Romania

Agricultural Insurance Alternatives

GlobalAgRisk INC.

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[1] This report was written by Dr. Jerry R. Skees, President of GlobalAgRisk, Inc. Comments are welcome as the report is still considered a work in progress. This report is being edited by a professional editor and a cleaner version should be ready soon. GlobalAgRisk, Inc. has a contract with the University of Kentucky where Skees is H.B. Price Professor of agricultural policy and risk in the Department of agricultural economics. In addition to making an important link between the University and GlobalAgRisk, this contract supports part of Skees' salary. A number of individuals contributed to the development of this report. Special assistance came from Dr. Barry Barnett and Mr. James Long. In addition, professionals at the National Institute of Meteorology & Hydrology of Romania contributed to thinking and data for the report. Data were also supplied from the National Statistic Institute of Romania. Data were obtained through the services of Mr. George Barba. Special appreciation is extended to all.

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Section 1: Executive Summary

This USAID-funded project report is in response to a request from the Minister of Agriculture for assistance in developing a catastrophic insurance program for agriculture in Romania. Agriculture is an important sector in the Romanian economy. In 1998, 36% of the employment and 16% of the gross domestic product in Romania came from agriculture. Thus, it is important to consider the problems associated with natural disasters that impact the agricultural sector. Given the importance of agriculture, such shocks also likely impact the growth path of the general economy.

The challenge of providing a base level of catastrophic protection for agriculture while controlling the cost is significant. What has become painfully clear is the degree to which major weather events (droughts, floods, and freezes) cause economic loss in the important Romanian agricultural sector. The Romanian Ministry of Agriculture estimated that the 2000 drought resulted in over $US 1 billion in economic losses. The 2002 crop yield is unlikely to be as poor as in 2000; nonetheless significant losses occurred due to a drought followed by excessive rains. The Romanian National Commission for Statistics has been tracking agricultural soil quality since 1977. In 1992, they reported that 3.9 million hectares were affected by frequent severe drought. This number increased to 7.1 million by 1997. This is roughly one half of the 14.7 million hectare agricultural land base in Romania. As this report investigates, the trends toward less rainfall in some regions and hotter summer temperatures are likely contributors to this problem.

A number of conditions changed since this project was initiated in the fall of 2001. Three fundamental changes created some new demands on this analysis in particular: 1) the international reinsurance market has become more restrictive and more expensive; 2) there have been significant changes in the weather markets; and 3) the Romanian government passed legislation for crop insurance.

A major focus of this report is to develop recommended strategies that would use limited government funds to foster private-sector innovation for an emerging agricultural insurance sector. These strategies are developed conditioned upon the three changes that are mentioned above.

To our knowledge, this report is the first investigation into the profile of crop risk for Romania. Thus, it provides the only known base for understanding the probable cost of alternative approaches. A key to any successful efforts at providing crop insurance in Romania must involve ex ante financing for the significant losses that are possible given high correlations in crop yields and weather events. The analysis demonstrates that very large losses are probable for any Romanian crop insurance program covering drought. Based on visits with high-level officials and documents supplied on the new crop insurance law, the government is not properly prepared for the financing of major crop losses. Any crop insurance program that is not positioned to make timely payments during a major drought year is set to fail.

The core challenge of providing any crop insurance program in Romania is the correlated risks that are present with crop yields. When a major drought occurs, it impacts a large number of farms at the same time. This type of correlated risk is not insurable in the classic sense. Therefore, new solutions must be considered. The spatial correlation of crop yields is used to make estimates about the spread of risk for Romania. This analysis points to the problems associated with the correlated risk and the insurance loss function. In particular the results show that any form of crop loss assistance in Romania will result in a relatively high frequency of excess payments (those that would exceed premiums). For example, the study shows that if 2002 were included, five of the past ten years would have had serious crop losses. The challenge of spreading that risk first in Romania and then into the international capital markets is presented in the study. Some possible models for doing this are presented.

Public Law 381 sets the stage for *heavy* government involvement in providing crop insurance. The law was a response to serious problems suffered in crop production in 2000 and 2002. However, the law also extended into other sectors in agriculture for calamities (livestock, poultry, hives and fish). These additional sectors merit some investigation. Nonetheless, the technical analysis of this report is limited to only major crops in Romania (maize, wheat, barley, sunflowers, and soybeans). Despite this limitation, these crops comprise between 60% and 70% of the value of all crops in Romania, providing a good foundation for the analytical work that follows.

While the technical aspects of the newly passed law are still being finalized, it is difficult to know important details. This makes any attempt to provide analysis of the government program a bit risky. Still current interpretations of the law motivate the analytical study of the government proposal. First, it is reported that the government will provide free assistance for losses due to drought. Second, nearly all other losses will be paid with insurance that has a subsidy at some level to be determined. The losses will be paid based on 70% of cost of production up to the point of the calamity. Further, losses will only be paid when crop yields are at 70% of normal or below (a 30% deductible).

In effect the government of Romania is embarking upon a multiple peril crop insurance plan. Such an undertaking represents a potential for a highly wasteful use of precious government resources. This is the major reason this report begins by providing background on world experience with multiple peril crop insurance. Policy makers in Romania desperately need to understand the cost and limitations of these programs. While these programs have many attractive features, they are expensive and require a significant infrastructure to implement. Such individual crop insurance is particularly problematic in a country like Romania. Given the small farm structure, the monitoring and implementation problems associated with a farm-level crop insurance program will very likely result in excessively high cost. Such cost can easily swamp any social benefits that may accrue from a crop insurance program in Romania. If significant investments are not made in monitoring, loss adjustment, and implementation, the crop insurance program planned for Romania will undergo tremendous moral hazard and adverse selection problems as will be explained in Section 2.

There are lower cost approaches to providing crop insurance that also mitigate the traditional problems associated with multiple peril crop insurance. Section 4 introduces the use of index-based insurance products; an alternative form of insurance that makes payments based not on measures of farm yields, but rather on either area-yields or some weather event like temperature or rainfall. Both area yield index-based insurance and weather index-based insurance products are reviewed. The case is made that this is a logical beginning for Romanian crop insurance. Index insurance holds significant promise for a number of reasons. In some situations, index insurance offers superior risk protection when compared to traditional multiple-peril crop insurance that pays indemnities based on individual farm yields. Second, index insurance provides an effective policy alternative for Romania as it seeks to protect the agricultural production sector from widespread, positively correlated, crop-yield losses (e.g., drought). Finally, when index insurance is used to shift the risk of widespread crop losses to financial and reinsurance markets, the residual idiosyncratic or independent risk often has characteristics that should open the door for local insurance markets to design more effective farm-level insurance products as market conditions permit.

Section 5 and 6 provide the details of the analytical work that was performed using Judet yield data supplied by the national statistics institute. Special procedures are used to first detrend these data and second to develop a profile of risk that maintains the spatial correlation for the crop risk and recast the problem into a portfolio model of value at risk for the current plantings. Furthermore, special procedures are used to simulate farm level yields and allow for cost estimates of multiple peril crop insurance alternatives.

Given the analytical work, section 7 makes estimates of the probable cost of the current crop insurance law. Estimates of the pure premium rates for a 70% multiple peril crop insurance program is roughly 6.5%. A true cost for this policy would be at least double this value given the loading that is needed for adverse selection, moral hazard, catastrophic loads, etc. The value of crops examined in this work is roughly US $1.5 billion. This value would increase to about $2.5 billion if all crops are considered. Since the government plans to only cover cost of production, this value can be reduced by a factor of roughly 60%. Thus, if all crops in Romania were insured, the total insured value would approach $1.5 billion. Drought losses in the US crop insurance program exceed 50% of the cause of loss. Some very preliminary analysis suggests that drought is the likely cause of loss in Romania. To be conservative on the cost estimates, we assume that drought is only 50%. Given this and other assumptions, if the government provides free drought insurance, the cost could quickly *average* $75 million per year[2]; some years could have cost at least 5 times this value or *in excess* of $375 million per year.

Beyond the cost for drought, additional cost need to be added for whatever subsidy is provided for the multiple crop insurance programs and for the livestock, poultry, hives and fish. Should farmers in Romania sign up for these programs it is easy to envision a program that would cost well over $100 million per year; some years could

[2] $1.5 Billion for cost of production for all crops multiplied by 50% for drought losses multiplied by a relatively low premium rate of 10%.

cost over $500 million. These cost estimates are for the government only. It is assumed that farmers will pay at least some of the cost for the insurance.

Section 8 introduces a recommended strategy that uses Judet yields to trigger payments – a recommended area yield index product that would trigger payments for yields that are less than a 1 in 5 year level. It is clearly demonstrated how such a base product removes the catastrophic risk, clearing the way for private sector products in Romania. This strategy avoids many of the problems with the current law. The probable cost of this strategy is also considerably less than the current law. A 1 in 5 year Judet area yield program for all crop losses could be provided at an average cost of less than $50 million. One can envision farmers paying a portion of this cost. Thus, the cost to the government should be about one-half of this value. Still, the extreme losses of these programs during bad weather years could exceed $200 million. This requires special financing via reinsurance markets. The report reviews ways to facilitate such an arrangement, including a system that would use weather data as one mechanism for reinsurance. Four recommended sources for funding are: 1) farmer premiums; 2) weather indexes for reinsurance; 3) traditional reinsurance; and 4) contingent loans from USAID or the World Bank.

Area-yield insurance and weather-based index insurance is evaluated as fully priced insurance alternatives. In addition, the concept of providing well specified free catastrophe insurance is also considered. The intent is to consider the feasibility of government assistance during the most serious years of crop failure. The assistance should be clear, understandable, and implemented in such a fashion that fosters private sector development. For example, to the extent that Judet data are reliable, a system could be established very quickly using predetermined trigger yields by Judet and crop to make payments. Using frequency as the anchor for yields that are considered catastrophic is a more logical approach than using the percentage below normal or average yields. A 1 in 7 year or a 1 in 10 year system might be considered. This report provides initial cost estimates for each of these alternatives.

Section 9 examines several issues using the limited weather data that were provided, including the use of weather-based insurance products. The weather data systems appear quite good historically, offering some significant promise for establishing a weather-based insurance. Here the limitation of these alternatives involves the complexity of the crop growth process given various weather events. This study demonstrates strong correlation between rainfall and corn and soybean yields. However, weather indexes will have to be more complex for wheat, barley and other fall-seeded crops. More weather events influence the yields for these crops. Some very preliminary results suggest that weather events could be used to reinsure a national program that pays using the Judet yields.

A unique method is developed to construct an optimal rainfall insurance contract (RIC) for maize. This method involves weighting the periods for rainfall using a 20 day cumulative rainfall. The method shows considerable promise as the reductions in relative risk that come from the optimal contract design are comparable to area yield insurance alternatives. A case is presented for maize in Galati judet to illustrate the contract and the actuarial procedures that would likely be applied to such a RIC.

Considerably more work is needed to determine the potential value of weather insurance for individual farmers. Part of that work should involve focus groups with farmers using weather data to motivate the effort. Farmers know very well what weather events worry them the most. A carefully designed focus group approach could reveal the most appropriate weather events to introduce insurance.

Finally, Sections 10 and 11 introduces a number of issues associated with possible organizational structures and regulatory environment for use of index-based insurance products. The case is made for a carefully crafted Risk Management Agency within government that would run elements the government based insurance program. Additionally, the issue of how to pave the way for index insurance products is developed in Section 11.

The approach

This report relies heavily on experience in the agricultural insurance industry; accepted product development methodologies; agricultural production, yield and weather data in Romania; as well as assumptions on relationships between farm-level yields and area-yields. The estimates provided are deemed "best estimates" given the available data. Limited farm-level data have been made available. Still, it is difficult to track these data through time since there is no information about what parcel of land the data are tied to from one year to the next. The relative costs and benefits of one program versus another is used as a primary basis for comparisons. In other words, one should focus as much on the relative position of the estimates for the various crop insurance programs as on the absolute cost estimates. Nonetheless, the absolute cost estimates are useful for providing some indication of the potential cost of many of the alternatives.

The estimates rely heavily on modeling the risk; still, the evaluation is both quantitative and qualitative. For example, while each alternative begins with an estimate of the average loss cost or pure premium (i.e., the annual premium rate that would result in an equal indemnity rate over time), premiums are also loaded for various factors; 1) a moral hazard and adverse selection load; 2) an administrative load; 3) a reinsurance or correlated risk load; and 4) a load for profits. The levels for these loads are based upon expert judgment. Again, the level of the loads are unlikely to be precise, the relative loads for one program versus another should reflect practices in the industry, however. Multiple-peril products will be subjected to more moral hazard and adverse selection than index products, thus the loads will be higher. The abuse must be anticipated and added to rates. Finally, careful consideration is made throughout of how alternative programs offered by the public sector may influence development in the private industry—what products will best serve the development of the industry? This, too, involves expert judgment.

Possible Objectives of the Romania Government

The objectives of the Romanian government are taken to be the development of a system that helps farmers cope with crop-yield disasters given a manageable cost and the provision of adequate coverage for farmers. The system must compliment product development in the private sector. The government should not crowd out private sector developments; rather they should attempt to provide base products that foster private sector developments.

Findings and Recommendations

Given the results of the analyses performed, recommendations follow. First, it should be clear that private sector companies will be unlikely to offer multiple-peril crop insurance, or even drought insurance, without some level of government support. Second, the droughts of recent years have created significant pressures for the government to find solutions. Third, while insurance solutions may be tried, they will be expensive. *Several key points motivate the recommendations***:**

1. Private sector companies will not offer crop insurance in Romania to any great extent without some level of government involvement.
2. The droughts in 2000 and 2002 have created significant pressures for the government to find solutions.
3. A combination of disaster payments, incentives for private sector insurance, investments in irrigation, and government adjustment policies to change the crops in drought-prone regions may be needed. The recommendations will only address the insurance and disaster-based solutions. That does not negate the important role of other government action.
4. If the government embarks on a standing disaster program, there should be clear rules for when and how farmers would be compensated for catastrophes.
5. The government of Romania should not try to protect individual farm losses. Protecting the sector from widespread disaster is a superior role for government. Protecting the sector from catastrophes should be key – not protecting individual farmers from isolated problems that do not hurt a large number of farmers. The private sector should insure isolated problems.
6. While there are needed improvements, the area-yield data that is developed by the Romania government could be useful in providing a partial solution. These data are generally available at the Judet level back to 1968. This study used data for maize, wheat, barley, sunflowers, and soybeans.
7. Farm-level data that were provided could not be tied to the same farm though time; this is a major problem when considering farm-level crop insurance solutions. Getting a time series of farm yield data from Romanian farms will be a serious problem for some years to come. The sector has undergone significant structural changes and the levels of inputs used have change greatly for farmers through time as well.
8. There are limited government funds available to underwrite the risk of a catastrophe crop insurance program.

9. It is essential that whatever plan is put in place for catastrophes, there be some limit on how much the government can lose. This necessitates the use the international reinsurance or capital market community to share in the catastrophe risk and smooth the losses that are possible.
10. There is a keen desire to foster private sector developments within Romania that will complement whatever the government does to provide catastrophe protection.

Recommendations

1) The government would provide a 1 in 5 year area-yield crop insurance program that uses Judet crop-yield estimates. The cost to the farmer would be based on pure premium rates that are established at the Judet level by crop to reflect relative differences in rates. Farmers would be allowed to purchase a value that is consistent with their expected cost of production.
2) Crop insurance payments would be based on the difference between the expected Judet yield and the actual estimate of Judet yields for the given year. This would become the base insurance product.
3) Private companies would be allowed to sell the base insurance product and offer companion products that would compliment this insurance; for example higher values of insurance could be offered using the same base product, individual insurance could be offered to cover losses at some level that are not paid by the area yield index; etc.
4) This disaster program can be packaged with products by private companies. The option could either be offered free or at a subsidized rate, depending on the government budget constraint.
5) Private companies would be encouraged to offer an add-on area-yield layers or more liability. This can be accomplished with much less correlated and ambiguous risk given the government base product.
6) Private companies could also offer 60% to 70% MPCI type policies for select farmers where the payment would be the maximum of either the MPCI policy or the free government policy.
7) Private companies could also begin offering some weather derivatives that would again pay the maximum of the government base policy or the weather product.
8) Government should be able to reinsure much of the risk from their policy by going to the capital markets with some level of weather insurance. This is done because most reinsurers would not trust the government yield statistics and would be much more likely to trust the weather data.

Section 2: Experience with Multiple Peril Crop Insurance[3]

Multiple-peril insurance would seem to address the issue of handling major crop failures, especially since most farmers favor farm-level insurance. However, significant problems have plagued multiple-peril crop insurance programs. It is important to understand these problems as this establishes the base for helping the Romanian government in their search for solutions. This is particularly important in light of the recent legislation that has passed on crop insurance for Romania.

Two types of crop insurance programs dominate: 1) named peril (such as hail); and 2) multiple-peril that covers losses from many perils (e.g., drought, flooding, wind, insects, and freeze). Hail coverage can also include losses from fire and wind damage. Hail insurance is generally successful around the world for a variety of reasons: 1) the losses are more nearly independent; 2) there is less adverse selection and moral hazard; and 3) good data and methods exists to both underwrite and assess losses. Crop-hail insurance is not discussed since it does not handle major crop failures such as droughts. Further, with assistance from the international reinsurance industry, private companies in Romania can offer private hail insurance.

While many look to the U.S. experience to learn and as a model for what might be considered, there are some important limitations for countries trying to replicate the U.S. program. Today, North American farmers pay only a fraction of the total cost of the crop insurance offered by the government (about 25 percent). There are few countries around the world that can afford such heavy subsidies. Further, looking back and understanding the growing pains of the US crop insurance program gives any country reason to pause. For over 15 years the U.S. program suffered from serious actuarial problems. Crop insurance losses exceeded unsubsidized premiums in every year but one from 1981 to 1993. By the early 1990s, the U.S. aggregate loss ratio was about 1.5, meaning that the program was paying out $1.50 for ever dollar of accounting-based total premium.[4] While the national number today is closer to 1.08, in many regions serious actuarial problems still plague the program. In the early years, private companies were reimbursed over 38 percent for every dollar of unsubsidized premium. While that number is below 25 percent today, the companies also expect to make about 15 percentage points for each dollar of total premium that they retain for risk sharing. Higher reimbursement expenses in the early years helped build the elaborate infrastructure that is in place today allowing the companies to deliver the crop insurance program for less than in the past.

The major lessons to be gleaned from the U.S. and other developed country experience are: 1) delivering farm-level multiple-peril crop insurance is complex and

[3] This section is largely taken from a paper drafted by Skees and Barnett for use in a book chapter that is being published by a crop insurer in Australia.

[4] Loss ratios for the US program are not calculated using the farmer paid premiums. Rather they are calculated using the premium as if it were not subsidized. This is referred to as the total premium. If farm paid premiums are used, the loss ratios are much higher.

expensive; 2) actuarial problems are to be expected when developing farm-level multiple-peril crop insurance; and 3) allowing private companies to sell government crop insurance products creates a new political force that creates still more demand for subsidies.

Experience to date indicates that it is extremely difficult, without massive government subsidies, to insure farm-level crop-yields from losses caused by any number of natural perils. Those who seek effective, agricultural risk management tools, offered with little or no government subsidy, need to understand the underlying problems with farm-level, multiple-peril crop insurance. These problems are discussed below. This discussion sets the stage for considering an alternative form of insurance that makes payments based not on measures of farm yields, but rather on either area-yields or some weather event like temperature or rainfall. This alternative form of insurance is often referred to as "index" insurance, since payments are triggered by realizations of a pre-specified index measure rather than by realized farm yields.

Index insurance holds significant promise for a number of reasons. In some situations, index insurance offers superior risk protection when compared to traditional multiple-peril crop insurance that pays indemnities based on individual farm yields. Second, index insurance provides an effective policy alternative for Romania as it seeks to protect the agricultural production sector from widespread, positively correlated, crop-yield losses (e.g., drought). Finally, when index insurance is used to shift the risk of widespread crop losses to financial and reinsurance markets, the residual idiosyncratic risk often has characteristics that should open the door for local insurance markets to design more effective farm-level insurance products as markets conditions permit.

Requirements for Multiple Risk Crop Insurance

Successful insurance programs require that the insurer have adequate information about the nature of the risks being insured. This has proven to be extremely difficult for farm-level yield insurance. Farmers will always know more about their potential crop-yields than any insurer. This asymmetric information is the major problem with insuring farm yields. If an insurer cannot properly classify risk, then it is impossible to provide sustainable insurance. Those who know that they have been favorably classified will buy the insurance; those who have not been favorably classified will not buy. This phenomenon, known as "adverse selection," initiates a cycle of losses (Goodwin and Smith; Ahsan, Ali, and Kurian; Skees and Reed; Quiggin, Karagiannis and Stanton). The insurer will typically respond with "across the board" premium rate increases. But this only exacerbates the problem, as only the most risky individuals will continue to purchase the insurance. The problem can only be corrected if the insurer can acquire better information to properly classify and assign premium rates to potential insureds.

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

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

The U.S. Federal Crop Insurance Program

There are a number of countries around the world that offer multiple-peril crop-yield insurance on individual farm yields. Very few of these offerings are made with no government involvement. In the U.S., multiple-peril crop insurance is designed to protect against losses from a wide array of natural occurrences, including hail, drought, excess moisture, plant disease, insects, and wind. The intent is to insure only acts of nature and not bad management. Policyholders must follow "generally accepted farming practices." While this provision is in place to reduce the impact of moral hazard, it is difficult to enforce.

Indemnifiable losses include quality adjusted yield shortfalls, prevented planting, and in some cases, replanting costs. Contracts for annual crops must be purchased no later than approximately six weeks prior to planting. Contracts for perennial crops must be purchased in the fall of the year before the crop is harvested. These dates are set to reduce the possibility that farmers will purchase insurance only when the likelihood of, and/or magnitude of, a potential loss is greater than normal – a phenomenon known as intertemporal adverse selection.

A payable loss occurs if the *realized yield* is less than the *trigger yield* (the trigger yield is sometimes called the yield guarantee). Payable losses (in bushels, hundred weight, tons, etc.) for an insurance unit are calculated as:

$$Payable\ Losses = \max\left(0, Trigger\ Yield - Realized\ Yield\right) \times Insured\ Acreage.$$

Trigger yield is based upon the coverage chosen and the insurance yield. Specifically,

$$Trigger\ Yield = Insurance\ Yield \times Coverage\ .$$

The *insurance yield* is an estimate of the long-run average yield for the insurance unit. A farm may have several insurance units. *Coverage*, as the term is used in the U.S. federal crop insurance program, is 100 percent minus the percent deductible. Available coverage levels typically range from 50 percent to 85 percent in 5 percent increments. Deductibles are one way to reduce the problems that emerge from adverse selection and moral hazard.

The policyholder selects an *indemnity price* that is less than or equal to a federal estimate (made prior to planting and sales closing) of the market price at harvest. The payable loss is converted into dollars as follows:

$$Indemnity = Payable\ Loss \times Indemnity\ Price$$

Liability is the amount that the insurance contract would pay if the realized yield were equal to zero (i.e., a 100 percent loss):

$$Liability = Trigger\ Yield \times Indemnity\ Price \times Insured\ Acreage.$$

The *gross premium* is calculated as:

$$Gross\ Premium = Gross\ Premium\ Rate \times Liability\ .$$

Gross premium increases as coverage levels increase. The farmer's premium is calculated as:

$$Farmer\ Premium = Gross\ Premium - Government\ Subsidy\ .$$

Actuarial Performance of the Crop Insurance Programs

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

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

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

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

Table 1 has only one case where the loss ratio of indemnities over premiums approaches 1 – Japan. In this case, the administrative costs needed to achieve this lost ratio are quite unbelievable – over 4 and ½ times higher than the farmer premium. It seems a very high price to pay to obtain 'actuarially sound' crop insurance. The other strategy in reaching this goal is to make the premium subsidy high enough that there is no adverse selection – even the low risk farmers soon learn that crop insurance is a good buy. Once these lower risk farmers are in the risk pool, this can improve the actuarially performance, especially when the system is measuring the unsubsidized premium against the loss experience. Obviously this is an accounting ploy and reflects little about the true performance of the program. This is what the U.S. has done in recent years (Skees 2001).

Table 1: Financial Performance of Crop Insurance in Seven Countries

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

Source: Hazell

With such poor performance one must ask if it is even possible to run an individual multiple-peril crop insurance program that is self-sustaining. Further, one should ask why we have such poor performance. Consider the information required to deliver and monitor this program. The insurer must know the following for every individual insured unit:

> **Insurance yield:** Estimating the expected yield for an insurance unit is a daunting task. For the U.S. federal crop insurance program, insurance yields are based on a simple average of the most recent 4- 10 years of realized yields on the insurance unit. Farmers can establish an initial insurance yield with as little as four years of yield records (there are significant penalties if farmers cannot provide at least four years of yield records). As the farmer builds toward 10 years of yield records, realized yield in a given year is incorporated into the calculation of insurance yield in subsequent years. When the farmer has built 10 years of yield records, the insurance yield is calculated as a rolling average of the most recent 10 years of realized yields. This is a rather crude method for estimating the central tendency in yields. Due to sampling error, insurance yields can either underestimate or overestimate the true central tendency depending on the random weather events over the most recent 4-10 years. The effect of sampling error is further compounded by the fact that for most multiple-peril crop insurance programs, insurance yields are also the primary (if not the only) mechanism for relative yield risk classification. Thus, the mechanism for establishing insurance yields can lead to adverse selection where only those farmers who believe they are getting a fair or better offer will chose to participate. Farmers who think the insurance yield is too low will not participate. Also, since farmers provide the yield records on which insurance yields are based, there are opportunities for fraud.

> **Loss adjustment:** It is complicated and expensive to measure realized yields so payable losses can be determined. Most farmers do not like the idea of having someone come to their farm to estimate the realized yield. Nor is loss estimation a precise science. As is implied by the word "estimate," measurement errors are common. Additional investment in personnel and training is required to minimize measurement errors. When losses are widespread, a very large workforce of trained individuals is needed. In the U.S., farmers are often allowed to self-report realized yields. Spot checks are conducted with penalties for filing false reports, yet there are opportunities for farmers to receive payments that are not warranted.
>
> **Gross premium rate:** For most insurance products, premium rate calculation is based on historical loss experience. However, calculating crop-yield insurance premium rates is more complex. One would ideally like to know the yield distribution for each individual farm. That is, one would like to know all of the possible yield outcomes and the probability of occurrence for each of those outcomes. But as indicated above, most crop-yield insurance programs have difficulty estimating even the central tendency in yields. Estimating factors that influence the higher moments of the yield distribution is much more problematic. Further, simply knowing the yield distribution for a well-classified group of farmers may not be enough. Extra losses (beyond those represented by the yield distributions) can occur due to moral hazard.

