the food security puzzle. *Food Policy* Vol.25 (No.3) June.

Skees, J..2003a. Drawing from lessons learned on index insurance to consider financing famine relief efforts. Presented at the Inter-American Development Bank,Washington, DC, February.

Skees, J..2003b. Risk management challenges in rural financial markets: blending risk management innovations with rural finance. Presented at the International Conference: *Paving the Way Forward for Rural Finance*, June 2-4, Washington DC, USA.

Skees, J. & Barnett, B. 1999. Conceptual and practical considerations for sharing catastrophic/systemic risks. *Review of Agricultural Economics,* Vol.21 (No.2) December.

Skees, J., Gober, S., Varangis, P., Lester, R. & Kalavakonda, V. 2001. *Developing rainfall-based index insurance in Morocco*. Working Paper, No. 2577, April. Washington, USA., World Bank.

Skees, J., Harwood, J., Somwaru, A. & Perry, J. 1998. The potential for revenue insurance policies in the south. *Journal of Agricultural and Applied Economics,* Vol. 30 (No.1) July.

Skees, J., Hazell, P. & Miranda, M. 1999. *New approaches to crop yield insurance in developing countrie*s. EPTD Discussion Paper No. 55. International Food Policy Research Institute.

Stoppa, A. & Hess, U. 2003. *Design and use of weather derivatives in agricultural policies: the case of rainfall index insurance in Morocco*. Presented at the International Conference: *Agricultural Policy Reform and the WTO: Where Are We Heading?*, June 23–26, Capri, Italy.

Turvey, C.G. 1992. An economic analysis of alternative farm revenue insurance policies. *Canadian Journal of Agricultural Economics,* Vol. 40.

Turvey, C.G. 2001. Weather derivatives for specific event risks in agriculture. *Review of Agricultural Economics,* Vol.23 (No.2), December.

Varangis, P. &Larson, D.L. 1996. *Dealing with commodity price uncertainty*. Policy Research Working Paper, No. 1667, October.World Bank.

Wenner, N. & Arias, D. 2003. *Agricultural insurance in Latin America: Where are we*? Presented at the International Conference: *Paving the Way Forward for Rural Finance*, 2-4 June, Washington, DC, USA.

World Bank. 2003. *Using markets to manage commodity risk.* Available at World Bank website (see below).

World Bank. 2004. *Managing agricultural risk, vulnerability and disaster.* In Agriculture Investment Sourcebook Module 10. Available at World Bank website (see below).

Wright, B.D. & Hewitt, J.A. 1994. *All-risk crop insurance: lesson from theory and experience*. In Hueth, D.L. & Furtan, W.H., eds. *Economics of agricultural crop insurance: theory and evidence*. London, England, Kluwer Academic Publishers.

Yabuki, N.,Varangis, P. & Larson, D.F. 1998. *Commodity risk management and development*. Policy Research Working Paper, No. 1963, August.World Bank.

Websites

Agricorp (Ontario, Canada): www.agricorp.com
Canadian Federal Ministry of Agriculture and Agri-Food: www.agr.gc.ca
International Food Policy Research Institute: www.ifpri.org
International Task Force on Commodity Risk Management in Developing Countries: www.itf-commrisk.org
Münich Re Group: www.munichre.com
Risk Management Agency, USDA: www.rma.usda.gov
Swiss Reinsurance Company: www.swissre.com
World Bank: www.worldbank.org