The U.S. government has made significant investments in attempting to address these and other informational challenges inherent in farm-level crop-yield insurance. While improvements have been made, the federal crop insurance program still suffers from problems related to inadequate or asymmetrically distributed information. Many of the more obvious and inexpensive improvements in information gathering and monitoring systems have already been made. Needed additional improvements will likely come at much higher marginal cost. That cost will be borne by taxpayers and/or policyholders. If the cost is passed on to policyholders, many will decide that the insurance is too expensive and opt out of the program.

Section 3: Reinsurance for Insuring Natural Disasters

Another requirement for traditional insurance products is that the loss events be independent, or at least not highly positively correlated. This characteristic allows the "law of large numbers" to generate a narrow confidence interval around the expected loss for the insurer's portfolio of insurance products. If risks are highly positively correlated (what some refer to as systematic risk) the law of large numbers is not relevant and the solvency of the insurer can be threatened by extremely large losses due to a single event. For multiple-peril crop insurance, losses, due to perils such as drought, freeze, or excess moisture, are typically highly positively correlated across exposure units. In Romania this is particularly true since the analysis presented below demonstrates that large losses would be present in about one half of the crop years in recent years.[5]

Since crop-yield risks are not independent, insurance markets are incomplete in most countries. The widespread nature of natural disaster losses undermines the ability of insurance companies to pool risks and offer affordable insurance coverage. Although crop losses are often widespread, they may not be completely correlated. General price movements for agricultural commodities are generally strongly correlated. Such correlated risks can be managed with futures exchanges. In many ways, crop and natural disaster risks are 'in-between' risks. They are neither completely correlated nor independent (see Figure 1).

Figure 1: Independent versus Correlated Risk

	In-Between Risk	
Nearly 0 correlation	largely correlated	100% correlated
Auto Accidents	*Natural Disasters*	*Commodity Prices*
Heart Attacks	*Rainfall/ crop-yields*	*Interest rates*
Insurance Markets	*Government/ Capital Mkts ?*	*Futures Markets*

New ways of thinking are required to introduce markets for such "in-between risks." When insurance is offered for natural disaster risks the rates must be loaded for catastrophes because of the nature of the risk. In effect, the potential seller must overestimate the pure risks. Insurance is available for natural disaster risk in developed economies. Homeowners can insure against damage from hurricanes and earthquakes. These risks are clearly different than most insurable risk. Unlike automobile insurance where the risks are largely independent, natural disaster risk are correlated with some low probability of very high losses as a widespread area is damaged by a single event. This requires special arrangements to share these risks in the capital markets. Primary insurers pass on certain levels of risk to an international reinsurance market.

The simplest form of reinsurance is a 'stop loss' where the primary insurer pays a premium to get protection if their losses exceed certain levels. Other forms of reinsurance are also common. Quota-share arrangements involve simply sharing both

[5] While 2002 data are not available, the evidence to date strongly suggest that this crop year will be among the most serious for crop losses in anyone's memory.

premiums and indemnities. If an insurance company has a book of business that is concentrated in a hurricane prone area they would likely need such reinsurance. If they have $100 million of property value insured with an average premium rate of 10 percent, they would collect $10 million in premiums. While this company may have another $10 million in assets to cover significant losses, they cannot cover losses beyond the combined $20 million level or beyond a loss ratio of 2 (indemnities/premiums). They may decide to buy a 'stop loss' where the reinsurer pays for all losses above the $20 million level.

The reinsurer has an interesting problem – how does one rate a policy for a low probability high-loss event? While there are very sophisticated models used to address this problem, most wise reinsurers will load the risk beyond levels experienced in the past. Things can always get worse. Or as anyone in the risk management business will emphasize "just because it has never happened, that doesn't mean it won't." The other problem is intertemporal. Suppose the big hit comes in the first year. This will require capital reserves to pay large losses. Rate makers load to build these reserves quickly for early losses. Finally, keep in mind that all of the issues of asymmetric information apply for the principle-agent relationship between the primary insurer and the reinsurer. Reinsurers must invest in monitoring and information systems to balance the information. This increases transaction costs. In the end, all of these costs must be summed together with the pure risk of the contract to develop a premium rate.

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

It is little wonder that premium rates can exceed the expectations of decision-makers who tend to forget bad events from natural disasters. These arguments are used to justify government involvement. Efficiencies are needed. Large international reinsurers can spread risks around the world – applying all of the principles of portfolio theory. If the portfolio of reinsurance is large enough, what may be low-probability high catastrophic events for a small company become a largely independent and diversifiable risk for the large reinsurer. There has been significant growth in the international reinsurance markets.

When considering the requirements for insurance, it is instructive to compare multiple-peril crop insurance with hail insurance. For well over 100 years, the private sector has sold crop hail insurance with no government involvement. Why has hail insurance succeeded without government involvement when multi-peril crop insurance has not? There are at least four reasons: 1) farmers have no better information than the insurer regarding the likelihood of a hailstorm; 2) farmers cannot, by changing their behavior, increase the likelihood of a hailstorm or the magnitude of damage from a hailstorm; 3) insurers can generally tell whether or not a loss was caused by hail and accurately estimate the damage without relying on information provided by the farmer; and 4) hail risk is largely independent across exposure units.

Reinsurance and Weather Markets

Much can be said about the international reinsurance community and their resistance to entering new and un-tested markets. The use of the capital markets for sharing 'in-between' risk remains in the infant stages, leaving the issue of capacity and efficiency in doubt. This raises questions about the role of government in sharing such risk. For the U.S., Lewis and Murdock recommend government catastrophic options that are auctioned to reinsurers. Part of the thinking is that the government has adequate capital to back stop such options and may be less likely to load these options as much as the reinsurance market. Skees and Barnett have also written about a role for government in offering insurance options for catastrophes as a means of getting affordable capital into the market.

Finally, development of weather markets has also prompted new thinking about sharing catastrophic risk in agriculture. In 2001, the Mexican agricultural insurance program used the weather markets to reinsurance part of their multiple crop insurance program. By using weather indexes that were based on temperature and rainfall in the major production regions, a weather index was created that was highly correlated with the Mexican crop insurance loss experience. This method of reinsurance proved to be more efficient than traditional reinsurance.

The Mexican deal is an important development for Romania and some of the ideas presented in this report. Reinsurers have now acquired many of the professionals who were trading weather. SwissRe acquired professionals from Enron and PartnerRe acquired professionals from Aquila. *Reinsurers are now in a position to offer reinsurance using weather-based indexes.* This type of reinsurance should be more affordable since it is not subject to the same adverse selection and moral hazard problems as traditional insurance.

The important lessons from both market developments for sharing catastrophe risk and the academic writing about how to do so with markets and government are: 1) developing something that is clear and transparent is critical; 2) having more data is always better for whatever is developed; and 3) indexing natural disasters or area-yields so that markets and or government can write insurance contracts on these risk is gaining in importance. Again, this amounts to relatively simple systems that can segment the risk into that which is high correlated leaving other market mechanisms to attempt to handle the independent risk.

Problems with Traditional Markets

Since catastrophe risks are not independent, and in the classic sense are uninsurable, how can markets share these risks most efficiently? The traditional mechanism is to share catastrophe risk with another insurance entity by what is called reinsurance. Reinsurance can take many forms. The two most common reinsurance arrangements are quota share and stop loss. A quota share is an arrangement where the primary insurance company shares premium and risk in some proportion with a reinsurance company. A stop loss can be thought of as another insurance contract – the primary insurer pays a premium to the reinsurer who agrees to pay for all losses beyond a certain threshold.

While reinsurance markets are extremely effective and have grown in recent years, there are significant limitations. First, price discovery is difficult. There is no price transparency. The international reinsurance market is a classic thin market with few buyers and sellers. Second, transaction costs are high. Reinsurance contracts can be unique, requiring costly legal fees to tailor the contract to the special circumstances. Monitoring must also occur to reduce the likelihood of moral hazard. Third, the prices that must be charged for reinsurance may simply not match the willingness to pay. In addition to covering the transaction costs, prices are to build reserves and account for the ambiguity of catastrophe risk (Jaffee and Russell; Skees and Barnett). A lack of understanding about the risks and events being insured may cause insurers and reinsurers to set premiums too high (Camerer and Kunreuther; Hogarth, and Meszaros;).

Froot develops four explanations for the high price and low use of catastrophe reinsurance: 1) reinsurers have market power; 2) the corporate form for reinsurance is inefficient; 3) frictional costs of reinsurance are high; and 4) moral hazard and adverse selection at the insurer level are high. Most of the analytical review provided by Froot boils down to items that increase the transaction costs of getting reinsurance for catastrophes. Foot goes on to point to how insurance regulations increase the transaction costs even further and how free government disaster assistance crowds out development of reinsurance markets. Finally, he discusses how decision makers may underestimate or simply not consider the very low likelihood of payment from reinsurance. Kunreuther also reviews these cognitive failure problems in insurance and reinsurance markets.

New Market Instruments for Sharing Catastrophe Risk

New innovations are emerging to address the limits of reinsurance (Cole and Chiarenza; Doherty; Lamm). Many of these innovations are being called insurance securitization. Insurance securitization involves the creation of a marketable security that is financed by premiums flowing from a contingent claims transaction – generally the traditional insurance and reinsurance transactions. The concept is simple: if the risk can be standardized in some fashion and packaged into a market security, then many investors can participate in the risk sharing. Since capital markets trade many times the value of the entire reinsurance capacity, this access to additional capital with lower transaction costs should compensate for many of the limitations in the reinsurance markets. Despite significant growth in the volume of insurance securities, they remain a small percentage of the overall reinsurance market (roughly 5 percent). Still these markets hold promise, and there is considerable excitement in the industry about their potential (Elliott).

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

Exchange-traded Indexes

Exchange-traded indexes offer the opportunity to receive payments based on the occurrence of some event. Sandor, Berg, and Cole write about the attributes needed for successful futures and options contracts on indexes. "First, the underlying index must be standardized and uniform. Second, the index formula must be well understood and verifiable. Third, the prices underlying the index and the index itself must be disseminated frequently and widely. Fourth, the index inputs should be competitively determined and not subject to manipulation. Finally, the market must perceive that the index accurately reflects value (p. 6)."

When an index contract is properly constructed, it is largely free of moral hazard since an individual who uses the index contract should be unable to influence the outcome that determines payments from the contract. Monitoring needs are reduced and transaction costs will be lower. The payment is solely based on the index, not on what happens to the insured's individual losses. And while this may lower the price as it controls moral hazard and lowers transaction costs, it does mean that the insured faces a basis risk – they can have a loss even when the index does not trigger a payment. The tradeoff between increased basis risk and lower moral hazard is key. Since incentives are more properly ordered with an index contract, one can expect that there are opportunities for more price transparency and increased liquidity. Ultimately, secondary markets may also emerge where individuals who purchase index contracts to protect against their risk exposure can sell the contracts as conditions change and they become more valuable to someone else who is at risk.

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

When the CAT contracts were first introduced (1992), there were fewer regions and they were larger in size. Restructuring the contracts and breaking the regions into smaller sizes helped the trading considerably. For all of the CAT contracts on the CBOT, the open interest exceeded 20,000 contracts in April and May of 1998 (Bouriaux and Himick). Since that time, open interest has declined as the entire reinsurance market has become softer.

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

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

Risk-linked Securities

Cat bonds are the most common risk-linked security. CAT bonds, just like corporate bonds, are debt instruments providing capital contingent upon the triggering of a certain event. CAT bonds are used to provide reinsurance protection. Over 30 such bonds providing over $10 billion of "synthetic reinsurance" have been sold since 1994. In exchange for taking the risk, those purchasing CAT bonds receive a relatively high rate of return if there are no catastrophes. However, they may lose some or all of their investment or earnings on their investment if a catastrophe does occur. Since catastrophes should be independent of the general economic trends, fund managers may use CAT bonds to diversify their portfolios with an equity that has zero correlation to traditional equity markets.

CAT bonds can be written to replace insurance losses from a single event such as an earthquake or a hurricane or they can be written to cover risk of aggregate losses for a portfolio of risk. In both cases, the likely trigger would be some high level of loss, thus, making them work just like a stop loss in reinsurance or as a call option on losses beyond some level. Primary insurers and reinsurers have used CAT bonds. Capital is captured with CAT bonds. For this reason, regulators like this tool because it eliminates the likelihood that a reinsurer will default. With a traditional reinsurer, defaults are more likely because reinsurers do not have to guarantee their ability to pay future losses.

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

Markets for Weather-Based Securities

Weather indexes began trading in 1996 as the U.S. power industry was deregulated. Some people lose and other win when certain weather events occur. When the same event has different impacts on different parties, a trade is possible. When the power industry was deregulated, revenues became more volatility. Extreme low and high temperatures create peak load problems for the electricity industry. When the local company cannot generate enough electricity, they must buy power on the open market to meet the additional demand. By using index contracts that pay when the temperature is either too cold or too hot, the company can hedge against this added cost. In some cases, power companies may also want to protect against normal temperatures since benign weather creates low demand.

As information systems improve and we learn more about the relationships between weather and crop yields and crop quality, it may soon be more useful to have a portfolio of weather contracts that meet particular needs. Farmers or agribusinesses may find such contracts are more dynamic than traditional crop insurance. For example, different weather events will have varying influence depending on the cumulative weather events that create a unique growing season. If the crop starts slow due to a cold wet spring, the timing of the weather may influence yields differently than a season with a quick start. Further, new varieties may be expected to respond differently to weather events than old varieties. This knowledge may be used to tailor the rainfall contracts to the new varieties rather than using historic yield records. Improvements in information systems will continue. Credible and inexpensive ways of measuring weather events will make these markets even more attractive when they are coupled with computer models that link weather events to yields or other variables that drive incomes.

Section 4: Index Insurance Alternatives

Index insurance makes payments based not on shortfalls in farm yields, but rather on measures of an index that is assumed to proxy farm yields. We will consider two types of index insurance products; those that are based on area-yields where the area is some unit of geographical aggregation larger than the farm, and those that are based on weather events.

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

The information needed to run an index insurance program is much less than what is needed for a farm yield insurance program. One needs sufficient data to establish the expected value of the index and a reliable and trusted system to establish the estimates of realized yield values. There is no need for any farm-level information. For example, area-yield insurance indemnities are based on estimates of official measurements of realized area-yields relative to expected area-yields. Areas are typically defined along political boundaries (e.g., counties in the U.S.) for which historical yield databases already exist.

The logic for using index insurance is relatively simple – there is no asymmetric information (Skees and Barnett). Farmers likely have no better information than the insurer regarding the likelihood of area-yield shortfalls or unusual weather events, thus there is no adverse selection. Farmers cannot, by changing their behavior, increase the likelihood of an area-yield shortfall (if areas are defined at large enough levels of aggregation) or an unusual weather event, thus there is no moral hazard. All of the information needed for loss adjustment is available from public sources. Thus, it is easy to tell whether or not a loss has occurred and accurately measure the indemnity, without having to rely on any information provided by the policyholder. All of these factors make it much less expensive for the insurer to provide index insurance than multiple-peril crop insurance. Thus, the cost of index insurance can be significantly lower than the cost of multiple-peril crop insurance. Also, since adverse selection and moral hazard are not problems, there is no need for deductibles.

There are numerous ways to calculate payments on index contracts (Skees, 2000). For GRP, indemnity is calculated as

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

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

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

where *Expected County Revenue per Acre* is equal to the product of the official estimate of price and expected county yield per acre and *Scale* is chosen by the policyholder but is limited to between 90 percent and 150 percent.[6]

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

An alternative design has been proposed for rainfall index insurance (Martin, Barnett, and Coble).[7]

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

$$if\ \ Realized\ \ Index > Limit\ ,\ else$$

$$Indemnity = Liability\ .$$

Here *Limit* is a parameter selected by the policyholder and bounded by 0 # *Limit* < *Index Trigger*. The choice of *Limit* determines how fast the maximum indemnity is paid. By their selection of *Limit*, policyholders can attempt to better match indemnities with expected losses over the domain of potential realized values for the index. For example, suppose that losses would occur when realized aggregate rainfall is less than 100 mm measured over a given time period at a given weather station. Further suppose that

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

[7] The presentation here is for index insurance that would protect against losses due to insufficient rainfall. Martin, Barnett, and Coble, present an analogous index insurance that would protect against losses due to excessive rainfall.

realized rainfall less than or equal to 50 mm would cause a complete loss. The policyholder would select an *Index Trigger* of 100 mm and a *Limit* of 50 mm. If realized rainfall is less than or equal to 50 mm the *Indemnity* would be equal to the full *Liability*.

One can easily see that the GRP contract is simply a specific case of this more general contract design with *Limit* set equal to zero. At the other extreme, the closer *Limit* is set to *Index Trigger*, the more the contract resembles a "zero-one" contract where *Indemnity* equals zero or the full *Liability* solely based on the condition if the *Realized Index* < *Index Trigger*.

Experiences in Index Insurance

In the U.S., participation in GRP has been relatively low for a variety of reasons. Obviously, is it quite different from traditional insurance, and this raises legitimate concerns from the insurance industry. Traditional insurers find it difficult to understand and accept an insurance product where indemnities are not based on farm-level yield losses. Farmer interest has also been mixed. Not surprisingly, most GRP policies seem to be sold in areas where crop insurance sales agents are most familiar with GRP. In 2000, about 5.6 million acres were insured under GRP. That is relatively small percentage of the total insured acreage in the U.S. It is very difficult for GRP to compete with highly subsidized farm-level insurance that is now being offered at coverage levels of up to 85 percent.

The Ontario rainfall insurance product was fully subscribed in the first year that it was introduced (2000). However, this is a limited pilot test of only 150 farmers and the product was introduced following a major drought. By 2001, 235 farmers had purchased about $5.5 million in liability with payments of $1.9 million[8]. This policy was targeted toward alfalfa hay production. Alberta has also introduced a rainfall index insurance product for forage production. This contract has been available for two years. In 2002, over 4000 ranchers subscribed to the contract. It is also reported that a major drought occurred this season and large payments will be made. Details of this contract are in the attachment at the end of this report.

For many emerging economies or developing countries, rainfall index insurance merits consideration (Hazell; Skees, Hazell, and Miranda). While basis risk may generally be lower with area-yield index insurance, there are several reasons why rainfall index insurance may be preferable in an emerging economy like Romania. First, as will be developed in more detail in this report, the historical Judet level yield data are likely prone to several problems. Second, current systems for developing Judet level yield data are not well understood and may still be limited. On the other hand, the meteorological data in Romania have a long history of being developed in a similar fashion over time. Third, is less costly to set up a system to measure weather events for specific locations than to develop a reliable yield estimation procedure for small geographical areas. Finally, either insufficient or excess rainfall is a major source of risk for crop losses in many regions. Drought causes low yields and excess rainfall can cause either low yields

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

or serious losses of yield and quality during harvest (Martin, Barnett, and Coble). For irrigated farms, a drought can also cause increased irrigation costs.

The World Bank Group is pursuing the feasibility of rainfall index insurance in a number of countries. The International Finance Corporation (IFC) of the World Bank Group is planning to may take a financial interest in making rainfall insurance offers in developing countries; Morocco is set to launch a new rainfall insurance contract in the fall of 2002. The IFC is interested in supporting these innovations so that developing countries can participate in emerging weather markets. A specially funded project was also awarded to a working group within the World Bank. This project has investigated the feasibility of developing weather-based index insurance for four countries: Nicaragua, Morocco, Ethiopia and Tunisia. Since that project began, several of the professionals involved have begun similar investigations in Mexico, Argentina, and the Romania at the request of those governments. The governments of Turkey, Brazil, India and Mongolia have made similar requests. There is clearly a growing international interest in weather insurance.

Basis Risk

The phrase “basis risk” is most commonly heard in reference to commodity futures markets. In that context, “basis” is the difference between the futures market price for the commodity and the cash market price in a given location. Basis risk is variation over time in the relationship between the local cash price and the futures price. Consider a U.S. example where farmers, in a specific locale chose to forward price their corn using the Chicago Board of Trade (CBOT) December futures contract. By selling December futures contracts, the farmers “lock in” a price at harvest that is conditional on an anticipated relationship between the futures market price and the local cash price. For instance, they may anticipate that when they harvest and sell their crop in November, the local cash price will be 20 cents per bushel lower than the November price on the December CBOT contract. If, however, local cash prices are much lower than expected relative to the CBOT, say, 35 cents per bushel below CBOT, the farmers do not get the price risk protection that they had hoped for. Their actual realized price, from the combined cash market and futures market activities, is 15 cents per bushel less than had been expected. Conversely, the local cash price may be much higher than expected relative to the CBOT price. For instance, the local cash price may be only 5 cents per bushel lower than the CBOT price. In this case, the farmers actual realized price, from the combined cash market and futures market activities, is 15 cents per bushel more than had been expected.

Basis risk is a common phenomenon in futures markets. While futures contracts can still be effective price risk management tools for farmers, the existence of basis risk implies that farmers will not always receive the anticipated price. Sometimes it will be higher. Sometimes it will be lower. Because of basis risk, forward pricing in the futures market does not eliminate *all* exposure to price risk.

Basis risk also occurs in insurance. It occurs when an insured has a loss and does not receive an insurance payment sufficient to cover the loss (minus any deductible). It also occurs when an insured has a loss and receives a payment that exceeds the amount of loss.

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

Recently, the academic literature on crop insurance has focused on basis risk that will naturally be part of any index insurance program. But there has been little discussion of the basis risk inherent in farm-level insurance. To illustrate how basis risk is possible for farm-level multiple-peril insurance programs, one need only consider the major underwriting mechanism used in the U.S. to establish the insurable yields. Recall that in the U.S., the insurance yield (a measure of central tendency) is based on a simple 4-10 year average of historical yield data for the insurance unit. The "square root of *n* rule" states that, for normal distributions, an average estimates the true central tendency of the distribution with standard error calculated as:

$$\text{Standard Error of the Estimate} = \frac{s}{\sqrt{n}}$$

where σ is the standard deviation of the true distribution and n is the size of the sample from which the average was calculated.

While crop-yields are probably not normally distributed, the implications of this statistical formula would still hold for most reasonable assumptions of crop-yield distributions. Namely, the higher (lower) the standard deviation of the true distribution, the higher (lower) will be the error in using an average as an estimate of central tendency. The higher (lower) the sample size, the lower (higher) will be the error in using an average as an estimate of central tendency.

Consider the error in using an average to estimate the central tendency of crop-yields with a sample size of only 4 to 10 years of farm yield data. For simplicity, we assume a corn farm where yield is normally distributed with a mean of 100 bushels per acre. We consider values for σ of 25, 35, and 45 bushels per acre. Figure 2 presents the standard error of the estimate for different values of σ and n. Clearly, the higher the variability in yield, measured by σ, the higher the error in using a simple average as an estimate of central tendency. However, it is also striking how much higher the error is when using 4 years of data rather than 10 years.

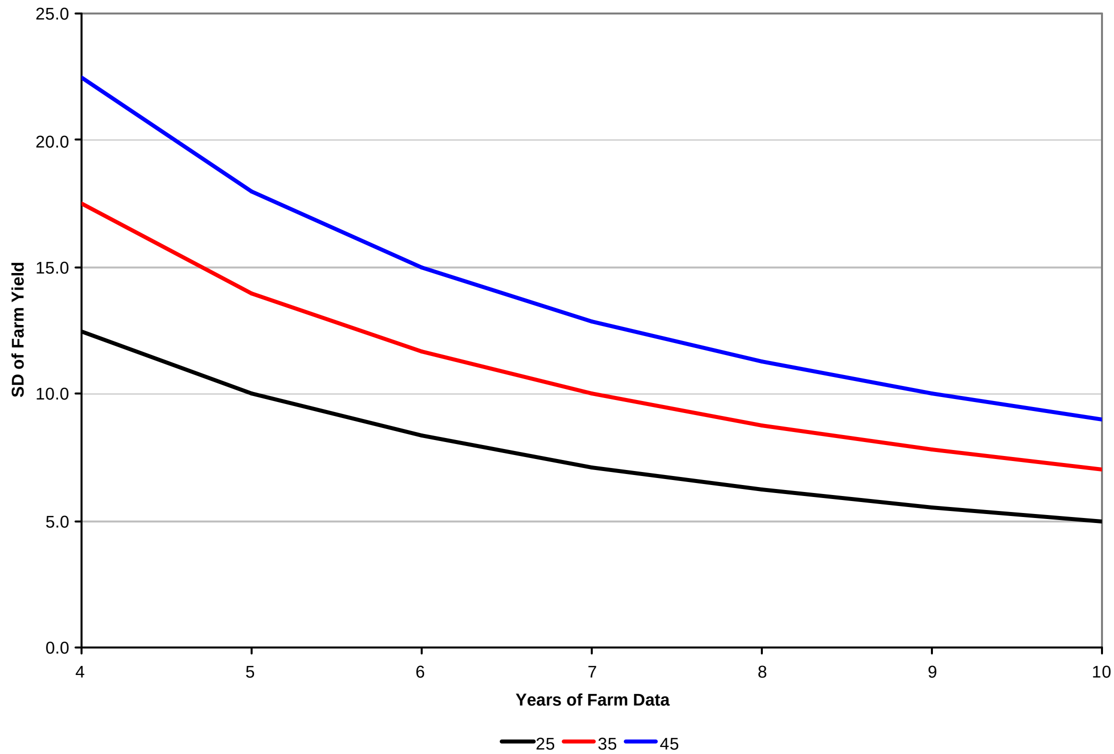


Figure 2: The relationship between estimating farm yields, the number of observations, and the standard deviation of the farm yields

If the standard deviation is 35 bushels per acre (which is a reasonable value for the U.S.), using only 4 years of data to estimate the insurance yield will result in a standard error of 17 bushels per acre. Thus, while two thirds of the APH yields would be between 83 and 117 bushels per acre, there is a 33 percent chance that the calculated insurance yield will be less than 83 or more than 117 bushels per acre. Now consider a situation where, because of the error in using a simple average as an estimate of central tendency, the insurance yield is calculated as 120 bushels per acre when the true central tendency is only 100 bushels per acre. If the farmer selects an 85 percent coverage level (15 percent deductible) the trigger yield will be 102 bushels per acre, which is higher than the actual central tendency! While the farmer has been charged a premium rate based on a coverage level of 85 percent, in effect, the farmer has been given a coverage level over 100 percent. Due to the estimation error, this farmer could receive an insurance payment when the realized yield is at, or even slightly above, the central tendency.

Alternatively, if the insurance yield is estimated at 80 bushels per acre, 85 percent coverage will generate a trigger yield of 68 bushels per acre. While the farmer has been charged a premium rate based on a coverage level of 85 percent, in effect, the farmer has been given a coverage level of only 68 percent. If central tendency were estimated accurately, a yield loss in excess of 15 bushels per acre would trigger an insurance payment. Because of the estimation error, this farmer must have a yield loss in excess of 32 bushels per acre to receive an insurance payment.

Because of the error in estimating central tendency, it is possible for farmers to receive insurance payments when yield losses have not occurred. It is also possible for farmers to not receive payments when payable losses have occurred. Thus, basis risk occurs not only in index insurance but also in farm-level yield insurance.

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

Longer series of data are generally available for area-yields or weather events than for farm yields. The standard deviation of area-yields is also lower than that of farm yields. Since n is higher and σ is lower, the square root of n rule suggests that there will be less measurement error for area-yield insurance than for farm yield insurance in estimating both the central tendency and the realization. Long series of weather data are also available, but it is not necessarily true that the standard deviation of weather measures will be less than that of farm yields.

Summary of the Relative Advantages and Disadvantages of Index Insurance

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

1. *No moral hazard:* Moral hazard arises with traditional insurance when insured parties can alter their behavior so as to increase the potential likelihood or magnitude of a loss. This is not possible with index insurance because the indemnity does not depend on the individual producer's realized yield.
2. *No adverse selection:* Adverse selection is misclassification problem caused by asymmetric information. If the potential insured has better information than the insurer about the potential likelihood or magnitude of a loss, the potential insured can use that information to self-select whether or not to purchase insurance. Those who are misclassified to their advantage will choose to purchase the insurance. Those who are misclassified to their disadvantage will not. With index insurance products, insurers do not classify individual policyholders' exposures to risk. Further, the index is based on widely available information. So there are no informational asymmetries to be exploited. It is true that some will find index insurance products more attractive than others. However, unlike individualized insurance products, such self-selection will not affect the actuarial soundness of index insurance products.
3. *Low administrative costs:* Unlike farm-level, multiple-peril, crop insurance policies, index insurance products do not require costly on-farm inspections or claims adjustments. Nor is there a need to track individual farm yields or financial losses. Indemnities are paid solely on the realized value of the underlying index as measured by government agencies or other third parties.
4. *Standardized and transparent structure:* Index insurance policies can be sold in various denominations as simple certificates with a structure that is uniform across

underlying indexes. The terms of the contracts would therefore be relatively easy for purchasers to understand.

5. *Availability and negotiability:* Since they are standardized and transparent, index insurance policies can easily be traded in secondary markets. Such markets would create liquidity and allow the policies to flow to where they are most highly valued. Individuals could buy or sell policies as the realization of the underlying index begins to unfold. Moreover, the contracts could be made available to a wide variety of parties, including farmers, agricultural lenders, traders, processors, input suppliers, shopkeepers, consumers, and agricultural workers.
6. *Reinsurance function:* Index insurance can be used to transfer the risk of widespread, correlated, agricultural production losses. Thus, it can be used as a mechanism to reinsure insurance company portfolios of farm-level insurance policies. Index insurance instruments allow farm-level insurers to transfer their exposure to undiversifiable, correlated, loss risk while retaining the residual risk that is idiosyncratic and diversifiable (Black, Barnett, Hu).

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

1. *Basis Risk:* It is possible for index insurance policyholders to experience a loss and yet not receive an indemnity. Likewise, they may receive an indemnity when they have not experienced a loss. The frequency of these occurrences depends on the extent to which the insured's losses are positively correlated with the index. Without sufficient correlation, "basis risk" becomes too severe, and index insurance is not an effective risk management tool. Careful design of index insurance policy parameters (coverage period, trigger, measurement site, etc.) can help reduce basis risk.
2. *Security and dissemination of measurements:* The viability of index insurance depends critically on the underlying index being objectively and accurately measured. The index measurements must then be made widely available in a timely manner. Whether provided by governments or other third party sources, index measurements must be widely disseminated and secure from tampering.
3. *Precise actuarial modeling:* Insurers will not sell index insurance products unless they can understand the statistical properties of the underlying index. This requires both sufficient historical data on the index and actuarial models that use these data to predict the likelihood of various index measures.
4. *Education:* Index insurance policies are typically much simpler than traditional farm-level insurance policies. However, since the policies are significantly different than traditional insurance policies, some education is generally required to help potential users assess whether or not index insurance instruments can provide them with effective risk management. Insurers and/or government agencies can help by providing training strategies and materials not only for farmers, but also for other potential users such as bankers and agribusinesses.
5. *Marketing:* A marketing plan must be developed that addresses how, when, and where index insurance policies are to be sold. Also, the government and other involved institutions, must consider whether to allow secondary markets in index insurance instruments and, if so, how to facilitate and regulate those markets.

6. *Reinsurance:* In most transition economies, insurance companies do not have the financial resources to offer index insurance without adequate and affordable reinsurance. Effective arrangements must therefore be forged between local insurers, international reinsurers, local governments, and possibly international development organizations.

Index insurance is a different approach to insuring crop-yields. A precondition for such insurance to work is that many farmers in the same location must be subjected to the same risk. When this is the case, index insurance has the potential to offer affordable and effective insurance for a large number of farmers. Such insurance requires a different way of thinking. It is possible to offer such contracts to anyone at risk when there is an area wide crop failure. Furthermore, unlike traditional insurance, there is no reason to place the same limits on the amount of liability an individual purchases.

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

Section 5: Developing a profile of risk for major Romanian crops

There are a limited number of ways to attempt to model various crop insurance alternatives given the available yield data. The Institute for National Statistics (INS) supplied data for five crops by Judet from 1968-2000. The harvested hectares and total production values were supplied. The crops include maize, wheat, barley, sunflowers, and soybeans. Using the value of crops sold at the farm gate from the OECD publication "Review of Agricultural Policies: Romania", these crops accounted for roughly 60% of the total crop value in 1998 and 66% in 1999. An important crop that is not included in this analysis is potatoes which ranked at about 37% in 1998 and 30% in 1999 of the total crop value. Maize and wheat are important crops accounting for around 50% of the crop value.

Table 2: Share of Crop Value

Crops Included	1998	1999
Maize	29%	40%
Wheat & Rye	18%	16%
Soybeans	1%	1%
Sunflower	7%	7%
Barley	4%	3%
Crops Not Included		
Potatoes	37%	30%
Sugar Beets	2%	2%
Rapeseed	0%	0%
Oats	1%	2%

This table was developed using the 2000 OECD publication "Review of Agricultural Policies: Romania"

The data provided included the surface area harvested and the total production in tones. Yield per hectare values are simply the total production divided by the surface area. These data were used to develop a model that allows a more complete examination of the spread of risk for multiple crops across Romania. Maintaining the spatial correlation among crops across Judets was an essential objective of these efforts. The first challenge was to identify the Judets and crops with some significant surface area in the later years and then develop procedures to fill in data that were missing. There are 167 Judet-crop combinations that represent some level of significance for these five crops and the 41 Judets in Romania. Missing values were filled in for these 167 Judet-crop combinations so that there is an actual yield value or a proxy value for all 33 years. Missing data were filled in by examining the crop with the strongest correlation. In some cases that was a crop within the same Judet and in others it was a neighboring crop (generally the same crop when the neighbor was used). The strongly correlated crop was used with special procedures to estimate a crop value for the missing data.

Adjusting Judet Yield Data for Trends

The next challenge was to adjust these time series for the central tendency through the 32 years. As expected, from 1968 to the mid 1980s there are generally positive trends in yields due to advances in technology and the application of more inputs. Romania had tremendous difficulties from the mid 1980s and into the early 1990s as they became independent and began the painful process of adjusting to a market-based economy, the application rates of inputs dropped off precipitously. In some areas this meant less fertilizer and chemicals, in others the change in irrigation likely accounts for major declines in the yields. Relatively robust econometric procedures are needed to capture the central tendency in yields when these types of major changes are occurring. The LOESS procedures in the SAS software were used.[9]

Once a central tendency (trend) was developed, the next issue was to 'detrend' the data into today's technology. The central tendency was extended to the 2002 crop year. Past data were detrended with the following equation:

$$\textit{Detrended yield}_{tjc} = (\textit{Actual yield}_{tjc} / \textit{Trend Yield}_{tjc}) \times \textit{Trend Yield2002}_{jc}$$

where t= year, 1968-2000 : j = Judet; 1-41: and c = crop; 1-5

Figure 3 provides an example of the actual yield per hectare, the trend yield, and the detrended yield series for maize in Dolj Judet. As described above, the actual yields increased steadily from 1968-the middle 1980s. The smooth line is the LOESS fit for the central tendency or trend. The lower line is the detrended data and represents the best estimate of the yield given today's (the year 2000) input and technology mix.

Estimating Value at Risk

Detrended yield data are used throughout to make estimates of the yield risk by Judet and crop. However, the next task is to develop the profile of risk given the historic estimates of yields and the best estimates of value at risk for the current spread of crops across Romania. Three years (1998-2000) are used to develop the estimate of the current plantings. A weighted average is used to make the estimate:

$$\textit{Current Planting}_{jc} = .5 \times \textit{HA2000}_{jc} + .33 \times \textit{HA1999}_{jc} + .17 \times \textit{HA1998}_{jc}$$

where j = Judet; 1-41: and c = crop; 1-5

Value at risk represents the best estimate of expected revenue for each crop at planting time in the crop year 2002. Value at risk is calculated using estimates of the

[9] SAS reports the following about LOESS "The LOESS procedure implements a nonparametric method for estimating regression surfaces. The LOESS procedure allows great flexibility because no assumptions about the parametric form of the regression surface are needed…. You can use the LOESS procedure for situations in which you do not know a suitable parametric form of the regression surface. Furthermore, the LOESS procedure is suitable when there are outliers in the data and a robust fitting method is necessary.

2002 expected yields, the current plantings, and the expected prices for the commodities in 2002.

$$\textbf{\textit{Value at Risk}}_{jc} = \textbf{\textit{Current Plantings}}_{jc} \times \textbf{\textit{Trend Yield2002}}_{jc} \times \textbf{\textit{Price}}_{c}$$

where j = Judet; 1-41: and c = crop; 1-5

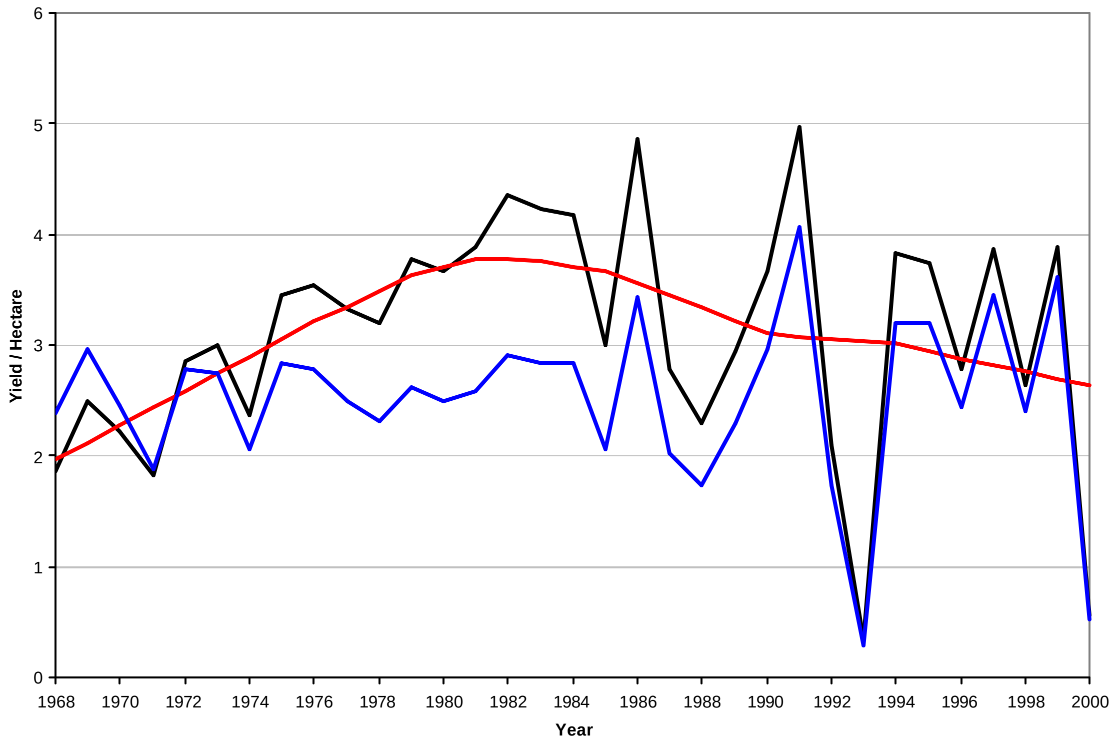


Figure 3: Actual and Detrended Yields for Maize in Dolj Judet

The prices used are in dollars per tone as estimated at planting in 2002: 1) maize = \$90; 2) wheat = \$106; 3) barley =\$82; 4) sunflower=\$192; and 5) soybeans=\$212. Table 3 has Judet Calarasi with a value at risk or a total expected revenue for these five crops just greater than US \$100 million. The value at risk numbers are used for a number of items. First, value at risk for the crop and Judet will drive the liability for any insurance designs. The liability is the maximum amount that will be paid by an insurance policy. Various assumptions must be made about the participation levels in insurance programs. For example, if the participation level is assumed to be 50%, the value at risk will be factored down by 50%. With some insurance products, a further reduction in the value at risk may occur before one has an estimate of the liability. Many insurance products have a deductible involved. If the deductible is 30%, payments will be made on 30% less than the total value. To be clear, if the assumption is made that only one half of the farmers in Calarasi would subscribe to an insurance product with a 30% deductible, the liability would be calculated as:

Liability = Value at Risk x Participation Rate x (1- deductible)

For Calarasi = $101,554,000 x .50% x (1-.3) = $35,544,000

While the expected 2002 revenue is based upon the expected yields for 2002, it is also useful to backcast the revenue estimates given the adjusted or detrended yields from 1968-2000. Again, this exercise is done with the best estimates of the current plantings and the current prices. In short, the exercise assumes that the weather events of the past would be a random draw with the current conditions. Since there are 33 past observations on yields, each yield draw is also assumed to be equally likely and independent from the previous year's yield. A potential limitation of this analysis is that price and yield are also implicitly assumed to be independent since the 2002 expected price is used throughout

$$\textbf{Revenue}_{tjc} = \textbf{Adjusted yield}_{tjc} \textbf{ x Hectares}_{tjc} \textbf{ x Price}_{c}$$

where t= year, 1968-2000 : j = Judet; 1-41: and c = crop; 1-5

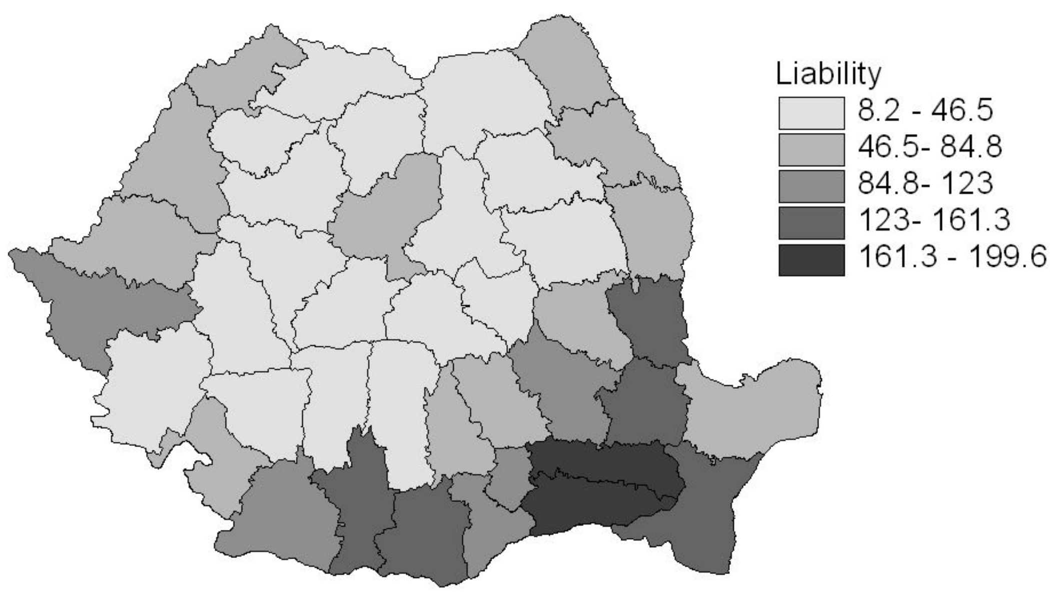


Figure 4: Map of Revenue (Liability) Estimates Per Total Hectares in the Judet (Maize, Wheat, Barley, Sunflowers, Soybeans).

Table 3: Estimates of Value at Risk in 2002 and Expected Yields for 2002 at Planting.

Judet	Value at Risk	EY Maize	EY Wheat	EY Barley	EY Sunflower	EY Soybean
Alba	$ 17,485,628	3.02	2.32	1.65	1.10	NA
Arad	$ 62,587,377	3.24	2.58	2.44	0.93	1.49
Arges	$ 23,725,085	2.60	1.99	2.23	0.70	NA
Bacau	$ 12,933,161	1.22	1.48	NA [10]	NA	NA
Bihor	$ 42,989,210	3.17	2.14	1.85	0.98	NA
Bistrita-Nasaud	$ 10,774,276	2.77	2.17	1.64	NA	NA
Botosani	$ 40,786,191	2.58	1.80	1.21	1.09	0.91
Braila	$ 73,236,057	3.17	2.72	2.61	1.13	1.47
Brasov	$ 9,501,414	2.64	2.85	2.08	NA	NA
Buzau	$ 55,394,353	2.86	2.56	2.75	1.19	NA
Calarasi	$101,553,598	3.09	3.30	3.30	1.15	1.64
Caras-Severin	$ 18,100,158	2.77	2.72	2.54	1.06	NA
Cluj	$ 21,574,317	2.77	2.25	1.75	1.14	NA
Constanta	$ 99,766,301	2.68	2.97	2.82	1.19	1.37
Covasna	$ 8,063,770	2.54	3.08	2.10	NA	NA
Dambovita	$ 24,543,883	2.60	2.09	2.06	0.73	NA
Dolj	$ 82,610,012	2.50	2.09	2.41	0.80	0.94
Galati	$ 57,086,168	2.79	2.29	2.28	1.05	1.79
Giurgiu	$ 38,059,311	1.98	2.44	2.86	0.79	0.78
Gorj	$ 23,555,330	3.35	2.65	NA	NA	NA
Harghita	$ 5,503,961	2.63	2.07	1.78	NA	NA
Hunedoara	$ 11,946,614	3.39	2.57	1.79	NA	NA
Ialomita	$ 83,506,469	3.17	3.07	2.97	1.27	1.68
Iasi	$ 45,764,252	2.88	2.36	2.16	1.41	1.48
Ilfov	$ 16,691,843	2.43	2.57	2.78	1.00	NA
Maramures	$ 7,566,781	2.47	1.97	1.77	1.08	NA
Mehedinti	$ 36,894,748	3.26	2.44	2.31	0.87	NA
Mures	$ 31,430,778	3.29	2.28	1.84	1.23	NA
Neamt	$ 23,704,555	2.90	2.32	1.72	1.10	NA
Olt	$ 69,934,956	2.30	2.38	2.63	0.83	1.02
Prahova	$ 30,619,046	3.23	2.56	3.10	1.02	NA
Salaj	$ 12,770,280	2.80	2.27	1.64	1.11	NA
Satu-1Mare	$ 33,179,327	3.03	2.50	2.19	1.12	NA
Sibiu	$ 9,877,996	2.66	2.11	1.48	NA	NA
Suceava	$ 15,249,263	2.60	2.28	1.54	1.25	NA
Teleorman	$ 80,703,209	2.12	2.47	3.13	0.79	1.20
Timis	$ 92,095,519	3.30	2.70	2.54	0.98	1.35
Tulcea	$ 40,569,580	2.46	1.73	1.39	0.83	1.28
Valcea	$ 18,567,909	4.20	2.91	NA	NA	NA
Vaslui	$ 42,400,732	2.19	1.95	1.77	1.02	1.10
Vrancea	$ 33,088,122	3.22	2.63	2.90	1.31	NA

[10] NA means that the crop is not significant in the Judet.

Methodology for developing Loss Cost Estimates

Given the corrections made to the Judet data described in the section above, it is now possible to take further steps that allow for a more complete assessment of the potential cost of various agricultural insurance proposals. Generally, the largest single cost from an insurance program is the indemnities paid. The calculation of empirical indemnities forms the basis for insurance premiums. In insurance rate-making, actuaries use the past experience on losses relative to the value insured as the basis for calculating what is termed the historic loss cost:

Loss cost = indemnities / liabilities

When an actuary has a large number of observations on loss cost, they use the simple mean of these data as the beginning point for rate-making. The mean of the series can also be thought of as the pure premium. Intuitively, it is a relatively simple notion that the average indemnities paid over time should be equal to the average premiums collected over time. The challenge is to develop reasonable procedures to estimate loss cost when there is no history of providing crop insurance. Loss cost estimates must come both from the empirical basis and from judgment about the level of adverse selection and moral hazard that may be present in different insurance products. Ultimately, the entire exercise will involve estimates of a likely premium for different crops in different Judets for the different insurance choices. The components of premiums are as follows:

1) **Loss cost** or pure premium estimates from historic data and/or simulation of data (this can include negative trends in losses).
2) **Loss cost** loading for adverse selection and moral hazard (in principle, farm-level insurance products will be loaded much more than index-based products).
3) **Catastrophic loading** or estimates of reinsurance costs and reserve loading (when the loss function has some high probability of large losses, reinsurance costs will be relatively high).
4) **Administrative cost** should include the cost of underwriting, sales, upkeep, actuarial services, loss adjustment, etc.
5) **Profits** will be added to all of these costs in many cases.

To simplify the comparisons of programs, the costs items 2-5 are loaded onto the pure loss cost as percentage loads. The empirical indemnities or the pure loss costs were estimated through empirical analysis of historical crop-yields. Once an estimate of premium rates is made, assumptions about the participation rates and deductibles can be made to estimate liability. This will provide a complete analysis of the insurance cost for a market-based estimate of premiums either on a hectare basis or on a national basis.

While the Judet data and the adjustments described in the section above provide the basis for estimates of any programs that pay on area-yields, special procedures are needed to estimate farm-level yields for each Judet, crop and year. These procedures have been used in modeling U.S. crop-yields and the U.S. crop insurance program. They have proven to provide good estimates of loss cost for the U.S. crop insurance program.

In simple terms, the procedures simulate a distribution of farm yields around the adjusted yield for each Judet, crop, and year. Special beta distributions are used to generate 300 simulated draws for synthetic farm yields. Figure 5 illustrates the results for wheat in Calarasi Judet for a good crop year (1997) and a bad crop year (1996). Under these procedures, each farm is assumed to have the same expected yield as the Judet. Thus, if a farm-level yield program is being evaluated, the simulated farm yields are used to estimate the payouts for each of the 300 farms given the specific deductible and crop year. These payouts are averaged across the 300 farms to provide a single estimate of the loss cost for that year.

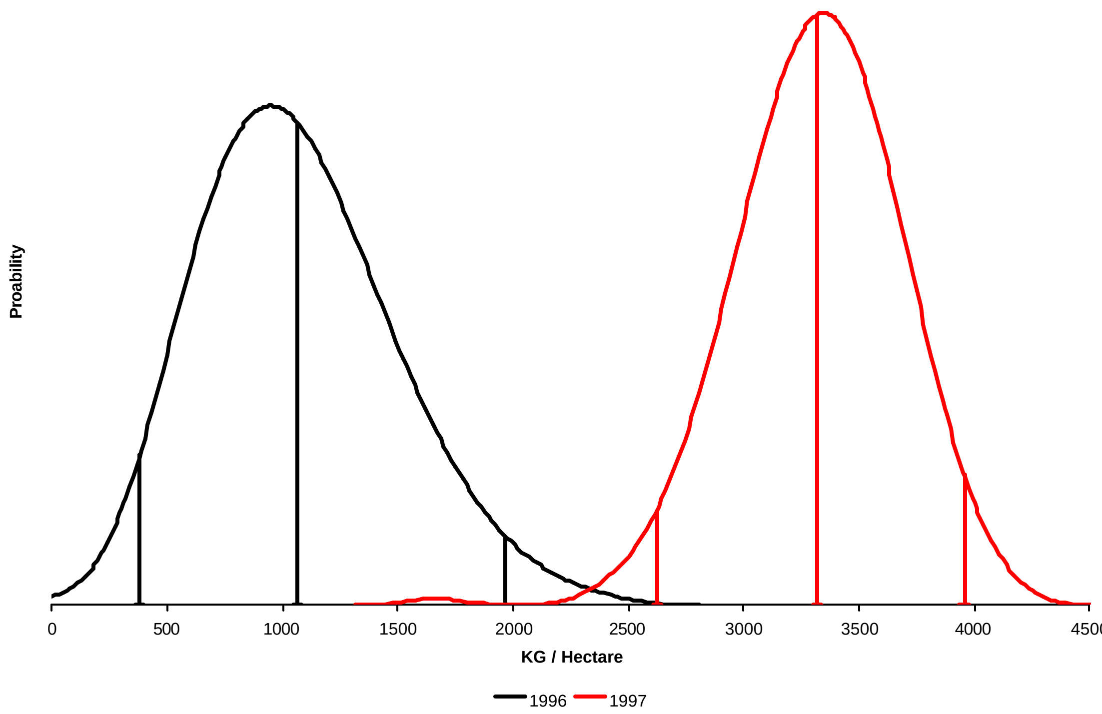


Figure 5: Simulated Farm Yields for Wheat in Calarasi Judet

Once transformed to the average loss cost or pure premium rate, the producer and aggregate program costs can be calculated. To demonstrate this process for wheat in Calarasi Judet, consider Table 4. The expected yield for 2002 is 3300 KG / Hectare. If an area-yield contract with a 10% deductible is considered, the payments begin when Judet yields are below 0.90 x 3300 or 2971 KG / Hectare. The payment calculation is based on the percentage below the trigger of 2971. For example, with the 1996 yield of 1531 the payment will be = (2971-1531) / 2971 or 48%.

Table 4: Loss Cost for Wheat in Calarasi Judet

Year	Yield	AY_90	MP_70
1968	3085	0%	5%
1969	2411	19%	21%
1970	3559	0%	1%
1971	3212	0%	3%
1972	4626	0%	0%
1973	3107	0%	4%
1974	3153	0%	4%
1975	2852	4%	9%
1976	3401	0%	2%
1977	3733	0%	0%
1978	3355	0%	2%
1979	2876	3%	8%
1980	3592	0%	1%
1981	3541	0%	1%
1982	3953	0%	0%
1983	2579	13%	15%
1984	3642	0%	1%
1985	1840	38%	42%
1986	2988	0%	6%
1987	3493	0%	1%
1988	3871	0%	0%
1989	3982	0%	0%
1990	3819	0%	0%
1991	3017	0%	6%
1992	3397	0%	2%
1993	2949	1%	7%
1994	2340	21%	23%
1995	3682	0%	1%
1996	1531	48%	54%
1997	4368	0%	0%
1998	2974	0%	6%
1999	3707	0%	1%
2000	3396	0%	2%
Average Loss Cost		4.5%	6.9%

Table 4 clearly indicated the years where a serious loss would have occurred (1996, 1985, 1969, 1994, 1983). The table also has the loss cost for a multiple-peril insurance plan with a 30% deductible. This suggests that the 10% deductible Judet area plan is roughly equivalent to the 30% deductible farm-level plan. As expected there are payments for the farm-level plan when the area plan does not pay. This, in part, explains why the average loss cost for the area plan is lower (4.5% versus 6.9%). These same procedures are used throughout for various deductibles and for some alternative designs on these basic products. Again, the major objective is to estimate a loss cost for every Judet, crop and year.

Aggregation of Indemnities and Liabilities

Insurance is a portfolio problem. The value at risk is a spatial aspect of the portfolio and, of course, time is the temporal aspect. While the major weather events in the same year have similar impacts across Romania, one can expect at least some degree of diversification if crops in the different regions are insured. The fact that the various crops also have different phonological calendars adds further diversification as the same weather events that damage the fall planted wheat and barley may not damage maize, sunflowers and soybeans. It is very important that the spatial correlation of the risk among crops across space and time has been maintained. The Romanian sample of 33 years can now be used to examine the profile of risk in today's terms by assuming that every Judet has the same level of participation in the crop insurance program. Keep in mind that the value at risk numbers are the best estimates of the expected revenue for each Judet and crop for the 2002 crop year. Thus, the amount insured for each is simply:

$$Liability_{jc} = Revenue_{jc} \times Participation\ Rate$$

where j = Judet; 1-41: and c = crop; 1-5

Given a liability, the loss cost numbers can easily be converted to indemnities for each Judet, crop and year:

$$Indemnity_{tjc} = Liability_{jc} \times Loss\ Cost_{tjc}$$

where t= year, 1968-2000 : j = Judet; 1-41: and c = crop; 1-5

Premium rates are the simple average of the loss cost and premiums are the product of premium rate and liability:

$$Premium_{jc} = Liability_{jc} \times Premium\ Rate_{jc}$$

where j = Judet; 1-41: and c = crop; 1-5

To develop the risk profile of the portfolio of insured crops one sums up all liabilities, indemnities, and premiums for each year (keep in mind that sum of liabilities and premiums will be the same for all years since the model is in today's terms). Once these values are aggregated to the national level it is easy to calculate the loss ratio for the 33 years. The 33 years of the national loss ratios (indemnities / premiums) will be used to make statements about the loss function for alternative crop insurance programs in Romania.

Section 6: Analysing Alternative Programs to Handle Catastrophic Yield Risk

As has been developed above, two value-added data sets are available for analyzing any number of policy alternatives designed to handle catastrophic yield risk: 1) the Judet data; and 2) the simulated farm data for each Judet and crop. A number of alternatives that either use Judet area-yields or farm yields or some combination of the two will be examined. This section systematically examines the relative costs and the profile of risk for a number of alternatives. In the next section, weather-based insurance alternatives are examined for a specific region (Southeast Romania).

This report examines the following options:

1) Area Base Insurance:

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

Liability = Price x Hectares x Judet Expected Yield

where hectares would be the farmer's plantings (or the total hectares in the Judet when performing this analysis)

The index trigger is set in two different fashions:

1) As a percent of the Judet expected yield (80%, and 90%)
2) At various frequency levels for the Judet yield (1 in 5; 1 in 7; 1 in 10; & 1 in 20 year events).

2) Multiple-peril Crop Insurance:

*Indemnity = max(0, Farm Yield Trigger – Actual Farm Yield) * Price * Hectares*

where farm yield triggers are examined for 60%, 70%, and 80% of the farm expected farm yield

3) Area-yield Insurance with Individual Payments

Indemnity = max(Multiple-peril Payment, Area-yield Payment)

Area-yield at 1 in 7 and 1 in 10; Farm Yield at 60% & 70% with the same indemnity payouts as presented above

Results

Results are developed for the value at risk portfolio of the five crops. Since the analysis is performed using this weighted average of crop value across Romania and with the 33 years of crop-yield risk, a rather complete profile of risk is possible. As an illustration of the tracking of two very different programs, Figure 6 presents the historic loss cost for the AYP that is based on triggers set at 1 in 7 years and the 60% coverage for a MPCIP. Again, the higher loss cost values in the more recent years is evident, especially considering that 2002 may be at about the same level as 2000.

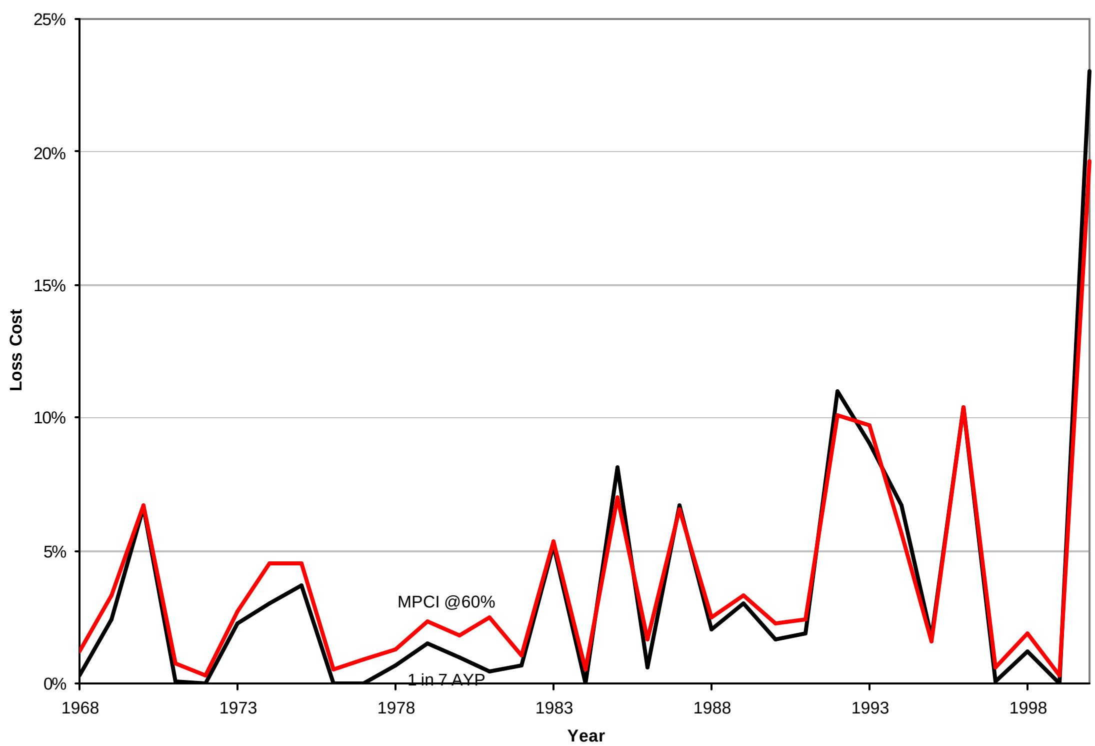


Figure 6: Historic Loss Cost Estimates for Area-yield 1 in 7 Year Trigger and MPCIP set at 60% Coverage.

Given different crop insurance program designs one can also make cross comparisons. Figure 7 provides a direct comparison of an area-yield program (AYP) with a multiple-peril crop insurance program (MPCIP) for the aggregate loss cost or pure premium. Farm yields will nearly always have more variance than area-yields. Thus, as expected, the MPCIP program cost curve is greater than the AYP curve. The curves also have the expected shape; the increase at an increasing rate as the coverage increase (deductible decreases). Estimates of the loaded premiums are also presented. These loads are based on expert judgment and industry standards. The loading assumptions are presented in the table below. Clearly these loads will be much greater for the MPCIP versus the AYP. Offering MPCIP at any coverage levels in excess of 70% is certainly not practical.

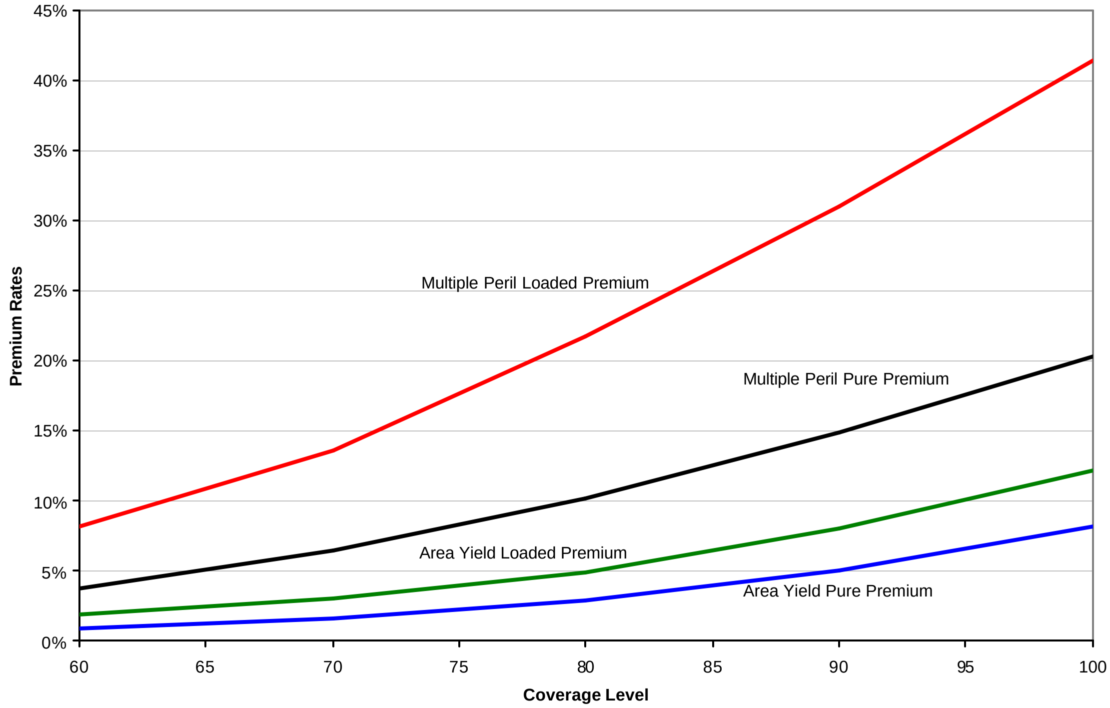


Figure 7: Comparison of pure and loaded premiums for MPCI versus AYP

Loading Premium Rates

Regardless of who pays for the insurance – the farmer, the government, or some combination – the Hazel ratio clearly communicates that all cost should be considered. This study considers all cost in sequence by expanding the A (administrative cost) in the Hazel equation to include a number of factors presented below.

$$\text{Hazel: } (I + A) / P < 1$$

The pure premiums that come from the pure loss cost history must be loaded in a logical and consistent fashion. Reinsurance loads are generally associated with the variance of the loss cost. The higher the variance, the greater the reinsurance loads. One method for loading reinsurance cost is to use the standard deviation from the loss cost. For the MPCI programs, a relatively simple 40% load is imposed by multiplying the standard deviation by 0.40. For example, with MPCI 60 in the table below the loaded reinsurance premium would be calculated as follows:

Loaded Reinsurance Premium = LC + (STD x 0.40)
= 3.8 + (4.1 x 0.40) = 5.4%
The actual premium load = 1 – (5.4 / 3.8) or 42%

Other loads are provided to account for moral hazard and adverse selection and the host of other administrative cost that will be associated with the different programs. Keep in mind that the small farm size in Romania would make the deliver and loss adjustment for a MPCI program very high. Thus, even the high load factors presented in Table 5 may be too conservative for the Romanian setting.

Table 5: Loading Pure Premium Rates

	MPCI 60	MCPI 70	AYP 80	AYP 90
Pure Premium (Loss Cost)	3.8%	6.4%	2.9%	5.0%
Standard Deviation on Loss Cost	4.1%	5.3%	3.9%	5.2%
Reinsurance Load	40%	40%	20%	20%
Actual Reinsurance Load	42%	33%	26%	21%
Moral Hazard & Adverse Selection	30%	35%	2%	2%
Claims & Loss Adjustment	13%	13%	5%	5%
General Administration	15%	15%	5%	5%
Sales Agents	15%	15%	5%	5%
Total Load Factor (1 + percent load)	215%	211%	143%	138%
Loaded Premiums	8.2%	13.6%	4.2%	6.9%

While the assumptions used to load the rates should be questioned and reexamined by others, the general direction of the loads are logical and provide a consistent basis for developing estimates of what the market would charge. The total load factors can also be referenced as a rather simple index of the efficient of the risk programs. Obviously, the question of the degree of basis risk for all these programs will be important. Assessing the basis risk is beyond the scope of this report, primarily due to data constraints.

Assessing the Correlated Risk Issue

The correlated risk among the Judets is a major issue. Various programs can now be analyzed to examine this issue in more detail and to motivate recommendations. The historic loss cost values can be used to develop a probability distribution function of losses. This will be referred to as the loss function. Figure 8 presents the hypothetical loss function for two very different types of crop insurance: 1) private hail and 2) multiple-peril. As the figure suggests, the losses around a target loss ratio of 60% for the private hail insurance are more symmetrical and have a very low probability of exceeding a loss ratio of 100%. Hail losses are generally not correlated across a wide area. Thus, it is unlikely that in any one year nearly all farmers would have a hail loss. By contrast, the MPCI losses include payments for all perils, including drought. When there is a drought in one area, it is likely that many surrounding areas are also suffering. Even though the average loss ratio for the hypothetical MPCI is 60%, these correlated risks create a MPCI loss function that has a long thick tail above the 100% loss ratio. Understanding the shape the loss function and the probability that losses will be above 100% is critical for assessing the sustainability of any insurance program. Keep in mind that these losses are used to justify government subsidies for MPCI through the world.

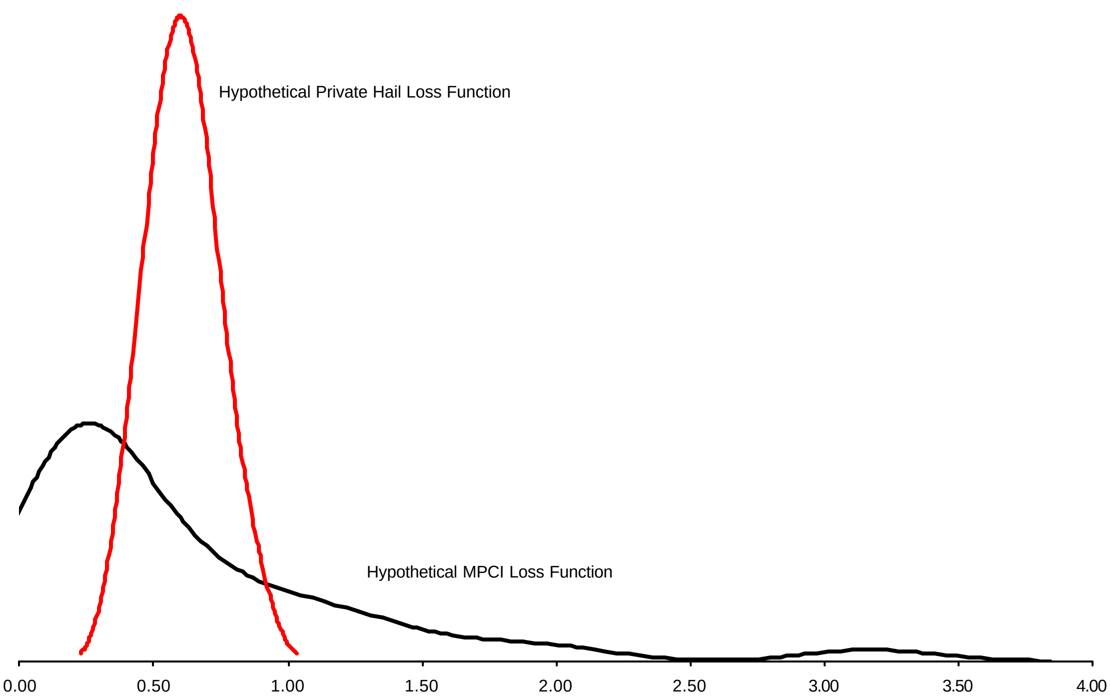


Figure 8: Hypothetical loss function for private hail versus MPCI

Without considering loaded premium rates, the odds of exceeding the loss ratio of 100% are roughly 1/3. The odds of exceeding 200% for most programs are roughly 15%. Even with loaded rates for reinsurance, the alternatives that are examined here generally have a 25% chance of exceeding a loss ratio of 100%. The odds of exceed losses in excess of two times the loaded premiums are at least 1 in 10 for most programs examined after the reinsurance loads have been imposed. Undoubtedly, the private markets in Romania are not prepared to take on this type of risk. To consider the potential value of these losses requires some assumptions about participation. Even with a conservative participation rate of 10% for these five crops, there would be roughly $150 million of exposure. Loss cost values that exceed 20% are not uncommon for the programs examined in this report. At a loss cost of 20%, indemnities for a $150 million program would be $30 million. These are very large losses for the insurance industry in Romania. If the participation rate were 50%, the losses for a year with a loss cost of 20% could exceed $150 million ($750 million of exposure x 0.20%).

Section 7: Forecasting the probable cost of the current crop insurance law

Public Law 381 sets the stage for *heavy* government involvement in providing crop insurance. The law was a response to serious problems suffered in crop production in 2000 and 2002. However, the law also extended into other sectors in agriculture for calamities (livestock, poultry, hives and fish). These additional sectors merit some investigation. Nonetheless, this report is limited to only major crops in Romania (maize, wheat, barley, sunflowers, and soybeans). Despite this limitation, these crops comprise between 60% and 70% of the value of all crops in Romania, providing a good foundation for making some estimates of the possible cost of the new insurance law.

While the technical aspects of the newly passed law are still being finalized, it is difficult to know important details. Without knowledge of the details on implementation, it is possible to make mistakes in estimating likely cost. Still current interpretations of the law motivate an attempt to assess cost of the government proposal. First, it is reported that the government will provide free assistance for losses due to drought. Second, nearly all other losses will be paid with insurance that has a subsidy at some level to be determined. The losses will be paid based on 70% of cost of production up to the point of the calamity. Further, losses will only be paid when crop yields are at 70% of normal or below (a 30% deductible).

In effect the government of Romania is embarking upon a multiple peril crop insurance plan. Such an undertaking represents a potential for a highly wasteful use of precious government resources. The beginning of this report documents the cost of various multiple peril crop insurance programs in others countries. This is done so that policy makers in Romania will begin to understand the cost and limitations of these programs. While these programs have many attractive features, they are expensive and require a significant infrastructure to implement. Such individual crop insurance is particularly problematic in a country like Romania. Given the small farm structure, the monitoring and implementation problems associated with a farm-level crop insurance program will very likely result in excessively high cost. Such cost can easily swamp any social benefits that may accrue from a crop insurance program in Romania. If significant investments are not made in monitoring, loss adjustment, and implementation, the crop insurance program planned for Romania will undergo tremendous moral hazard and adverse selection problems as has been developed elsewhere.

Given the analytical work presented in section 6, it is possible to make estimates of the probable cost of the current crop insurance law. Estimates of the pure premium rates for a 70% multiple peril crop insurance program are roughly 6.5%. As estimated in section 8, the true market cost for this policy would be about 14.2%. The value of crops examined in this work is roughly US $1.5 billion. This value would increase to about $2.5 billion if all crops are considered. Since the government plans to only cover cost of production, the total crop value can be reduced by a factor of roughly 60%. Thus, if all crops in Romania were insured, the total insured value would approach $1.5 billion. Drought losses in the US crop insurance program exceed 50% of the cause of loss.

Drought is also the dominant cause of loss in Romania. To be conservative on the cost estimates, we assume that drought is only 50%. Given this and other assumptions, if the government provides free drought insurance, the expected losses can be calculated using some straightforward assumptions.

- ✓ Drought accounts for 50% of the expected crop losses a 70% MPCI
- ✓ A conservative premium rate of 10% will be used
- ✓ A value of $1.5 billion will be assumed eligible for assistance

10% x 50% x $1.5 billion = $75 million.

Thus, it is not unreasonable to expect that the average cost of the free drought assistance in Romania could be $75 million per year. Given the shape of the loss functions that are presented in section 5, one can also expect years with excess loss that are five times the average loss values. Therefore, in the biggest drought years, such a program could have cost that exceed $357 million. Keep in mind that these estimates are developed using a conservative premium rate of 10% and not the 14.2% value that is estimated in section 8 below.

Beyond the direct cost associated with providing free drought insurance, there is mention of additional subsidies that would be provided for the multiple crop insurance program and for the livestock, poultry, hives and fish. While it is difficult to know what these added cost may be; one can take a relatively straightforward approach at estimating them. For example, if we assume that the premium subsidy is a modest 20% of premium and that participation rates in the insurance are at 50%, it is easy to envision added another $25 million to the $75 million annual estimate above.

- ✓ 50% participation on a value of $1.5 billion
- ✓ 20% premium rate subsidy on a premium rate of 14%

These cost estimates are provided as a baseline only. There are many assumptions that will change the estimates. However, the methods and information presented in this report can be used for a variety of assumptions. It is hoped that policy officials in Romania will attempt to make similar cost estimates using their own assumptions. The assumptions developed here may well underestimate what these programs could cost the Romania government. Thus, any information that elevates the debate and discussion regarding the likely cost of these programs could be critical at this moment in Romanian history.

Section 8: Recommended strategies for Romania

The recommendations that follow are motivated by the goal to use limited government resources to the best means possible to remove the catastrophic tail in the loss functions while providing incentives for the private sector to offer products that have less catastrophic risk. There are numerous ways to use area or Judet yields to trigger either insurance payments or some form of free disaster aid. For free disaster aid, it is important that the definition of a disaster be well-grounded in a logical framework. There are two primary dimensions of a disaster that should be considered: 1) frequency and 2) severity. If the weather events are severe one out of three years, this should not be considered a disaster. Such an event represents the natural state of the area and it would be bad public policy to continue to try to provide assistance on such a frequent basis. Other systems should be used to mitigate this risk, including assistance to either relocate or change the agricultural enterprises to ones that are more drought tolerant.

Distributions on crop-yields are very different than distributions for a natural disaster such as an earthquake. While a major earthquake may occur only 1 in 50 years or 1 in 100 years, a major earthquake is generally always serious in terms of the loss. In some cases, the probability distribution of an earthquake generally will have a very large frequency with zero losses and a small frequency with severe losses. Thus, severity is quite important for an earthquake. Crop-yield distributions are more parametric in shape, meaning that the degree of severity is more gradual once a frequency threshold is crossed. Thus, frequency captures most of the characteristics that are important for declaring a disaster in crop-yields.

Given that there are 33 observations of crop-yields by Judet, a yield distribution can be developed using two procedures: 1) the empirical data can be used directly; or 2) a fitted distribution can be estimated with the data. Given some strong outliers, fitting the distributions to establish the strike yields is logical. However, the empirical data must be used for other analysis since maintaining the spatial correlation is critical. For the fitted distributions, the Judet-crop data are used to develop kernel estimates of the probability distribution function (pdf) for all 167 Judet-crop combinations. The kernel smoother decreases the outlier problems. The kernel pdfs are converted to cumulative distribution functions (cdfs). A cdf makes it possible to make a selection of the strike yield that corresponds with different frequencies. Several alternative frequencies can be used to trigger payment based on the Judet yield and the farmer's expected revenues. It is relatively straightforward to consider selling these as insurance products, providing them as free disaster aid, or some combination.

Four different frequency levels are examined in this analysis.

1) A 1 in 20 year event or lower (5^{th} percentile)
2) A 1 in 10 year event or lower (10^{th} percentile)
3) A 1 in 7 year event or lower (14.2^{th} percentile)
4) A 1 in 5 year event or lower (20^{th} percentile)

The estimated annual costs of the various free disaster programs for the five crops are presented in Table 6 below. These costs assume 100% participation or that the total insured value is roughly $1.5 billion. While 33 years of data suggests that a free disaster program that triggers when yields in the Judet drop below the 1 in 10 year level would average about US $23 million, the last 15 years averaged US $39 million (excluding estimates for the 2002 crop year disaster). The extent to which these trends will damage any potential interest of the outside capital will be discussed below. However, most of what is presented in the immediate sections that follow will use the 33 years of data and will not address the fact that recent years have much more serious losses. The relative comparisons will be similar even with the trends. The cost of any of the alternatives presented, however, will be higher when the recent experience is weighted more heavily.

Table 8.1: The Estimated Cost of Various Free Disaster Programs for the 5 Crops

Disaster Design	1968-2000 (yearly avg)	1986-2000 (yearly avg)
Pay 1 in 20	10 Million $	20 Million $
Pay 1 in 10	23 Million $	39 Million $
Pay 1 in 7	33 Million $	53 Million $
Pay 1 in 5	49 Million $	73 Million $

The Costs in this table represent the pure cost with no loading.

Providing a well structured disaster payment for the infrequent events by Judet and crop may present an excellent beginning for Romania. The specifics of how such a program may be structure and what would need to be done to make it work will be presented in the next section. What is important is that this type of free disaster program can provide a strong base for private sector products. For example, the government could offer the 1 in 10 year area disaster program for free. Private companies could be offered the opportunity to register farmers for this program and farmers could be required to purchase some level of privately provided insurance to match the publicly provided disaster payments. A large advantage of such a system would be the degree to which it removes some of the correlated risk. As an example of private sector products that could be offered consider the following:

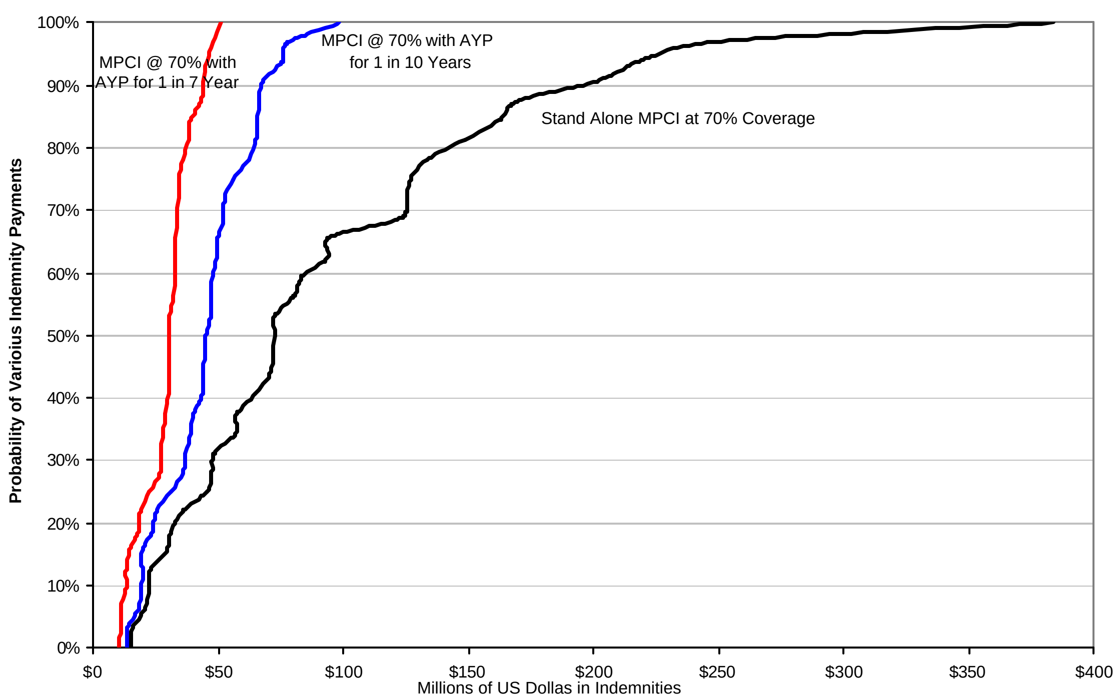
1) Private sector area-yield insurance at higher levels.
2) Private sector multiple-peril crop insurance that pays when the government based area-yield does not pay.
3) Private sector products that complement the area-based disaster programs, such as private sector hail insurance.
4) Private sector weather products (to be examined in the next section).

The analysis presented in Table 7 presents the pure and loaded premium rates for several of these alternatives. While the area-yield trigger at 1 in 7 years suggest a pure premium rate of 4.5%, a MPCI policy at 70% coverage has a pure premium rate of 6.4%. The loaded premiums are more spread (6.4% for the AYP and 14.2% for the MCPI policy). However, if a combined policy were available, whereby the government offered a free disaster program with a 1 in 7 year trigger yield and the private sector paid for any losses not paid by this policy for a MPCI policy at 70%, the MPCI policy might be made available for around 4.0%. A major reason why this might be possible is that the government policy would remove much of the catastrophic loss exposure. This example is meant to illustrate the principles of using the government area-yield policy to remove the catastrophic risk. At this time, private companies would need to consider a number of important issues before offering MPCI policies. Nonetheless, Figure 9 demonstrates the degree to which such a combination of policies might remove the large losses and allow the private insurers opportunities to offer new products.

Table 8.2: Pure Premium and Loaded Premium Rates for Programs Analyzed

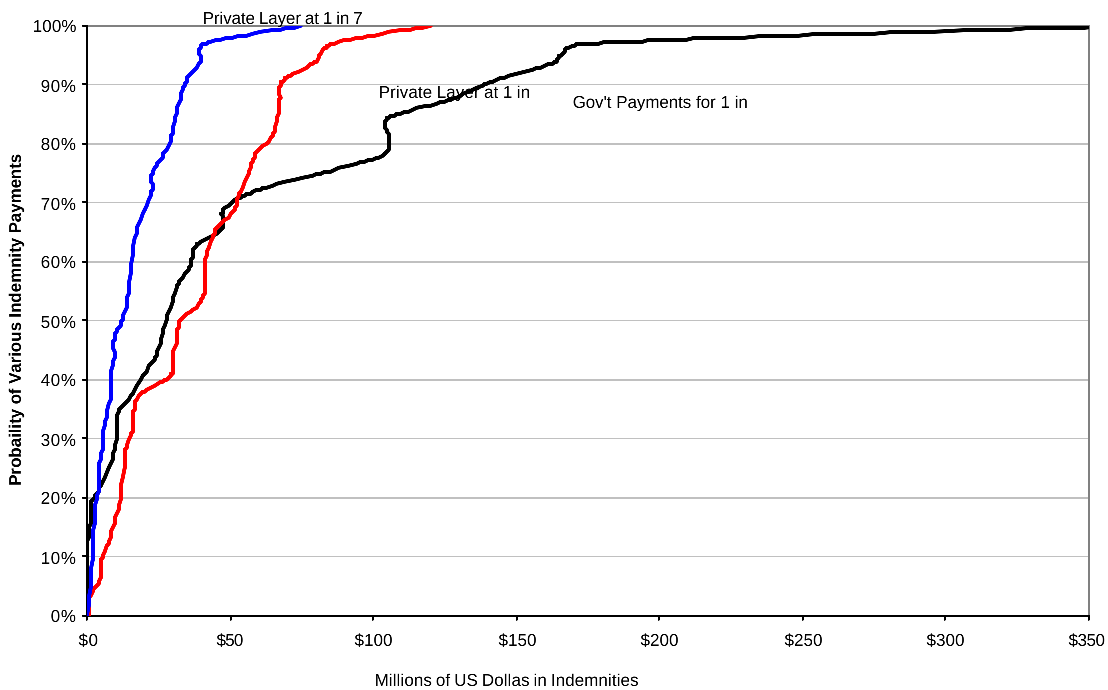
	Pure Premium Rates	Loaded Premium Rates
Area-yield @ 80% of Judet EY	2.9%	4.2%
Area-yield @ 90% of Judet EY	5.0%	6.9%
Area-yield with trigger 1 in 7 years	4.5%	6.4%
Area-yield with trigger 1 in 10 years	3.5%	5.0%
Multiple-peril Farm-level @ 60%	3.8%	8.6%
Max of MPCI 60% / Area 1 in 7	0.6%	1.3%
Max of MPCI 60% / Area 1 in 10	1.1%	2.2%
Multiple-peril Farm-level @ 70%	6.4%	14.2%
Max of MPCI 70% / Area 1 in 7	2.0%	4.0%
Max of MPCI 70% / Area 1 in 10	3.0%	6.2%
Multiple-peril Farm-level @ 80%	10.2%	22.5%
Area-yield Between 1 in 10 & 1 in 7	1.0%	2.0%

Figure 8.1: Offering MPCI Coverage with a Government Disaster Program



Another opportunity for private companies would be to offer an area-yield insurance policy that pays when the government policy does not. For example, the government could provide a free AYP at 1 in 10 year events and the private sector could offer to pay for the difference between that policy and one that would trigger more frequently; for example, the AYP policy that triggers at 1 in 7 year events or 1 in 5 year events. The losses for these combined policies are presented in Figure 10.

Figure 8.2: Private Sector Products that Would Pay for a Layer of Area-yield Between the Free Government 1 in 10 Strike and a Strike Set at 1 in 7 or 1 in 5.



Example of Disaster Program Payments per Hectare for Calarasi Judet

Maize in 2000: Realized Yield = 1.23 ton
Trigger Yield = 2.63 ton
Maize price = US $ 91 per ton

Assumed cost of production @ 60% of value making 1 ton of insurance = $54.60
Indemnity calculation = (2.63-1.23) x $54.60
Payment = $76.40

Table 8.3 Calarasi estimated payments for various crops for the 1 in 5 Year AYP

	Wheat	Barley	Maize	Sunflower	Soybeans
Expected Yield ->	3.30	3.30	3.09	1.15	1.64
Trigger Yield ->	2.76	2.78	2.63	1.05	1.25
2000	$ -	$ -	$76.39	$ 28.84	$ 87.74
1999	$ -	$ -	$ -	$ -	$ -
1998	$ -	$ -	$ -	$ -	$ -
1997	$ -	$ -	$ -	$ -	$ -
1996	$78.19	$11.59	$ 7.65	$ -	$ -
1995	$ -	$ -	$ -	$ -	$ -
1994	$26.73	$25.41	$ -	$ -	$ -
1993	$ -	$ 5.98	$ -	$ -	$ -
1992	$ -	$ -	$ -	$ -	$ -
1991	$ -	$ -	$ -	$ 6.37	$ -
1990	$ -	$ -	$ -	$ -	$ 9.00

Recommendations

1) The government would provide a 1 in 5 year area-yield crop insurance program that uses Judet crop-yield estimates. The cost to the farmer would be based on pure premium rates that are established at the Judet level by crop to reflect relative differences in rates. Farmers would be allowed to purchase a value that is consistent with their expected cost of production.
2) Crop insurance payments would be based on the difference between the expected Judet yield and the actual estimate of Judet yields for the given year. This would become the base insurance product.
3) Private companies would be allowed to sell the base insurance product and offer companion products that would compliment this insurance; for example higher values of insurance could be offered using the same base product, individual insurance could be offered to cover losses at some level that are not paid by the area yield index; etc.

4) This disaster program can be packaged with products by private companies. The option could either be offered free or at a subsidized rate, depending on the government budget constraint.
5) Private companies would be encouraged to offer an add-on area-yield layers or more liability. This can be accomplished with much less correlated and ambiguous risk given the government base product.
6) Private companies could also offer 60% to 70% MPCI type policies for select farmers where the payment would be the maximum of either the MPCI policy or the free government policy.
7) Private companies could also begin offering some weather derivatives that would again pay the maximum of the government base policy or the weather product.
8) Government should be able to reinsure much of the risk from their policy by going to the capital markets with some level of weather insurance. This is done because most reinsurers would not trust the government yield statistics and would be much more likely to trust the weather data.

Section 9: Considerations for weather-based insurance

There are numerous considerations for designing weather index insurance contracts. Since these contracts pay only based upon the weather event, it is most desirable to have strong correlations between the weather event and the crop yields. This section highlights some of the procedures that are used to make these determinations. The testing and analysis performed is primarily for illustration only at this point. More complete testing and analysis is needed before recommendations regarding weather index insurance can be made.

Weather data requirements

Pricing of weather insurance by international risk insurers requires that the data complies with a few prerequisites:

- Data must be measured and reported by a third party.
- Time series of meteorological data must at least cover the last 25 years.
- Quality of time series must be analyzed and:
  - i) missing data must be documented,
  - ii) changes to location of measurement (re-location of measuring instrument; changes to environment affecting measurements) must be documented,
  - iii) changes to method of measurement and reporting of data must be documented,
  - iv) changes / replacements of measuring instruments must be documented.
- Depending on points i) to iv) above measures must be taken and documented to fill data gaps and homogenize time series

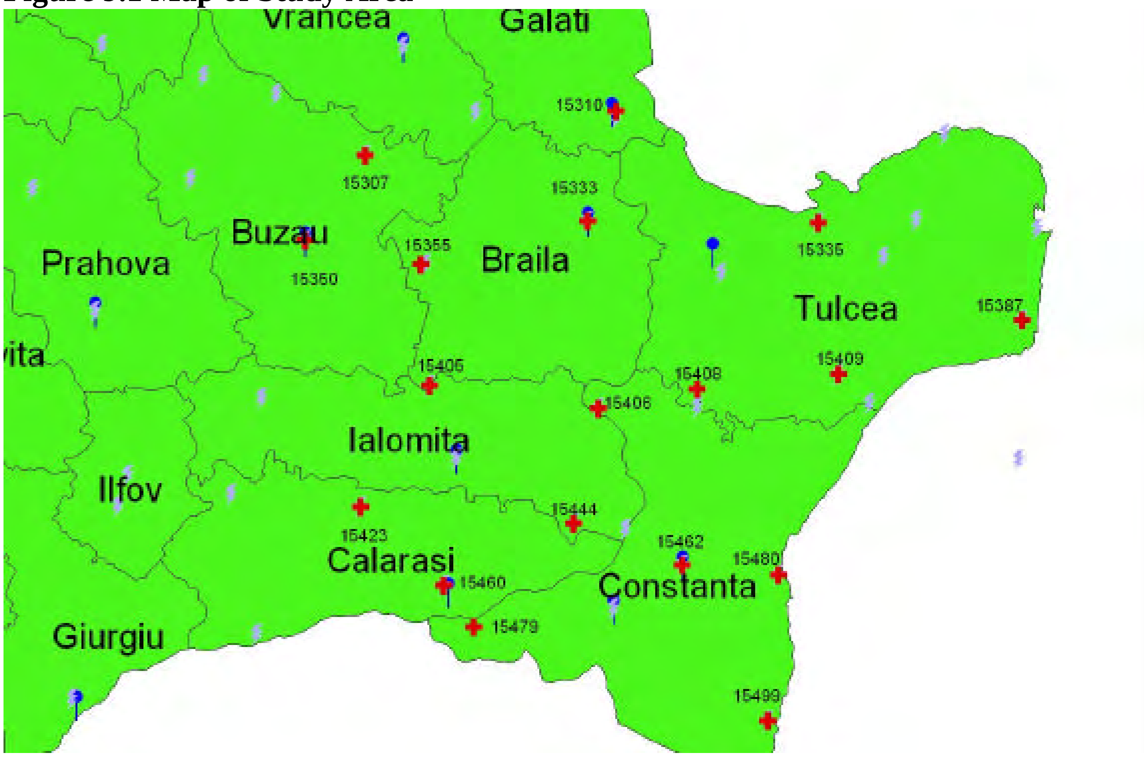
Observations from time spent with professionals from INMH suggest that Romania could meet these types of requirements with existing resources. Nonetheless, some support for cleaning data and filling in missing data may be needed.

The trend adjusted data are used to perform the analysis. These data are compared to basic weather data to first determine the correlations that are most important. This analysis is also based upon interviews with the INMH professionals regarding the crop growth calendar. Limited data for farms was also made available. These data were compared to the judet data and for most of the judets in the pilot area, the results were encouraging in that there is reasonable correlation between a 'quasi judet' that is created with the average of the farms and the judet. Nonetheless, the data are not adequate for more rigorous testing. Thus, the judet data are used for the testing of some weather-based insurance products.

Test Area

Figure 9.1 below gives the map for the test area. The crosses are weather stations where daily data were provided. There are seven judets within the study area. All stations were used except the station in the most eastern part of Tulcea (station 15387). There is no crop production in this area of the judet. Thus, using the weather station information would be inappropriate. Weather station data were averaged within each judet to obtain an average weather variable for the judet. Some of the border judets have only a single weather station that was supplied. Thus, there are most certainly limitations in the data used for this portion of the study.

Figure 9.1 Map of Study Area



Procedures

Maize is the most promising crop for weather insurance products in the seven southeastern judets where weather data was supplied. Maize is planted in the spring (April-May) and harvested in September-October. Adequate rainfall during the period April-August influences maize yields. However, extreme temperatures in excess of 32 degrees Celsius can damage the maize crop. A general regression of the following form was developed to test the correlations:

$$Adjusted\ Yield_{jy} = C + b_1 * Rain_{jy} + b_2 * Hot_{jy}$$

where j = Judet; 1-7: and y=year 1968-2000.

Rain = cumulative rain from April-August
Hot = frequency of days > 32 degrees C

Results of these regressions are presented in the following pages. In excess of 40% of the variation in maize yields can be explained using these very simple regressions. The variables were of the expected signs. Galati judet has the strongest relationships for this regression. The problem with such regressions is that the rainfall events are given equal weights throughout the growing season. The timing of rain is also very critical to the growth process. Thus, a more elaborate procedure was developed to test the distribution pattern of rainfall and design 'optimal' rainfall contracts.

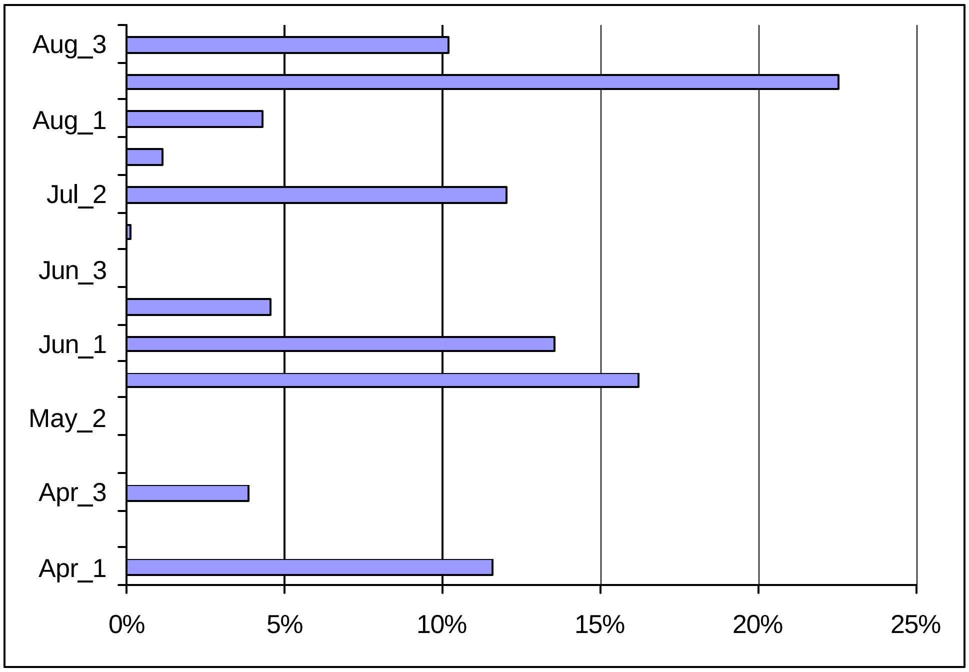
Designing an optimal rainfall contract for maize

The daily rainfall data were transformed to obtain the cumulative rainfall for every 20 day period at day 1, day 15, and day 30 of each month. In interviews with the INMH professionals it was determined that 20 days was a reasonable length of time; if it does not rain within a 20 day period, the crop is at considerable risk. These data were developed for the months April-August. Thus, there are 15 data points for each season (3 periods x 5 months). The problem was set up to determine the appropriate weights for each period given the following constraints:

1) The weights must sum to 1
2) Each weight must be => 0
3) The pure premium of the insurance contract must be <=7.5%

The objective function was to maximize the reductions in relative risk for the judet when comparing judet yields without insurance and with insurance. The rainfall insurance strike was set at 85% of the weighted average rainfall during the period. To determine the robust nature of the designs the models were run for 1968-2000 and for 1986-2000. Comparisons are made below. To illustrate how this further, Galati is used as a case example. The optimal weights for the different periods appear in figure 9.1.

Figure 9.1: Optimal weights for 20 day period rainfall for Galati



Given this optimal structure, the relative risk of the judet yields can be reduced by about 20% for a pure premium policy at 7.5%. The weighted average cumulative rainfall is 437 mm. A strike at 85% of this value means that payments will begin anytime the weighted average rainfall is less than 371.5 mm (.85 x 437). The average judet yield during the period is 2.893 tones per hectare or 2893 units. If each mm of rainfall is considered a tick, the payment for each tick is set as (2893 divided by 371.5) or 7.8 units payment for each tick. Thus, if rainfall is 361.5 or 10 mm below the strike, the payment will be 78 units (7.8 x 10).

The contract language may look as follows:

We will pay you 7.8 units (1 unit is 0.001 tones) for every 1 mm of rainfall less than 371.5 when using our weighted average rainfall measures for the period April 1 to August 30. The rainfall measures from Galati station #15310 will be used with our weights for each period to determine the actual realized weighted rainfall for the period.

The illustration for Galati is continued in Table 7.2. Payments are made in yields for ease of exposition. It would be a relatively easy matter to convert everything to a - value. The table should be self explanatory. RIC = Rainfall insurance contract and AYI= Area Yield Insurance (that pays for 1 in 5 year yields and below). Thus, a direct comparison of the RIC and AYI products can be made for this case. However, one must be careful with such comparisons since the pure premium rate for the RIC is 7.5% compared to AYI of 3.5%. The revenues with and without the two insurance products are presented in the table as well. The relative risk (CV) without insurance is about 30%; this value goes to 24% with the RIC and 26.4% with the AYI. The series in the column "Weighted Rainfall" can be used to develop premium rates. The RIC payment series gives an average payment of 217 units. The maximum payout (liability) is 2893 units. Thus, the pure premium rate is 217/2893 or 7.5%

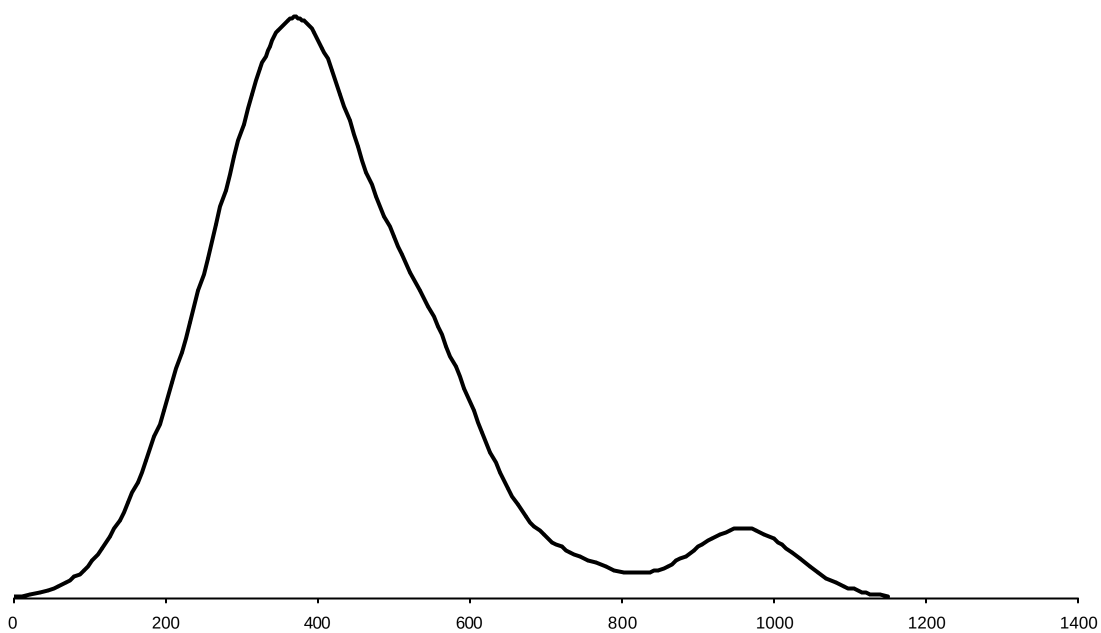
Table 9.2 Illustration of Payments from RIC and AYI for Galati Maize

Year	Adjusted Yield	Weighted Rainfall	RIC Payment	Yield Equivalent After RIC	Net Position With RIC	AYI 1 in 5 2146	Net Position With AYI
1968	2749	357	109	2641	-108	0	2673
1969	2789	361	80	2652	-137	0	2713
1970	2883	534	0	2666	-217	0	2807
1971	3156	366	42	2981	-175	0	3080
1972	3387	392	0	3170	-217	0	3311
1973	2529	567	0	2312	-217	0	2453
1974	2473	590	0	2256	-217	0	2397
1975	2932	566	0	2715	-217	0	2856
1976	3311	371	0	3094	-217	0	3235
1977	2412	423	0	2195	-217	0	2336
1978	3560	726	0	3343	-217	0	3484
1979	3277	415	0	3060	-217	0	3201
1980	2323	498	0	2106	-217	0	2247
1981	2308	280	711	2802	494	0	2232
1982	4084	535	0	3867	-217	0	4008
1983	2901	371	0	2684	-217	0	2825
1984	3481	420	0	3264	-217	0	3405
1985	3076	426	0	2859	-217	0	3000
1986	2979	325	361	3123	144	0	2903
1987	1430	232	1089	2302	872	716	2070
1988	2851	350	171	2805	-46	0	2775
1989	3027	362	74	2884	-143	0	2951
1990	1606	296	591	1980	374	540	2070
1991	5288	958	0	5071	-217	0	5212
1992	2203	530	0	1986	-217	0	2127
1993	3535	473	0	3318	-217	0	3459
1994	1642	190	1416	2841	1199	504	2070
1995	2073	290	631	2487	414	73	2070
1996	2657	275	753	3193	536	0	2581
1997	4906	959	0	4689	-217	0	4830
1998	2355	386	0	2138	-217	0	2279
1999	3814	372	0	3597	-217	0	3738
2000	1473	226	1132	2388	915	673	2070
Mean Values	**2893**	**437**	**217**	**2893**	**0**	**76**	**2893**
Std. Deviation	**867**	**178**	**392**	**692**	**392**	**204**	**763**
CV	**30.0%**			**23.9%**			**26.4%**

Illustrative Pricing of RICs

Information in table 9.2 offers the opportunity to illustrate more fully how a RIC of this nature might be actuarially priced in the insurance markets. While the pure premium from the empirical data gives a rate of 7.5%, the insurance markets will not offer such a contract at this rate. The data series in the column 'weighted rainfall' would first be used to develop a kernel distribution. This has been done and the kernel distribution appears below in figure 9.2.

Figure 9.2: Kernel Distribution of Galati Weighted Rainfall Series (1968-2000)



The pure premium rate given this distribution increases from 7.5% to 9.1%. A common loading procedure is to expand the loads on the standard deviation of the payout series. Generally, a load of 33% of the standard deviation is added to the pure premium. The standard deviation of this series is about 14%. Thus, adding 33% of 14% to the pure premium rate of 9.1% gives an expected price of 13.7%. Other rules can also be imposed by actuaries as they attempt to load this contract. Another common rule is to examine the recent 'burn rate'. In this case the five year burn rate also exceeds 13% (753+1132) divided by the total exposure of 2893. Other rules could be used as well. For example, some actuaries examine the value at risk and make assessments of the maximum value lost at 2% probability. This, gives some indication of how close to the maximum liability the payments may be. For this case, the exposure at the 2 percentile is roughly 60% of the liability. Thus, using these procedures would be unlikely to add more to the premium rate in the actuarial analysis.

Despite the heavy loads that may be imposed in a full pricing of the RICs, it is unlikely that a well-diversified insurance provider would charge these full prices. This is especially true if the RIC in question adds value to the portfolio so that the risk are either not correlated with the book of business for the insurer or very lowly correlated. Thus, the estimates of 13% for this case likely represent the upper level of rates that might be charged for such a RIC.

Results for the seven Judets

Similar procedures were used to find optimal RIC contracts for the seven judets in the test market. Table 9.3 illustrates the reduction in relative risk that can be obtained from such contracts for the two time periods.

Table 9.3 Reductions in relative risk possible from RICs for Maize

	1968-2000	1986-2000
Buzau	20%	24%
Buzau	19%	11%
Calarasi	17%	10%
Constanta	16%	12%
Galati	22%	16%
Ialomita	20%	17%
Tulcea	16%	12%

In every case, a RIC shows promise. The design and details of such contracts are important however. The reader should keep in mind that these results are developed within sample and are subject to statistical error. While formal testing for these errors was not performed, the issue of over fitting is always important. One way to examine the potential overfit issue is to examine how the relative weights change for the different periods.

	APR	APR	APR	MAY	MAY	MAY	JUN	JUN	JUN	JUL	JUL	JUL	AUG	AUG	AUG
	1	15	30	1	15	30	1	15	30	1	15	30	1	15	30
	Weights for 1986-2000														
Braila	0%	0%	0%	0%	0%	17%	0%	11%	5%	0%	26%	5%	6%	5%	25%
Buzau	0%	0%	0%	0%	0%	3%	0%	23%	15%	0%	21%	25%	0%	0%	13%
Calarsi	0%	0%	28%	0%	0%	1%	3%	39%	0%	0%	8%	0%	6%	3%	9%
Constanta	7%	0%	20%	1%	1%	7%	5%	29%	0%	0%	13%	0%	0%	0%	17%
Galati	3%	0%	1%	11%	0%	24%	0%	0%	0%	11%	0%	0%	26%	3%	22%
Ialomita	0%	0%	21%	0%	0%	4%	9%	21%	9%	0%	8%	0%	0%	28%	0%
Tulcea	0%	0%	7%	0%	0%	0%	0%	35%	24%	0%	10%	0%	0%	0%	23%
	Weights for 1968-2000														
Braila	12%	0%	7%	5%	0%	15%	0%	22%	5%	0%	5%	0%	9%	7%	12%
Buzau	7%	3%	1%	0%	0%	0%	0%	16%	4%	0%	13%	27%	7%	0%	21%
Calarasi	0%	0%	2%	13%	0%	1%	2%	25%	0%	3%	10%	0%	12%	11%	22%
Constanta	0%	1%	0%	7%	5%	17%	0%	16%	3%	0%	7%	18%	0%	3%	24%
Galati	12%	0%	4%	0%	0%	16%	14%	5%	0%	0%	12%	1%	4%	23%	10%
Ialomita	0%	0%	28%	0%	0%	2%	0%	20%	1%	0%	19%	0%	0%	9%	20%
Tulcea	0%	0%	0%	0%	0%	0%	0%	12%	2%	0%	27%	3%	2%	11%	42%

This table suggests that the same periods are reasonably robust for the two different time periods. Further, the information shows some spatial characteristics that are also important. For example, the last period in August receives a strong weight in a number of judets. Keep in mind that this period is a measure of the cumulative rainfall for the 20 day period, August 9-29.

Summary, other investigations, and future research needs

This section introduces a unique RIC design for maize in the study area. There are numerous modifications or additions that can be made to this RIC. For example, excess heat companion weather insurance might be useful. However, much of this is beyond the scope of this study. This work was undertaken to illustrate both how such an optimal contract might be designed and the methods that would be used to price such weather insurance contracts in the market. Additional work that is not reported here was undertaken to determine if weather insurance contracts could be used for wheat and barely yields. While preliminary, the conclusion was that these crops are far to complex for effective and relatively simple weather insurance, more work is needed on this topic. In particular, such work should be pursue along the lines of the protocol outline for the maize project.

Finally, the professionals within INMH have a vast knowledge and models that can be used to identify weather events that impact different crop yields in different regions within Romania. One of their papers appears in Appendix C.

Section 10: Recommendations on Organizational Structure

Under the proposed system of insurance farmers incurring financial hardship due to crop loss will be able to benefit from two levels of financial compensation:

- Government Catastrophe Program (GCP) – that will provide compensation to farmer in the event of a crop catastrophe and is determined by a pre-defined trigger;
- Private Insurers "Wrap Around" Program (PIP) – that will complement the Government arrangements by providing additional indemnification for the crop losses as well as a set of traditional insurance products such as a property, motor and liability covers etc.

The success of the GCP unfortunately does not rely simply on the underwriting but to a large extent on the way in which the Program is implemented. In order for any National Insurance Program to work it must gain the acceptance not only of Government but also of the insurers, banks and most importantly the farmers as each of these groups are integrally involved with its operation. The following discussion considers first the role of each of the participants in the organizational structure and then looks at the implementation strategy of the Program.

The GCP is the Area Yield Insurance discussed in Section 6. If the product is to be designed as a standing a fully subsidized disaster program, the triggers should be set at 1 in 10 years. On the hand, if the product is to be sold as an insurance product, the 1 in 5 year trigger should be workable. The question of how to link the private products to the GCP is very important to assure that the government effort will leverage private sector innovation without undue cost to the government.

Ultimately both farmers and bankers should be joint beneficiaries from the GCP. Both are exposed to the production risk of crop loss, the farmer incurs a revenue loss and the bank a credit risk of loan default. Their support for the Program relies on a clear understanding of its operation particularly in regards the level of compensation paid under the GCP and what additional amount may be required under the wrap around products to ensure compensation is sufficient for their own farm enterprise.
So many pilot agricultural Programs particularly in Asia - Thailand, Vietnam and China have failed because the amount of compensation paid was not what the farmers had anticipated. In fact, farmer's confidence in the Program relies on the smooth operation of all aspects not just the compensation amount but also timely claims settlement, loss adjustment and its general administration. The burden remains with the farmer/bank to ensure they have purchased sufficient top up cover from the private insurers, and to submit a claim to the intermediary when a loss occurs.

Intermediaries: Insurance Providers

National Government – It is proposed that a separate Risk Management Agency (RMA) be established within the Romanian government to oversee the operation of the

GCC. More is developed below about the important functions of the government RMA. The RMA would provide the base product to be sold by other intermediaries.

Private Insurers – There are already several insurers providing a limited number of different agricultural insurance products. Nonetheless, these markets are unlikely to develop without the appropriate regulatory environment. The RMA would be responsible for developing such an environment. In addition to complementary crop insurance products, the private insurers are expected to a range of traditional insurance products from the property, motor and liability classes.

Banks and credit institutions – In some cases, the emerging banking industry may offer the most appropriate institutional arrangement for sharing risk with farmers. Banks may be allowed to offer companion loans with the base GCP. This could facilitate a number of developments; including the possibility of expanding credit availability to farmers with crop risk.

Reinsurers – While traditional reinsurers are likely to be reluctant to enter the Romanian market, they may be willing to enter with the base GCP. In particular, the concept of reinsuring using weather events is possible. Once this opportunity is exploited, other possible arrangements become more likely.

The Government Risk Management Agency

It is proposed that an office be established within the Romania government that will oversee the operation of the entire Program. It should include coordination and oversight of the following:

1) Marketing and Education

Prior to introduction of a new program it is proposed that the government undertake a comprehensive marketing campaign to farmers within the proposed market area. The objective of such a campaign will be to alert farmers to the fact the GCP is available and that these programs will replace the existing emergency relief measures. This campaign will: 1) explain the operation of the GCP; 2) eligibility; 3) what triggers losses; 4) how and when will compensation for losses be made; 5) etc.

It is recommended that whatever program is put in place that it be voluntary. Even with free catastrophe protection, there will be a need for marketing and education. The RMA can be involved in these efforts in a variety of ways. They should be involved in some direct education and promotion on the Program. They may use some of the existing infrastructure within Romania for some of this effort. Educational software and worksheets can easily be developed to show farmers what the estimated payments would have been for past years. This is very straightforward and will be a good check for farmers giving them confidence that the program matches the catastrophe experience in their area. Farmers remember bad years. Seeing that the program has recorded those bad years and giving them some idea of what payments would be should a similar year repeat itself is very helpful for education and marketing. Again, some level of activity on the part of farmers is critical; even for a free disaster payment (e.g., farmers must register their crops and plantings).

2 Data Management System

Clearly the RMA is the key to good data and a reliable program. The RMA will be expected to deal with underwriting data including indemnity values in regions where the insurance is offered, mapping systems and accounts data. To be eligible for a payment, each grower must register every year notifying name location and size of farm, and crop types and average crop-yield. Very clear records must be maintained on planted hectares. There can be no discrepancies and no opportunities to report greater plantings after it is clear that a disaster is emerging. Procedures for spot checking the accuracy of the data on hectares planted and penalties for misrepresentation must be established. Common sense should prevail and some level of acceptable tolerance should be allowed. Computer systems and data management systems will need to be established to make these functions efficient and operational for all of Romania. These type of data will have other benefits for planning and anticipating what is happening in Romanian agriculture. No farmer should be eligible for the benefits of the government catastrophe program unless they are willing to supply these type of data. Very careful accounting procedures should be employed to make certain that the aggregate hectares in judets matches expectations. Clearly, over reporting of hectares planted could have a devastating impact on the Program. The reported hectares planted should be made available within 30 days after normal ending dates of planting.

3 Improved Estimates for Judet Yields

This is critical, as all parties will desire that the best estimates possible emerge from government sources. The process must be secure and tamper proof. Further some serious efforts must be made to develop the best estimation procedures possible. While the limited information we have suggest that the judet yield estimates are reasonable, more is needed. We understand that local officials from both the Ministry of Agriculture and the Institute of Statistics make estimates. However, the procedures are not clear. Should international reinsurer be willing to reinsure losses based on these estimates, they will likely require some third party audits during particularly bad years.

We have modeled the most straightforward reinsurance agreement – a simple stop loss. Any reinsurer will be concerned that if they have such an arrangement with the Romanian government when things start to go bad there is no incentive to limit the low estimates of farm yields. Once everyone in Romania is certain that the stop loss will be exceeded, there would be great temptations to report even lower yields by judet. For this reason, the reinsurer will either insist on an outside audit procedure and/or some reinsurance arrangement where the Romanian government is sharing in losses even under the worst conditions. These arrangements are referred to as quota-share arrangements. They can take on many forms. The simple model would be to share the losses in a proportional fashion – no matter how bad things might get. For example a 50% share

might be worked out. This would not limit the government's losses from the program. For this reason, we did not model such arrangements. In short, the government will likely either have to accept a reinsurance agreement where their losses are not limited, or accept a third party review and audit of their area-yield estimation procedures.
The United States Department of Agriculture has a long history of developing yield estimates. The National Agricultural Statistical Service is available to provide technical assistance to other countries on the procedures. When significant sums of money are at stake based on an official estimate from government, the incentives for fraud and abuse of the estimation procedure increase. Secure systems are important. Double and triple checks may be required. Locking up the analysts when the final numbers are agreed upon may also be considered. All of this expense would be money well spent when negotiating terms with an international reinsurance company.

Finally, some consideration may be given to developing sub-judet yield statistics. This would enhance the value of the area-yield program for farmers. The fundamental question becomes which system would be more cost effective and more efficient – a secure and refined sub-judet estimate of yields? Or investments in determining farm yields? For a catastrophe program that is declared based on the area-yield losses, it is likely that putting the investment in improved area-yield estimates for sub-judets would be a more equitable and efficient use of funds. To decrease the odds that farmers in a sub-region would have a crop loss and not be paid using the judet yields, sub-regional estimates would be very useful. Further, this is preferred over a farm-level multiple-peril program for all of the reasons that have been discussed throughout this report.

Underwriting Parameters

The RMA should undertake an annual review of the parameters used in negotiating reinsurance. It is recommended that this is undertaken in conjunction with a specialist agricultural reinsurance broker. Ideally, a long-term contract should be sought with the reinsurance community. In addition, the Romanian government should be careful to keep an eye toward developments in the capital markets that were discussed earlier in this report. While these markets are no better than traditional reinsurance in the current market, the products being recommended in this report are ideally suited for some of the new capital market developments. There may be a time in the near future when these developments offer superior risk protection at a lower price. More likely however, they can be used to complement some other arrangements with traditional reinsurers.

Loss Adjusters

The RMA will do most loss adjustment with declaration of the judet yields and a required reporting of farm yields should they chose to follow our recommended proposal. As we have discussed previously our recommended program would run fine if farmers under report their yields since the payment will be limited by what happens in the area. Therefore, farm-level inspections will not be needed. Should the RMA decide to pay down to whatever farm yield farmers report, timely, accurate and objective loss adjustment procedures will be necessary. Under these conditions, it is proposed that the loss adjustment be coordinated from a central controller. The controller will be responsible for ongoing training of loss adjusters throughout the country.

Information Exchange

One of the key objectives of the proposed organizational structure is that it will allow for an exchange of information between Private Insurers and the Government. The type of information exchanged will include loss data, total insured values across regions.

Phasing in the Program

Before the initiation of the government catastrophe plan, it is recommended that the government undertake a campaign to obtain support from both the private insurance market as well as the banks in the operation of the proposed insurance. It is proposed that there be a period of at least six months prior to the release of the insurance during which time the government will call for comment from the private insurance market. This period will also allow time for the private insurers to revise their existing products and consequently renegotiate their reinsurance arrangements. Like the insurers the banks should be informed and asked to provide comment on the new arrangements as well.

Private Sector Product Development

Putting an infrastructure in place as is described above could have a tremendous influence on private sector development in Romania. There would be very clear and measurable indicators of what constitutes a disaster by judet and by crop. Private sector companies could simply use the government system to offer additional liability to farmers, bankers, agribusinesses, or anyone who is at risk when there is a major crop failure in a region. Reinsurance and capital market developments could flourish if the international markets gain confidence that the system has integrity. Integrity will largely be measured by a secure and reliable system for developing area-yields. Banks pool independent risk of a group of farmers. The instruments that would be created with our basic model would offer Banks the protection they need from widespread disasters.

Private insurance in Romania could have many opportunities to complement the basic government catastrophe insurance. They could simply match the liability in the policy offered by the government, they could add an additional area-yield insurance, or (for select customers) they could do a wrap around policy that would cover individual farm losses. The catastrophe policy we recommend would open these doors in very significant ways. The analysis performed above demonstrates how well the GCP removes the correlated risk and opens the door for add-on products.

Section 11: Considerations on the Regulatory Framework[11]

This report assesses the feasibility of area yield and weather index insurance. We do not use the term derivatives, because derivatives are not the appropriate instrument at the farm level. Making these products insurance products is important. Insurance instruments impose certain restrictions on the product and its marketing. The major distinction is that when the area yield or weather index is sold as an insurance product, a case must be made that those purchasing the contracts have an insurable interest. Any number of parties can have an insurable interest when it comes to agriculturally oriented area yield or weather insurance products (e.g., the farmer, the farm banks, agricultural input suppliers, gain elevators, etc).

In general derivatives are not construed as insurance, unless specific circumstances provide for an insurable interest of the insured party. In the U.S. the New York Insurance Department issued an informal opinion in 2000 that effectively challenged weather derivatives because the derivative had no relationships with the economic losses of many of the purchasers and there was continuous opportunity to change positions on the contract.

By contrast, area yield or weather index insurance is characterized by an upfront premium payment and index determined payouts at the end of a specified contract period. Further, the insurance trigger is met in insurable interest of the insured party – following simple eligibility criteria that insured party have an insurable risk that is related to the probable index payments. In two respects the area yield and weather index insurance concept is not aligned with traditional insurance and traditional insurance legislation: the loss risk exposure definition and the loss compensation definition.

The area yield and weather index insurance coverage is different from traditional insurance coverage. Traditionally non-life insurance insures a specific loss related to a physical asset or an activity and the potential damage to the asset or interruption of the activity. However area yield or weather index based insurance does not necessarily insure a specific asset or activity but rather the income risk exposure of the insured party. In practice, a farmer could choose to insure considerably more value than the yield of a specific crop or even all his crops, he or she could also wish to insure the income derived from off-farm sources that may also be negatively impacted by bad weather events that trigger payments from the weather index insurance. For example the off-farm job may be with a processing firm that depends heavily on the amount of the crop produced in the area. Area yield or weather index insurance could cover both of the crop yield and the off-farm job exposures as well as other unspecified income risks if those are exposed to drought risk. This is different from traditional insurance which usually does not cover

[11] An early version of this section was drafted by Ulrich Hess and Jerry Skees for a World Bank project in Ukraine. It is modified here to fit the Romanian environment.

unspecified income risks.[12] Thus, both area yield and weather index insurance are conceptually comparable to derivatives, as the payouts are *derived* from an index and not specified economic losses.

Insurance legislation in Romania likely defines the types of coverage insurers can underwrite and therefore may not contemplate the use of area yield or weather related "income" insurance. It is not likely that legislation in Romania prohibits this type of insurance if there is an insurable or "material" interest from the insured party. The broader principle underlying insurance regulations is the anti-gambling concern. A farmer who buys area yield or weather index insurance in excess of the expected value of the crop could be seen as a gambler. A dentist buying weather insurance could be perceived as a gambler not covered by the law. Both of these phenomenon are common in derivative markets, where traded notional volumes exceed several times the physical amounts of the underlying commodity. However, for area yield or weather insurance to work best, the farmer who has the multiple exposures as described above should be allowed to purchase more value than the crop value. This may be challenging when government support is provided. Nonetheless, a base level can be made available with government support and more protection could be purchased beyond that level at full price.

To satisfy traditional insurance regulation requirements, the regulator and insurers need to define eligibility criteria for insured parties, making sure the insured party has an insurable interest, based on hectares or other verifiable insured party specific parameters. Thereby the insurance coverage per hectare could be limited to a reasonable expected economic value or input costs.[13] For example in the U.S., the Group Risk Plan (GRP) is an area yield index insurance product. The GRP pays based on what happens to county yields. Farmers are allowed to purchase coverage at values that are up to 1.5 times the county expected value. This allows for farmers with yields that are greater than the county average to obtain adequate protection.

Area yield and weather index insurance payouts can deviate from actual damage suffered. As described above, this is referred to as basis risk. Basis risk is the potential mismatch between the insurance payout and the actual loss suffered by the insured party. Nearly all insurance has some level of basis risk. Traditional crop insurance relies on the loss adjustment of the insured party's declared losses – disputes between the loss adjustment numbers and the farmer's view of the loss are common. More fundamentally, the methods for developing yield coverage levels are subject to significant measurement

[12] There are exceptions, such as the innovative Adjusted Gross Revenue Pilot Program in the United States, which provides an insured producer protection against low revenue due to unavoidable causes. Even in this program though the program specifies types of incomes, "Covered farm revenue includes income from crops and agricultural commodities, including incidental livestock". Source: Risk Management Agency, USDA

[13] Eventually the regulator might decide to allow for the creation of a real primary and secondary derivative market for weather risk, where weather risk insurance derivatives can be traded freely regardless of the holders nature and risk exposure.

error. This creates an even greater basis risk for traditional insurance. Area yield or weather index insurance relies on the index to reflect the risk exposure of the insured party. To the extent that the area yield or weather index is highly correlated with the economic losses, the cost savings associated with much lower monitoring and loss-adjustment costs can easily compensate for the potentially greater basis risk. Since moral hazard and adverse selection are not problems, area yield or weather index insurance does not require the large deductibles that accompany traditional crop insurance. This also reduces the likelihood that a farmer will have a loss and not be paid with the index insurance.

In some cases, insurance regulators prohibit payments when there are no losses. It is important to recognize that these type of rules are not important for index type insurance products. First in the case of area yield or weather index insurance the actual *real* losses incurred will always exceed the payouts if the regulator accepts the broad definition of economic losses introduced above. Therefore, the rule would not be violated or insured parties could declare formally that economic losses exceeded insurance payout. Second the rationale for this type of regulation precluding payouts in excess of true losses is to combat fraud and abuse of the insurance instrument for either money laundering or tax avoidance purposes, rather than the maintenance of sound insurance principles.

Regulatory capacity

There are some specific demands on regulatory capacity posed by area yield or weather based index insurance. To begin, the regulator needs to license products and monitor portfolios and the insurer's ability to pay for claims. Area yield or weather index insurance differs from traditional insurance products only insofar as the coverage is limited to one or a clearly defined basket of risk parameters. An actuarial analysis of the historical series for these parameters as well a loss or burn analysis to determine loss histories usually reveals a rather accurate picture of the exposure.

Area yield or weather index insurance introduces at least three new challenges for regulators:

1) The nature of the risk parameters: weather risk is subject to structural changes that the regulator should understand at least in principle: global warming and climate patterns (e.g. El Nino in certain parts of the world), as well as the nature of micro climates are prime examples.
2) The nature of the reinsurance markets: as opposed to traditional crop insurance the ultimate risk takers in the weather risk market are not necessarily the big name reinsurers, but could be banks or even power traders. While the contractual format will be a reinsurance treaty with an acceptable reinsurer, there are potentially more efficient risk transfers should the regulator chooses to accept other risk transfer formats.
3) The nature of risk portfolio management: The insurer may have unique opportunities for risk diversification and hedging. An area yield or weather risk

portfolio can be managed in a fashion that allows for limited risk capital to support a large amount of underwritten notional risk if at least some of the exposures offset one another due to low correlations. For example, if an insurer writes both flood and drought risk in a place for the same period, only one of the two contracts can pay out and the same traditional insurance reserves can support twice as much premium underwriting. Therefore the regulator should recognize the hedging and portfolio diversification effects on capital needs and allow for a competitive use of risk capital by insurers and reinsurers.

Analysis and oversight of new types of products and insurers in the market requires specific skills and profiles currently not available in the Romania regulatory environment.

Weather risk reinsurance and moral hazard

Insurers and reinsurers primarily rely on weather data measured by the synoptic weather stations in Romania. Although verification mechanisms such as fallback stations and even satellite data might be used, the primary data has to be highly reliable and accurate. Certainly the weather data has to be tamperproof. Introducing insurance that pays based on weather measures could cause certain individuals to attempt to tamper with the measurement instruments to 'create a payment'. The best guarantee against tampering is a fully independent third party, unrelated to any party in the insurance contract. As soon as government takes a substantial interest in the reinsurance or insurance of weather insurance contracts, this independence is compromised. Four aspect of the contract can reduce the incentives for tampering and increase the confidence of all parties in the integrity of the system:

1) the arms length nature of the transaction: third party determination of the weather events;
2) a neutral stance from the government in taking risk on the contract;
3) careful contract designs that do not involve a zero-one payment schedule whereby a very fine measurement difference will result in full payment; and
4) secondary systems to collaborate measurements from the official weather stations (this could be satellite imagery or simply redundant and lower cost instruments that are nearby).

Currently the weather service organization in Romania is nominally independent of ministries, but depends on state funding. Governance mechanisms and weather service culture suggest that the weather service produces reliable data similar to most Western weather services. Romania belongs to the World Metrological Organization (WMO). Standard training and acceptable measurement instruments and reporting are common among members of WMO.

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Appendix A: Statistical Results

Models of Judet Maize Yields= f (rainfall, frequency of high temperatures)

-------------------------------- Judet=Braila --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	6048966	3024483	12.95	<.0001
Error	30	7008576	233619		
Corrected Total	32	13057542			

Root MSE	483.34169	R-Square	0.4633
Dependent Mean	3209.78788	Adj R-Sq	0.4275
Coeff Var	15.05837		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1911.05064	500.20143	3.82	0.0006
rain	1	6.31687	1.73609	3.64	0.0010
hot	1	-1081.76849	1020.25433	-1.06	0.2975

-------------------------------- Judet=Buzau --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	9776331	4888165	15.74	<.0001
Error	30	9316274	310542		
Corrected Total	32	19092605			

Root MSE	557.26337	R-Square	0.5120
Dependent Mean	2988.72727	Adj R-Sq	0.4795
Coeff Var	18.64551		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2168.50565	525.05394	4.13	0.0003
rain	1	4.29331	1.51263	2.84	0.0081
hot	1	-3291.88021	1241.37198	-2.65	0.0127

-------------------------------- Judet=Calarasi --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	6252230	3126115	12.45	0.0001
Error	30	7532333	251078		
Corrected Total	32	13784564			

Root MSE	501.07661	R-Square	0.4536
Dependent Mean	3188.78788	Adj R-Sq	0.4171
Coeff Var	15.71370		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2135.15643	508.66556	4.20	0.0002
rain	1	5.92359	1.75203	3.38	0.0020
hot	1	-1243.67996	915.42886	-1.36	0.1844

------------------------------- Judet=Constanta --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	6542297	3271149	12.39	0.0001
Error	30	7921885	264063		
Corrected Total	32	14464182			

Root MSE	513.87043	R-Square	0.4523
Dependent Mean	2791.93939	Adj R-Sq	0.4158
Coeff Var	18.40550		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1955.35262	386.13560	5.06	<.0001
rain	1	5.29913	1.67525	3.16	0.0036
hot	1	-6125.57443	2652.99528	-2.31	0.0280

-------------------------------- Judet=Galati --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	14901545	7450772	24.39	<.0001
Error	30	9164556	305485		
Corrected Total	32	24066101			

Root MSE	552.70716	R-Square	0.6192
Dependent Mean	2893.03030	Adj R-Sq	0.5938
Coeff Var	19.10478		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	569.88897	511.08934	1.12	0.2737
rain	1	10.64478	1.84522	5.77	<.0001
hot	1	-764.55914	1338.20643	-0.57	0.5720

------------------------------- Judet=Ialomita -------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5222214	2611107	12.61	0.0001
Error	30	6212293	207076		
Corrected Total	32	11434507			

Root MSE	455.05653	R-Square	0.4567
Dependent Mean	3228.66667	Adj R-Sq	0.4205
Coeff Var	14.09426		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2704.57630	426.85707	6.34	<.0001
rain	1	3.68886	1.44914	2.55	0.0163
hot	1	-2308.97807	922.95148	-2.50	0.0180

-------------------------------- Judet=Tulcea --------------------------------

Dependent Variable: Adjusted Yield

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	6944206	3472103	10.06	0.0005
Error	30	10349280	344976		
Corrected Total	32	17293486			

Root MSE	587.34657	R-Square	0.4016
Dependent Mean	2601.87879	Adj R-Sq	0.3617
Coeff Var	22.57394		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1449.76248	433.71020	3.34	0.0022
rain	1	7.08426	2.10029	3.37	0.0021
hot	1	-4481.09065	2725.14535	-1.64	0.1105

AEC 780-02[14]

AGRICULTURAL WEATHER RISK MANAGEMENT

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August 19-23, 2002
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Background

Weather risks create social and commercial problems for society. Economic losses from natural disaster risks have increased in the past few decades. While it may be true that climate change is increasing the incidents of severe weather events, it is also true that more people and property are now exposed in vulnerable or high risk areas. How society responds is important. If the response is to provide free assistance, this can create a cycle of losses. More people and economic activity will move into the vulnerable area when the risks of doing so are totally borne by society. This behavior exacerbates the problem as the exposure is increased and waiting for the next natural disaster. Similarly, when free assistance is provided for agriculture more plantings will be made and more crop losses will occur when the next disaster occurs.

Insurance markets provide a partial answer to natural disaster risk. However, natural disaster risks are not insurable in the classic sense because these risks are correlated, meaning that many losses will result from the same natural hazard event. Financing this type of risk has become particularly challenging in recent years. Traditional reinsurance markets have limited financial capacity. Other forms of financing natural disaster risk have emerged in the past decade, including catastrophic bonds and weather markets. Much of what can be learned from these markets also has a bearing on agricultural risks. Still, there are important differences between a natural disaster risk like hurricanes and droughts. A hurricane is generally a low-frequency high consequence risk. A drought can have severe consequences as well. However, in many agricultural regions of the world, droughts occur with far greater frequency.

Many governments in the developed world have attempted to deal with agricultural risks by implementing multiple peril crop insurance programs. These

[14] This course can be added for credit as AEC 780 002 for the fall semester. The call number is 06865.

[15] Dr. Barry Barnett of the University of Georgia provided valuable assistance in the development of this course. Dr. Leigh Maynard of the University of Kentucky will teach a segment on futures markets. This course was developed as part of a USAID funded project on agricultural insurance in Romania.

programs are very costly. Few developing countries can afford such programs. The need for new solutions that use markets, government, and the international donor community are increasing. This course will be targeted at developing both the conceptual understanding and practical tools to help you find new solutions. We begin by attempting to frame the problem, particularly in the context of emerging or developing economies where funds are limited. Next we move to developing the basic understanding of two contingent claims markets; 1) insurance and 2) futures markets. The third day is spent introducing the weather markets and providing real data to motivate your thinking about how to develop weather insurance to aid in managing crop yield risk. On the fourth day, we continue this quest with some further empirical examples and computer tools that can be used to price risk. In addition, we have a special visitor on Thursday afternoon from AWS, the largest private network of weather stations in the world. Advances in technology and information systems that allow for secure and accurate measures of weather events will be a key to developing new weather risk management instruments. Finally, we close with a forward look at the new risk sharing markets and institutions that provide some hope for limited resource countries as they attempt to manage natural disaster risk ex ante.

The course will move quickly and the readings are a burden. Obviously, there is only so much that can be accomplished in a week. However, it is my desire to motivate you to further inquiry by providing a basic understanding of the issues and the tools needed to address natural disaster risk, and in particular, crop yield risk.

COURSE OBJECTIVES:

1. Develop an understanding of the role of government in natural disaster policy.
2. Provide a basic knowledge about how insurance works.
3. Introduce the concepts behind weather insurance and weather markets.
4. Demonstrate the methodologies needed to develop weather-based insurance for agricultural risks.
5. Provide you with ‘hands-on’ experience in modeling risk and designing weather derivatives.
6. Motivate your further inquiry into understanding how society can more effectively address natural disaster risk.

GRADING AND EXPECTATIONS

While this course meets during the week of August 19-23, those of you wishing to obtain credit for the course will sign up for the fall. Thus, you will have time to complete some of the needed assignments to earn a one hour credit. Two criteria will be used to assign your grade: 1) 30% will be provided based upon your participation and engagement during the week and 2) 70% will be based upon a research paper that is due by November 15. During the week, we will have a few exercises that will be used to gauge your participation. These will include some computer exercises that will help you understand some basic concepts. The paper can be jointly developed with one other colleague in the course or it can be a product of your own. The major objective of the paper will be to design and price a weather insurance contract. Data will be supplied.

August 19 Natural Disasters and Government Policy

Readings:

Skees, Jerry R., Peter Hazell, and Mario Miranda. "New Approaches to Public / Private Crop Insurance." EPTD Discussion Paper No. 55. Environment and Production Technology Division, International Food Policy Research Institute, Washington DC. Nov. 1999.

Skees, Jerry R., Panos Varangis, Donald Larson, and Paul Siegel "Can Financial Markets be Tapped to Help Poor People Cope with Weather Risks?" World Bank Working Paper and Chapter for UNU/Wider 2002.

Scott E. Harrington. 2000. "Rethinking Disaster Policy." *Regulation* 23:40-46.

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

Topics:

Political Incentives for Disaster Assistance.
Disaster Assistance versus Insurance: Efficiency, Consistency, and Equity.
Disaster Assistance and the Demand for Insurance.
Experience With U.S. Disaster Insurance Programs: Low Demand, Adverse Selection, Moral Hazard, and Rent-Seeking.
New approaches to structuring markets and government solutions.

August 20: Managing Risk With Contingent Claims Contracts: Insurance and Futures Markets

Readings from Skees:

Barry J. Barnett and Keith H. Coble. 1999. "Understanding Crop Insurance Principles: A Primer for Farm Leaders." Mississippi Agricultural & Forestry Experiment Station Bulletin 1087.

Soybean Group Risk Plan (GRP): A Pilot Test for 1993 and 1994. United States Department of Agriculture, 1993.

Barnett, Barry, Yingyao Hu, J. Roy Black, and Jerry R. Skees, "Is Area Yield Insurance Competitive with Farm Yield Insurance?" Submitted for publication consideration to *American Journal of Agricultural Economics,* July 2002.

Readings from Maynard (Futures, Hedging, and Options)

Stoll, Hans R. and Robert Whaley, **Futures and Options: Theory and Applications.** Chapter 4 "Hedging with Futures Contracts."

Purcell, Wayne and Stephen Koontz. **Agricultural Futures and Options: Principles and Strategies.** Chapter 7. Prentice Hall

Topics:

What is Risk?
Why is Risk a Problem?
Different Types of Risk.
Risk Management Tools.
Insurance as a Risk Management Tool.
Conditions for Insurability.
Triggering Criteria.
Underwriting.
Rate-Making.
Measures of Profitability.
Farm-Level Yield and Revenue Insurance Products.
Asymmetric Information: Moral Hazard and Adverse Selection.
Transactions Costs.

August 21: Weather Markets and Weather Insurance

Readings

Connie Paoletti. August 2001. "A Beginner's Guide." *Weather Risk, An Energy Power Risk Management and Risk Special Report*, Risk Waters Group, London, United Kingdom.

Dischel, Robert. "An Introduction to the Weather Market: Dawn to Mid-Morning." Chapter 1 in **Climate Risk and the Weather Market.** Risk Waters. London, England. 2002.

Ruck, Thomas. "Hedging Precipitation Risk." Chapter 3 in **Climate Risk and the Weather Market.** Risk Waters. London, England. 2002.

Steven W. Martin, Barry J. Barnett, and Keith H. Coble. 2001. "Developing and Pricing Precipitation Insurance." *Journal of Agricultural and Resource Economics* 26:261-74.

Topics:

Contract Design.
Data Requirements.
Advantages Relative to Farm-Level Insurance.
Basis Risk.
Potential Applications (Direct Sales to End-Users, Reinsurance, Wrap-arounds, Disaster Assistance).

August 22: Empirical Cases of Weather Insurance in Developing Countries

Jerry Skees, Stephanie Gober, Panos Varangis, Rodney Lester, and Vijay Kalavakonda. April 2001. "Developing Rainfall-Based Index Insurance in Morocco." The World Bank Policy Research Working Paper 2577.

Panos Varangis, Jerry Skees, and Barry Barnett. "Weather Indexes for Developing Countries." Chapter 1 in **Climate Risk and the Weather Market.** Risk Waters. London, England. 2002.

August 23: Trends in Risk Sharing for Catastrophe Risk

Russ Banham. August 2001. "Cat Bonds Come of Age." *Weather Risk, An Energy Power Risk Management and Risk Special Report*, Risk Waters Group, London, United Kingdom.

Joseph Cole and Anthony Chiarenza. July 1999. "Insurance Risk – Securitisation: The Best of Both Worlds. *Risk Magazine, Insurance Risk Supplement.*

Graciela Chichilnisky and Geoffrey Heal. 1998. "Managing Unknown Risks." *Journal of Portfolio Management* 24:85-91.

Further Readings (available upon request)

Dwight M. Jaffee and Thomas Russell. 1997. "Catastrophe Insurance, Capital Markets, and Uninsurable Risks." *Journal of Risk and Insurance* 64:205-30.

Jerry Skees, Peter Hazell and Mario Miranda. November 1999. "New Approaches to Crop Yield Insurance in Developing Countries." International Food Policy Research Institute, EPTD Discussion Paper No. 55, Washington D.C.

Jerry R. Skees, J. Roy Black, and Barry J. Barnett. 1997. "Designing and Rating an Area Yield Crop Insurance Contract." *American Journal of Agricultural Economics* 79:430-38.

J. Roy Black, Barry J. Barnett, and Yingyao Hu. December 1999. "Cooperatives and Capital Markets: The Case of Minnesota-Dakota Sugar Cooperatives." *American Journal of Agricultural Economics* 81:1240-46.

Del Jones. December 11, 2001. "Playing the Weather Game." *USA Today*.

Don Stowers. August 2001. "Slow but Steady." *Weather Risk, An Energy Power Risk Management and Risk Special Report*, Risk Waters Group, London, United Kingdom.

STUDY OF THE CROPWAT MODEL IN ROMANIA

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Abstract

In the last years, the importance of the agrometeorological models development to assess different decisions regarding the irrigation planning and management was considerably enhanced, due to their capacity of simulating different alternative options related to the irrigation application. Many existing models, such as SWAP, AMBAV, IRRFIB, CROPWAT, can be used for irrigation modeling in order to offer complex and precise information to the end-users. In this paper a short description of the CROPWAT model, including input/output data and the calculation methods is presented and also the problems associated with model validation in the climatic conditions of Romania. Using climatic, crop and soil data, the model calculates reference evapotranspiration, crop water requirements, and crop irrigation requirements and allows the planning of irrigation schedules under varying water supply conditions. The model validation has been carried out for six maize growing seasons during the years 1995-2000 at Craiova agrometeorological station. The comparative analysis of the daily soil moisture deficit simulated by the model with the real one, proved the fact that, generally, the CROPWAT model has described very well the dynamics of soil moisture change during the analyzed vegetation periods.

Key words: Model, Maize, and Soil Moisture.

INTRODUCTION

The agricultural production growth and stabilization, in the conditions of the extreme climatic events occurrence, such as severe pedological droughts, can be ensured by using many methods, the most important one being the irrigation, provided the environmental preservation and protection. Many existing agrometeorological models can be used to evaluate the soil moisture dynamics and soil water deficits at the rooting depth of the different agricultural crops, in order to provide information necessary in taking decisions on irrigation planning and management.

The present paper proposes a general description of the CROPWAT model, including the requested input/output data and the computation methods used in simulating the main components of the water balance in soil. In addition, the analysis of the model results in the rainfed conditions and comparisons of soil moisture deficit with data measurements were performed for maize vegetation seasons at Craiova agrometeorological station in the interval 1995-2000.

Materials and Methods

Model description

CROPWAT is application software for irrigation planning and management, developed by FAO -Water Resources, Development and Management Service. Its main functions are: to calculate reference evapotranspiration, crop water requirements and crop irrigation requirements; to develop irrigation schedules under various management conditions and water supply schemes; to estimate rainfed production and drought effects; and to evaluate the efficiency of irrigation practices.

CROPWAT is meant as a practical tool to help agrometeorologists, agronomist and irrigation engineers to carry out standard calculations for evapotranspiration, crop water-use studies and more specifically, the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rainfed conditions or deficit irrigation.

Procedures for calculation of the crop water requirements and irrigation requirements are based on methodologies presented in FAO Irrigation and Drainage Papers No. 24 "Crop water requirements" and No. 33 "Yield response to water".

The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-water balance using various options for water supply and irrigation management conditions.

There are two new versions of the CROPWAT software available:

- **CROPWAT v 7.0** that contains a completely version in Pascal, developed with the assistance of the Agricultural College of Velp, Netherlands. It overcomes many of the shortcomings of the original 5.7 version. CROPWAT 7.0 is a DOS-application, but it runs without any problem in all MS-WINDOWS environments.

- **CropWat for Windows** that is written in Visual Basic and operates in the Windows environment. It has been developed with the assistance of the International Irrigation & Development Institute (IIDS) of the University of Southampton, UK. Martin Smith (FAO), Derek Clarke (Institute of Irrigation and Development Studies- Southampton University UK) and Khaled El-Askari (National Water Research Center-Cairo, Egypt) developed actually available version 4.3.

Both versions use the same FAO (1992) Penman-Montieth method for calculating the reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. Some of the interpolation methods used in CropWat for Windows are slightly different (up to 2%) to those used in CROPWAT 7.0. The main differences between the two versions are as the following:

- CropWat for Windows uses graphs and forms to display results;
- CropWat for Windows can deal with multiple crops with up to 30 crops in a cropping pattern; these crops are assumed to be co-existing in the same parcel of land;
- Irrigation Schedules can be calculated for individual blocks of each crop; the time base for results can be daily, weekly, decade or monthly;
- Color and black &white graphs can be printed through the standard Windows Print Manager;
- A “Scheduling scenario file” can be saved and read in quickly at a later date;
- CropWat for Windows uses monthly climatic data only, whereas CROPWAT 7.0 can use decade data as well as monthly data;
- CropWat for Windows allows user-defined irrigation events plus the option to add adjustments to the calculated soil moisture deficit for different reasons (such as: to apply actual rainfall data, to amend soil moisture deficit to bring it in to line with field measurements of soil moisture, to allow for capillary rise contribution to the soil moisture, to allow for deep percolation out of soil profile). This provides a flexible tool for managing the soil moisture during the growing season.

Both versions of software are compatible with use of the same CLIMWAT database and rainfall files. CLIMWAT for CROPWAT is a worldwide climatic database to be used in combination with CROPWAT. The climatological data in this database are: maximum and minimum temperature, mean daily relative humidity, sunshine duration, wind speed, precipitation and calculated values for reference evapotranspiration and effective rainfall. The original database has been compiled by the Agrometeorological Group of the FAO Research and Technology Development Division and has been converted into a format suitable for use by CROPWAT.

The standard data covers only selected sites in some countries. Among European countries CLIMWAT database covers following areas: Belgium 3 sites, France 44 site, Italy 60 sites, Cyprus 27 sites, Greece 20 sites, Portugal 3 sites, Spain 58 sites, Luxembourg 1 site, former Yugoslavia 21 sites.

Input

Calculations of the crop water requirements and irrigation requirements are carried out with inputs of climatic, crop and soil data. For the estimation crop water requirements (CWR) the model requires:

a) Reference Crop Evapotranspiration (Eto) values measured or calculated using the FAO Penman-Montieth equation based on decade/monthly means climatic data of: minimum and maximum air temperature (°C), relative humidity (%), sunshine duration (hours) and wind speed (m/s). From these data the model estimates the reference evapotranspiration Eto (mm/day) and also radiation (MJ/m^2/day) for each month or decade. Also mean annual values are calculated automatically.
b) Rainfall data (daily / decade / monthly data);
monthly rainfall is divided into a number of rainstorms each month;
c) A ***Cropping Pattern*** consisting of the crop type, planting date, crop coefficient data files (including Kc values, stage days, root depth, depletion fraction, Ky values) and the area planted (0-100% of the total area); a set of typical crop coefficient data files are provided in the program.
In addition, for *Irrigation Scheduling* the model requires information on:
d) Soil type**:** total available soil moisture, maximum rain infiltration rate, maximum rooting depth, initial soil moisture depletion (% of total available moisture);
e) Scheduling Criteria – several options can be selected regarding the calculation of application timing and application depth (e.g. 80 mm every 14 days, or irrigate to return the soil back to field capacity when all the easily available moisture has been used).

Output

Once all the data is entered, CropWat 4 Windows automatically calcula tes the results as tables or plotted in graphs. The time step of the results can be any convenient time step: daily, weekly, decade or monthly. The output parameters for each crop in the cropping pattern are:

-*reference crop evapotranspiration* – Eto (mm/period);
-*crop Kc*-average values of crop coefficient for each time step;
-*effective rain* (mm/period)-the amount of water that enters the soil;
-*crop water requirements*–CWR or Etm (mm/period);
-*irrigation requirements*–IWR (mm/period);
-*total available moisture*–TAM (mm);
-*readily available moisture*–RAM (mm);
-*actual crop evapotranspiration*–Etc (mm);
-*ratio of actual crop evapotranspiration to the maximum crop evapotranspiration*-Etc/Etm (%);
-*daily soil moisture deficit* (mm);
-*irrigation interval* (days) & *irrigation depth applied* (mm);
-*lost irrigation* (mm)–irrigation water that is not stored in the soil (i.e. either surface runoff or percolation);
-*estimated yields reduction* due to crop stress (when Etc/Etm falls below 100%).

Calculation methods

The Windows version of CropWat model allows to make modification in Eto calculation: possible modification of Angstrom's Coefficients a and b and selection of Eto distribution model. The values of decade or monthly Reference Crop Evapotranspiration (Eto) are converted into daily values using four distribution models (the default is a polynomial curve fitting).

The model calculates the Crop Water Requirements (CWR) as *Eto*CropKc*.

The average values of crop coefficient (Kc) for each time step are estimated by linear interpolation between the Kc values for each crop development stage. The "Crop Kc" values are calculated as *Kc*Crop Area*, so if the crop covers only 50% of the area, the "Crop Kc" values will be half of the Kc values in the crop coefficient data file.

For crop water requirements and scheduling purposes, the monthly total rainfall has to be distributed into equivalent daily values. CropWat for Windows does this in two steps. First the rainfall from month to month is smoothed into a continuous curve (the default curve is a polynomial curve, but can be selected other smoothing methods available in the program e.g. linear interpolation between monthly values). Next the model assumes that the monthly rain falls in 6 separate rainstorms, one every 5 days (the number of the rainstorms can be changed). In the files with rainfall data, the effective rainfall is automatically calculated. The user is able to choose the method:

-fixed percentage of rainfall (percentage interactively defined by user);
-dependable rain (FAO/AGLW formula):

$Peff=0.6*Pmon-10$ for Pmon[70 mm

$Peff=0.8*Pmon-24$ for Pmon>70 mm

-empirical formula (locally derived) - possible modification of all coefficients and thresholds in FAO/AGLW formula;
-USDA Soil Conservation Service (this method is the default):
$Peff=(Pmon*(125-0.2*Pmon))/125$, for Pmon [250 mm and
$Peff=125+0.1*Pmon$, for
Pmon>250 mm.

For the scheduling calculations can be selected two options: *Irrigation Scheduling and Daily Soil Moisture Balance.* The Irrigation Scheduling option shows the status of the soil moisture every time new water enters the soil, either by rainfall or a calculated irrigation application. Daily Soil Moisture Balance option shows the status of the soil every day throughout the cropping pattern, how the soil moisture changes in the growing season. User defined irrigation events and other adjustments to the daily soil moisture balance can be made when the Scheduling Criteria are set to "user-defined".

Total Available Moisture (TAM) in the soil for the crop during the growing season is calculated as Field Capacity minus the Wilting Point times the current rooting depth of the crop. Readily Available Moisture (RAM) is calculated as *TAM * P,* where P is the depletion fraction as defined in the crop coefficient (Kc) file. To avoid crop stress, the calculated soil moisture deficit should not fall bellow the readily available moisture.

The program and the manual developed by Martin Smith, Derek Clarke & Khaled El-Askari can be downloaded from FAO's FTP server:
http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/cropwat.htm

MODEL VALIDATION

The validation of the CropWat for Windows version has been carried out for six maize growing seasons during the years 1995-2000 at the Craiova agrometeorological station located in the southern part of Romania (44°19' N, 23°52' E). For the purpose of this study, the model was run in rainfed conditions with the monthly climatic data (minimum and maximum air temperature, relative humidity, sunshine duration and wind velocity) and also with the application of daily actual rainfall data for the whole maize growing seasons (user adjustment). These climatic data were provided by the National Institute of Meteorology and Hydrology, Bucharest, Romania.

Real data of phenology and soil moisture content have been collected from the field at the Craiova agrometeorological station. The soil moisture content has been measured every ten days starting from sowing until harvest time.

Maize crop was planted at different date between 20-30 April and the full maturity occurred between 30 August-14 September. For validation, the standard crop coefficient data files that are included in the program were used, only the stage days and the crop high was modified according to the observed crop phenology (for each crop development stage I, II, III, IV). The crop is assumed to be planted all at the same time and cover 100% of the projected area.

RESULTS

Figure 1 shows the results simulated with the CropWat for Windows for daily evolution of reference evapotranspiration (Eto), crop water requirements (CWR) and irrigation water requirements (IWR) during the maize growing seasons, in the specific weather conditions of each year from the interval 1996-2000. During the months June, July and the first half of August (which correspond with the phenological phases: silking–grain filling), the reference evapotranspiration reaches the most high values, 5.5–6.5 mm/day, and water requirements up to 6.5–7.8 mm/day. Maize water requirements follow the slope of a typical Kc curve and it rises above the reference evapotranspiration

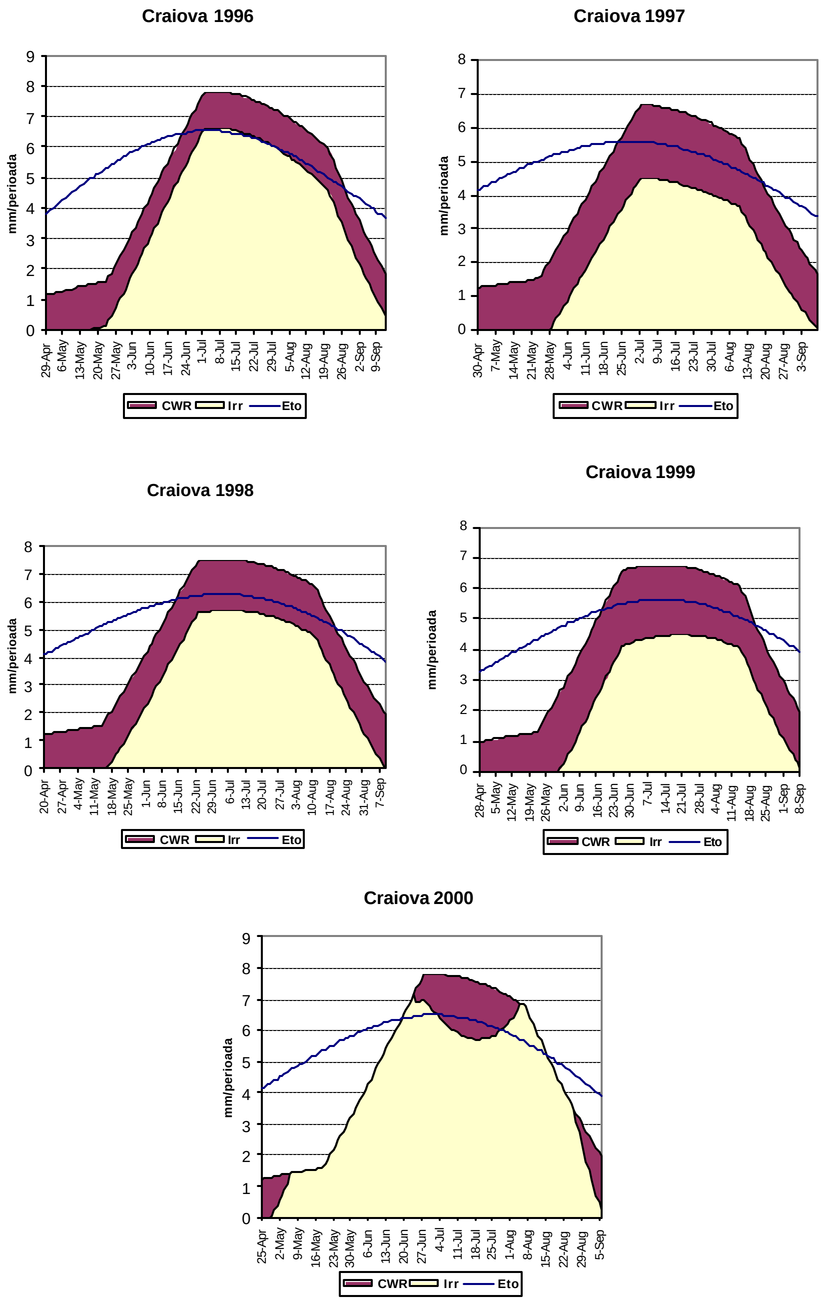

Figure 1. Daily evolution of the reference evapotranspiration (ETo), crop water requirements (CWR) and irrigation requirements (Irr) during maize growing season, in the specific weather conditions from the interval 1996-2000

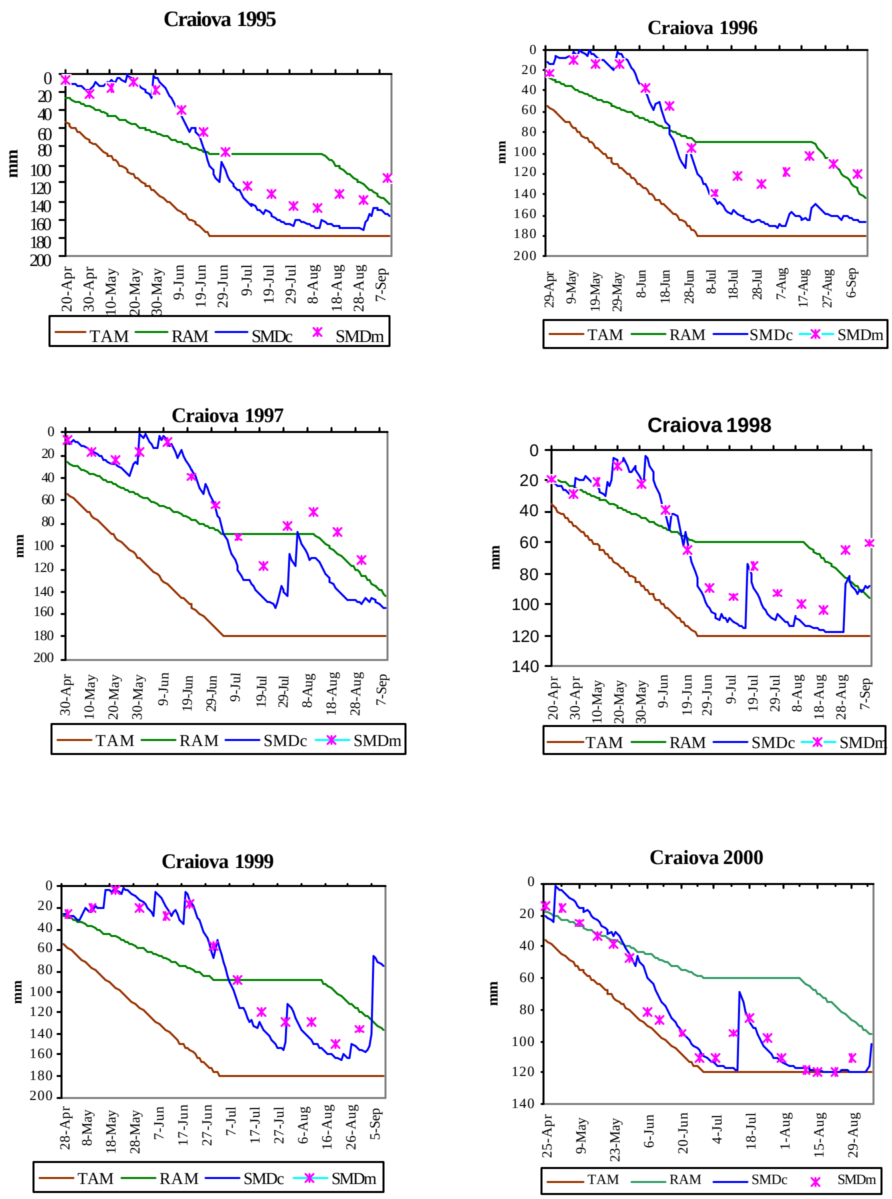

Figure 2. Comparison between simulated (line) and measured (points) soil water deficit during the maize growing season (1995 - 2000) at Craiova site. *TAM: Total Available Moisture, RAM: Readily Available Moisture, SMDc: Soil Moisture Deficit calculated, SMDm: Soil Moisture Deficit measured*.

curve when the crop coefficient is greater than 1.0. The effective rainfall makes the difference between crop water requirement and irrigation water requirement.

The cumulated values of the reference evapotranspiration, crop water requirements, irrigation water requirements, total and effective precipitation and also the percentage of yield reduction due to crop stresses over the whole maize growing season are centralized in table 1.

Figure 2 illustrates as graphics the results of CropWat model validation regarding soil moisture changes during the maize growing season for each year of the period 1995-2000 at Craiova site. The comparison between simulated (line) and measured (points) soil water deficit shows a very strong correlation, especially in the first part of the growing seasons. The soil moisture deficit reaches the limit of the easily available moisture (RAM) in the last decade of June (in the years 1995, 1996 and 1998) and in the first decade of July (in the case of 1997 and 1999 years), after that it increases or decreases according with specific weather conditions of each year. For the year 2000, due to the low precipitation during the vegetation season (92 mm) associated with high temperature, the soil moisture deficit reaches RAM in the first decade of May. Beginning from June the soil moisture deficit increases up to the limit of total available moisture. In this case, the rainfed maize crop was practically compromised; the yield reduction is estimated to be 90% (Table 1).

As shown by Figure 3, the simulated soil moisture deficit is quite similar to the measured ones indicated by a high correlation coefficient of r^2=0.936. The mean differences between the simulated and measured values are small from 8 mm to 20.5 mm and also, average relative response (%) varies between 4-16%.

Tabel 1. Results simulated with the CropWap for Windows model, in cumulated values on the whole maize vegetation season from the analyzed years

Specification	1995	1996	1997	1998	1999	2000
Reference evapotr. (mm)	680	756	651	780	651	752
Crop water requirements (mm)	590	667	544	687	583	644
Total rainfall (mm)	194	201	306	332	360	92
Effective rainfall (mm)	182	185	270	283	301	78
Irrigation requirements (mm)	330	487	291	413	314	556
Yield reduction (%)	56.4	62.3	27.3	61.5	36.9	90

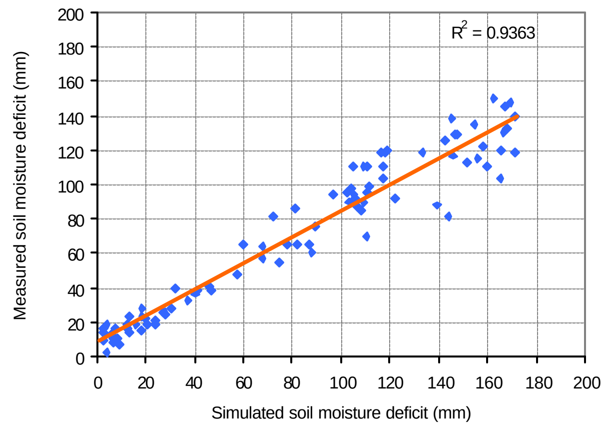

Figure 3. Comparison of measured and simulated soil moisture deficit at Craiova site in the period 1995-2000. *The continuous line is found by linear regression.*

CONCLUSIONS

The validation of CropWat for Windows model in Romania has emphasized a good performance in simulating the main components of the water balance in soil. The model has described very well the dynamics of soil moisture change during the all six maize growing seasons analyzed (the interval 1995-2000) at Craiova site.

The comparison between simulated and measured soil moisture deficit shows a very strong correlation.

The advantage of CROPWAT software is very limited number of necessary input data practically consisting of climatic information. The model is easy to use and suitable for an operative application in the irrigation management.

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Judet	Crop	Hectares	Expected Yield	Trigger Yield	Premium Rate
Alba	BARLEY	10435	1.65	1.36	1.5
Alba	CORN	36632	3.02	2.46	2.3
Alba	SUNFLOWER	1867	1.10	0.87	2.4
Alba	WHEAT	22769	2.32	1.90	1.3
Arad	BARLEY	20371	2.44	2.03	2.1
Arad	CORN	120328	3.24	2.71	2.3
Arad	SOYBEAN	11231	1.49	1.17	4.2
Arad	SUNFLOWER	16242	0.93	0.75	2.4
Arad	WHEAT	60482	2.58	2.22	3.0
Arges	BARLEY	3728	2.23	1.62	2.3
Arges	CORN	53159	2.60	2.18	4.3
Arges	SUNFLOWER	16844	0.70	0.58	2.4
Arges	WHEAT	38910	1.99	1.50	2.9
Bacau	CORN	99059	1.22	1.04	1.8
Bacau	WHEAT	12613	1.48	1.20	2.6
Bihor	BARLEY	12135	1.85	1.53	1.3
Bihor	CORN	96038	3.17	2.55	3.5
Bihor	SUNFLOWER	19230	0.98	0.66	2.4
Bihor	WHEAT	42972	2.14	1.81	2.4
Bistrita-Nasaud	BARLEY	5751	1.64	1.28	2.2
Bistrita-Nasaud	CORN	29434	2.77	2.23	1.7
Bistrita-Nasaud	WHEAT	11237	2.17	1.73	2.2
Botosani	BARLEY	11653	1.21	1.04	2.8
Botosani	CORN	124716	2.58	2.16	2.1
Botosani	SOYBEAN	2517	0.91	0.74	3.1
Botosani	SUNFLOWER	20785	1.09	0.91	1.4
Botosani	WHEAT	28497	1.80	1.45	3.7
Braila	BARLEY	10091	2.61	2.14	3.1
Braila	CORN	108503	3.17	2.67	2.7
Braila	SOYBEAN	24166	1.47	1.24	3.2
Braila	SUNFLOWER	62566	1.13	1.02	1.2
Braila	WHEAT	63805	2.72	2.24	2.2
Brasov	BARLEY	11262	2.08	1.67	2.1
Brasov	CORN	8773	2.64	2.06	2.7
Brasov	WHEAT	18116	2.85	2.25	2.5
Buzau	BARLEY	3301	2.75	2.03	3.9
Buzau	CORN	122047	2.86	2.33	3.6
Buzau	SUNFLOWER	41053	1.19	1.09	0.8
Buzau	WHEAT	49139	2.56	1.93	4.0
Calarasi	BARLEY	19769	3.30	2.78	2.5
Calarasi	CORN	106405	3.09	2.63	2.6
Calarasi	SOYBEAN	20700	1.64	1.25	3.6
Calarasi	SUNFLOWER	76908	1.15	1.05	2.1
Calarasi	WHEAT	119552	3.30	2.76	3.4
Caras-Severin	BARLEY	3323	2.54	1.94	3.7
Caras-Severin	CORN	43299	2.77	2.11	3.5
Caras-Severin	SUNFLOWER	2624	1.06	0.69	5.4

Judet	Crop	Hectares	Expected Yield	Trigger Yield	Premium Rate
Caras-Severin	WHEAT	20582	2.72	2.24	3.8
Cluj	BARLEY	18850	1.74	1.45	1.9
Cluj	CORN	47428	2.77	2.18	1.9
Cluj	SUNFLOWER	3091	1.14	0.91	1.7
Cluj	WHEAT	26164	2.25	1.82	1.5
Constanta	BARLEY	33551	2.82	2.29	2.2
Constanta	CORN	92982	2.68	2.21	2.2
Constanta	SOYBEAN	1712	1.37	1.02	1.8
Constanta	SUNFLOWER	105375	1.19	1.07	1.0
Constanta	WHEAT	141175	2.97	2.39	3.2
Covasna	BARLEY	13875	2.10	1.68	2.2
Covasna	CORN	4658	2.54	1.83	3.7
Covasna	WHEAT	14062	3.08	2.62	2.4
Dambovita	BARLEY	4901	2.06	1.62	2.5
Dambovita	CORN	68829	2.60	2.11	3.6
Dambovita	SUNFLOWER	8976	0.73	0.61	2.8
Dambovita	WHEAT	27826	2.09	1.60	3.1
Dolj	BARLEY	11260	2.41	2.08	3.6
Dolj	CORN	161807	2.50	2.03	5.9
Dolj	SOYBEAN	3670	0.94	0.61	3.1
Dolj	SUNFLOWER	56106	0.80	0.67	4.5
Dolj	WHEAT	154559	2.09	1.72	4.4
Galati	BARLEY	6064	2.28	1.76	3.6
Galati	CORN	121071	2.79	2.15	3.5
Galati	SOYBEAN	6197	1.78	1.35	2.3
Galati	SUNFLOWER	40800	1.05	0.93	1.6
Galati	WHEAT	59958	2.29	1.67	3.8
Giurgiu	BARLEY	10172	2.86	2.36	2.4
Giurgiu	CORN	80361	1.98	1.41	4.2
Giurgiu	SOYBEAN	4066	0.78	0.53	5.1
Giurgiu	SUNFLOWER	39760	0.79	0.69	2.7
Giurgiu	WHEAT	55844	2.44	2.02	3.6
Gorj	CORN	66062	3.35	2.70	3.1
Gorj	WHEAT	12197	2.65	2.00	3.0
Harghita	BARLEY	10631	1.78	1.42	3.9
Harghita	CORN	4963	2.63	2.03	2.6
Harghita	WHEAT	12624	2.07	1.72	2.7
Hunedoara	BARLEY	6237	1.79	1.47	1.4
Hunedoara	CORN	25719	3.39	2.81	2.4
Hunedoara	WHEAT	11341	2.57	2.19	2.0
Ialomita	BARLEY	12744	2.97	2.46	3.6
Ialomita	CORN	110426	3.17	2.72	1.3
Ialomita	SOYBEAN	8911	1.68	1.31	2.4
Ialomita	SUNFLOWER	61641	1.27	1.18	1.1
Ialomita	WHEAT	92257	3.07	2.39	3.4
Iasi	BARLEY	6345	2.16	1.83	2.9
Iasi	CORN	120387	2.88	2.33	1.6

Judet	Crop	Hectares	Expected Yield	Trigger Yield	Premium Rate
Iasi	SOYBEAN	2227	1.48	1.14	2.6
Iasi	SUNFLOWER	14756	1.40	1.13	1.8
Iasi	WHEAT	33222	2.36	1.93	3.6
Ilfov	BARLEY	5461	2.77	2.15	2.6
Ilfov	CORN	31928	2.43	1.82	4.1
Ilfov	SUNFLOWER	12883	1.00	0.86	2.6
Ilfov	WHEAT	21595	2.57	2.11	3.7
Maramures	BARLEY	1255	1.77	1.36	2.0
Maramures	CORN	24692	2.47	2.14	3.3
Maramures	SUNFLOWER	1440	1.08	0.92	3.0
Maramures	WHEAT	7304	1.97	1.65	2.8
Mehedinti	BARLEY	3386	2.31	1.84	3.3
Mehedinti	CORN	70854	3.26	2.25	6.8
Mehedinti	SUNFLOWER	10630	0.87	0.68	3.6
Mehedinti	WHEAT	52031	2.44	1.85	3.7
Mures	BARLEY	20791	1.84	1.43	1.4
Mures	CORN	66339	3.29	2.72	2.2
Mures	SUNFLOWER	1668	1.23	0.95	3.5
Mures	WHEAT	33250	2.28	1.77	1.7
Neamt	BARLEY	8384	1.72	1.43	1.6
Neamt	CORN	60888	2.90	2.63	1.8
Neamt	SUNFLOWER	3722	1.10	0.81	2.6
Neamt	WHEAT	23008	2.32	1.79	2.4
Olt	BARLEY	15141	2.63	2.24	2.7
Olt	CORN	130759	2.30	1.71	6.4
Olt	SOYBEAN	1020	1.02	0.66	2.7
Olt	SUNFLOWER	53055	0.83	0.70	2.7
Olt	WHEAT	121375	2.38	2.05	3.8
Prahova	BARLEY	4070	3.10	2.48	2.2
Prahova	CORN	64950	3.23	2.68	2.7
Prahova	SUNFLOWER	10440	1.02	0.91	2.1
Prahova	WHEAT	31018	2.56	2.02	3.3
Salaj	BARLEY	6996	1.64	1.23	2.6
Salaj	CORN	29669	2.80	2.13	3.0
Salaj	SUNFLOWER	4430	1.11	0.87	2.5
Salaj	WHEAT	13719	2.27	1.72	2.0
Satu-1Mare	BARLEY	9457	2.19	1.81	1.6
Satu-1Mare	CORN	64752	3.03	2.50	2.6
Satu-1Mare	SUNFLOWER	21093	1.12	0.78	3.7
Satu-1Mare	WHEAT	33958	2.50	2.04	2.1
Sibiu	BARLEY	4630	1.48	1.18	3.2
Sibiu	CORN	29175	2.66	2.17	2.9
Sibiu	WHEAT	10034	2.11	1.71	3.3
Suceava	BARLEY	7784	1.54	1.27	2.7
Suceava	CORN	37074	2.60	2.18	1.7
Suceava	SUNFLOWER	1579	1.25	1.01	1.7
Suceava	WHEAT	21127	2.28	1.86	3.0

Judet	Crop	Hectares	Expected Yield	Trigger Yield	Premium Rate
Teleorman	BARLEY	18492	3.13	2.55	3.5
Teleorman	CORN	125112	2.12	1.58	6.3
Teleorman	SOYBEAN	2718	1.20	0.74	4.8
Teleorman	SUNFLOWER	84391	0.79	0.70	3.5
Teleorman	WHEAT	145399	2.47	1.99	2.6
Timis	BARLEY	50410	2.54	2.09	2.1
Timis	CORN	134833	3.30	2.61	2.6
Timis	SOYBEAN	13135	1.35	0.87	5.6
Timis	SUNFLOWER	45005	0.98	0.77	2.9
Timis	WHEAT	100448	2.70	2.26	2.7
Tulcea	BARLEY	13033	1.39	1.08	4.0
Tulcea	CORN	79528	2.46	1.93	2.4
Tulcea	SOYBEAN	6352	1.28	1.01	3.0
Tulcea	SUNFLOWER	57725	0.83	0.72	1.0
Tulcea	WHEAT	56232	1.73	1.31	3.9
Vaslui	BARLEY	7102	1.77	1.41	3.6
Vaslui	CORN	128556	2.19	1.70	4.2
Vaslui	SOYBEAN	1747	1.10	0.66	5.1
Vaslui	SUNFLOWER	31880	1.02	0.87	2.1
Vaslui	WHEAT	43751	1.95	1.45	3.7
Valcea	CORN	41677	4.20	3.39	2.3
Valcea	WHEAT	8551	2.91	2.24	1.3
Vrancea	BARLEY	4014	2.90	2.27	3.0
Vrancea	CORN	76224	3.22	2.57	4.5
Vrancea	SUNFLOWER	10795	1.31	1.12	1.8
Vrancea	WHEAT	25392	2.63	2.19	3.7

Agriculture Financial Services Corporation

Lack of Moisture Insurance Pilot Program

What is Lack of Moisture Insurance?

- a program designed to compensate producers when accumulated moisture at a weather station (selected for insurance) falls below its threshold level – the threshold for each station is 80% of its normal level
- the greater the shortfall of moisture compared to normal, the larger the compensation to producers

Which crops are eligible?

- native pasture and improved pasture are eligible (community pasture is optional)
- there is no offsetting between the two crops

Who is eligible to buy Lack of Moisture Insurance?

- producers with a minimum of 20 acres of dry land, native or improved pasture

What are the rules that apply to this insurance?

- you must insure all acres of the types of pasture you select to insure, however, you have the option to include or exclude community pasture
- community pasture acres are determined based on its carrying capacity
- you must select a weather station from the eligible stations provided

How many dollars per acre coverage am I able to buy?

- coverage can be purchased in one dollar increments

Pasture	Minimum Per Acre	Maximum Per Acre
Native Pasture	$5	$10
Improved Pasture	$10	$20

Where does weather station information come from?

- specific Environment Canada weather stations and selected AFSC offices will gather the precipitation data used to determine losses for this program
- the insured's production is not considered when determining a loss – only moisture conditions at the selected weather station act as a trigger for payments

How is spring soil moisture considered in the program?

- spring soil moisture and accumulated precipitation during May, June and July is used to determine moisture conditions for this program
- the Conservation and Development Branch of the Alberta Ministry of Agriculture, Food and Rural Development provides "spring" moisture information, while Environment Canada and AFSC provide precipitation information
- soil moisture for each station is based on measurements in the area where the weather station is located

How is spring soil moisture determined?

- spring soil moisture for the township is derived from samples taken from sites across the province during the latter part of April
- each site is measured in 30 cm increments to a depth of 90-100 cm and the results are adjusted to medium-textured soil and categorized into four groupings: high, medium, low and very low
- the categories of moisture, expressed in mm of available water, is as follows: high = 160 mm, medium = 100 mm, low = 50 mm, and very low = 15 mm
- to learn more about how moisture is measured, more detailed information is available at your local AFSC district office – you may also contact the following website for more information: http://www.agric.gov.ab.ca/navigation/sustain/climate/index.html

How is normal moisture calculated for insurance purposes?

- normal moisture (calculated in millimeters) for each weather station is calculated using the following formula: spring soil moisture + May's normal precipitation + June's normal precipitation + 1/2 of July's normal precipitation

How is annual moisture calculated?

- annual moisture for each weather station is calculated as: spring soil moisture + May's precipitation + June's precipitation + 1/2 of July's precipitation

July precipitation is weighted less, and daily moisture is capped.

- July precipitation is weighted by 50% because at this time of the season moisture has little impact on plant growth compared to earlier in the year
- if daily precipitation in a month used for insurance is greater than the normal for the month, precipitation will be capped (example: if a station has a May normal of 50 mm, then daily rainfall data for May would not exceed 50 mm for that station)

What periods are used to calculate normals?

- spring soil moisture records are calculated for the period 1988-2000
- precipitation normals are calculated for the period 1971-2000

(over)

Agriculture
Financial Services
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Finance It. Protect It. Help It Grow.

Payment Schedule

Annual moisture as a % of normal	Payment Rate % of $ coverage	Annual moisture as a % of normal	Payment Rate % of $ coverage
> = 80	0	> = 58 & <60	55
> = 78 & <80	5	> = 56 & <58	60
> = 76 & <78	10	> = 54 & <56	65
> = 74 & <76	15	> = 52 & <54	70
> = 72 & <74	20	> = 50 & <52	75
> = 70 & <72	25	> = 48 & <50	80
> = 68 & <70	30	> = 46 & <48	85
> = 66 & <68	35	> = 44 & <46	90
> = 64 & <66 *	40 *	> = 42 & <44	95
> = 62 & <64	45	< 42	100
> = 60 & <62	50		

Note: > = means “greater than or equal to”; and < means “less than”

Example: Claim Calculation

Data for this example only	Normal	Current Year	Claim Calculation
Spring soil moisture May precipitation June precipitation July precipitation	40 mm 38 mm 60 mm 50 mm	15 mm 28 mm 50 mm 25 mm	2500 acres x $20/acre = $50,000 coverage If your dollar coverage = $50,000 Claim payment is 40% of $50,000 = $20,000
Normal Moisture = Spring moisture 40 mm + May 38 mm + June 60 mm + July (0.5 x 50 mm) = 163 mm			
Current year’s moisture = Spring moisture 15 mm + May 28 mm + June 50 mm + July (0.5 x 25 mm) = 105.5 mm			
Current year’s payment trigger calculation = 105.5 mm ÷ 163 mm = 64.7 % of Normal			
See the Payment Schedule - Example: 64.7% * of normal would trigger 40% * of dollar coverage			

What other information do I need to know?

- claim payments are determined by the data collected from the weather station you select and have nothing to do with the production you generate on your farm
- coverage and premium adjustments earned in other AFSC insurance programs are NOT transferable to Lack of Moisture Insurance
- the early payment discount of 5% (payment on or before June 25) will apply
- land insured under this program cannot be insured under any other AFSC insurance program including the Satellite Imagery Insurance Pilot Program
- premiums are subsidized – the Federal and Provincial Government share in premium costs in the same manner they share costs under all crop insurance plans, and producers do not pay any administration costs
- contact your local AFSC district office for information about the program and stations nearest your farm

AFSC has insurance offices throughout the province. Call one of our regional insurance offices and we will refer you to the one closest to you:

Lethbridge (403) 382-4532
Red Deer (403) 340-5326
Camrose (780) 679-1258
Fairview (780) 835-4975

To call toll-free in the province, call the Alberta Government RITE number 310-0000 and dial the AFSC office you want. Or contact the AFSC Head Office at 1-800-396-0215.

PI-25/FEB02/10M

Financing Natural Disaster Risk Alternatives for Drought In Romania

Dr. Jerry R. Skees
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University of Kentucky

Topics to be Covered

- Framing the Problem
- World experience (U.S. / Canada/ Mexico)
- Advantages / disadvantage of traditional approaches
- Alternative approaches – Index insurance
- World Bank Case Studies (Mexico, Morocco, Mongolia)

Topics to be Covered

- Romanian research

✓Modeling the profile of risk

✓The Potential for weather-based index insurance

✓Findings / implications for helping derive a strategy for Romania to share agricultural risk

Framing the Problem

- Agriculture production has suffered from serious droughts in 2002 and 2000.
- Agriculture droughts in Romanian are not a new phenomena; what is new is the challenge of providing both a social and a commercial solution to the problem
- In some areas of Romania, the negative trends in rainfall are of concern

Why Consider Agricultural Insurance in Romania?

- Agricultural Policy Reform
- Disaster responses in Romania have been done with no planning (Ad hoc)
- Expensive and unpredictable disaster assistance can be disruptive to growth path
- Cost can be a direct drain on the budget (In 2000 reports suggest that cost were as high as $250 million dollars)

Why Consider Agricultural Insurance in Romania?

- Properly designed agricultural insurance markets could play an important developmental role
- Agricultural insurance can be a critical link to credit: both access and terms of credit could be improved with insurance
- Insurance -> Credit -> Development

A number of Alternatives to Drought should be considered

- Adjustments to other crops in some regions: e.g. incentives to switch from maize to sorghum
- Investments in irrigation infrastructure

OUR FOCUS

- Structured strategies for finding solutions to the correlated risk problems of weather
- Government supported crop insurance

Key Objectives

1) Use limited government resources to create agricultural insurance in Romania
2) Focus the government effort on risk that create the biggest social problems; droughts
3) Foster effective development of a private agricultural insurance sector that is responsive to farmer needs
4) Retain as much of the risk inside Romania as possible before going to the expensive international reinsurance market
5) Properly align the incentives to use government and markets making certain that abuse is controlled

Understanding the risk

Comparing

1) To insure hail losses
2) To insure earthquake losses
3) To insure drought losses

Consider Hail Insurance

- Hail – largely independent risk : at the extreme, maybe scores of farms suffer losses from the same hail storm, but there are generally limits: loss function is generally tightly centered around the target loss ratio (Insurance companies try to set premiums so that they are greater than indemnities)

  Loss Ratio = Indemnities / premiums

Consider Hail Insurance

- Hail is an insurable risk since the events are largely independent
- Since hail can be insured in the market, the government is not needed for private hail insurance
- Private hail insurance has been successfully provide in North America for over 125 years

Consider Earthquake Insurance

- Low probability (1 in 25 or 1 in 50 years)
- Nonetheless, the loss function is highly skewed toward very large, correlated losses requiring special financing from the international reinsurance markets and, many times special arrangement inside emerging economics (e.g., Turkish Catastrophic Insurance Program).
- Single event; relatively easy to verify the loss and the damage

Consider Drought Insurance

- A frequent event (1 in 5 / 1 in 7) with high correlated losses.. Everyone can have a wreck at the same time
- Loss function has a thick tail to the right with frequent-heavy losses much more likely than with earthquakes
- Classically NOT an insurable risk!
- Cause of loss is not easy to verify as a combination of events can cause a crop loss

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Multiple Peril Crop Insurance

- A frequent event (1 in 3 / 1 in 5) with high losses
- Loss function has a thick tail to the right with heavy losses much more likely than with earthquakes
- Classically NOT an insurable risk!
- Losses are paid using deductibles from the estimated average yield for individual farms
- Serious adverse selection and moral hazard problems

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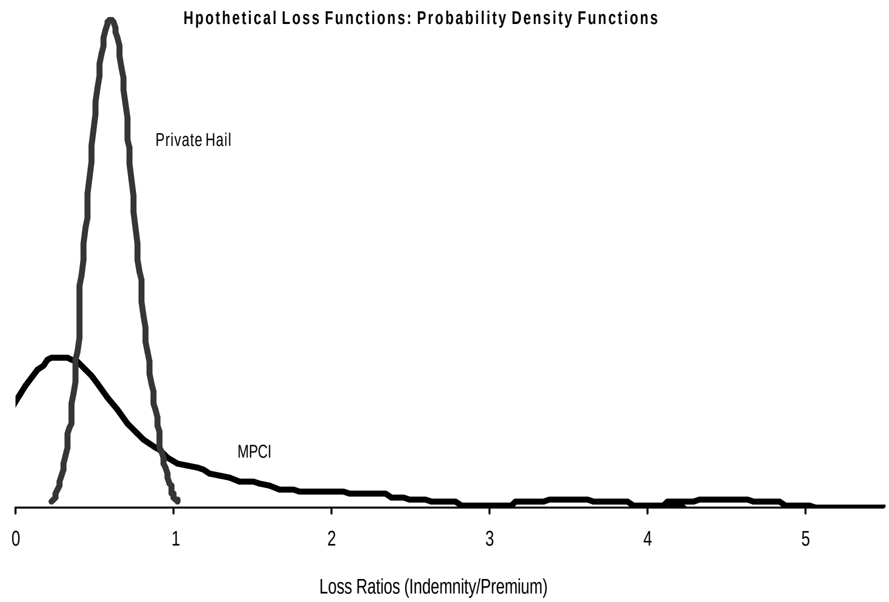

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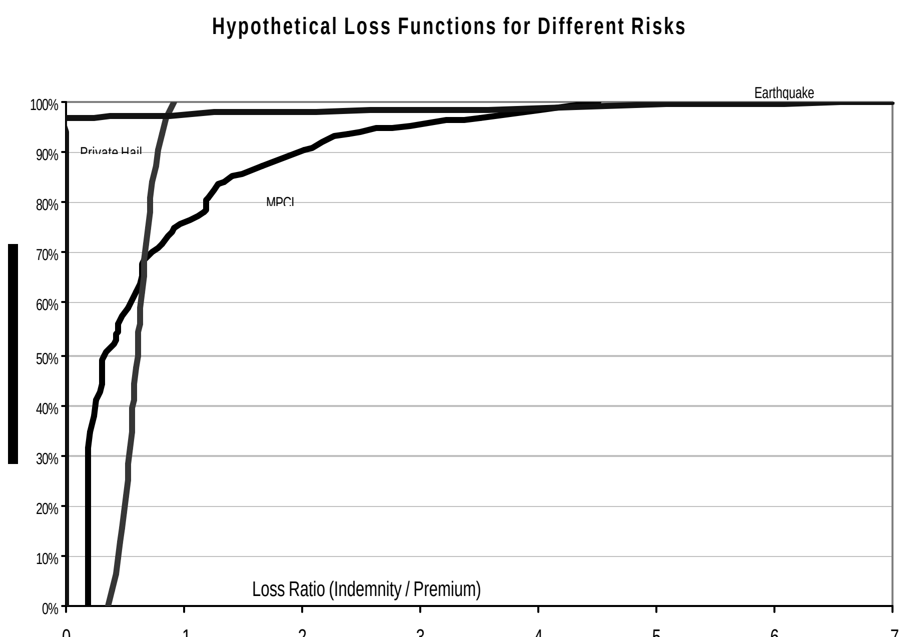

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First Steps

- Financing risk and creating government programs that will change the shape of the loss function so that it looks more like that of private hail
- This is the FIRST step toward paving the way for private sector agricultural insurance

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Focus of Research

- Steps:

1) Model loss function
2) Consider role for gov't / markets
3) Consider viable & affordable insurance products, including weather-based indexes
4) Pricing insurance and determining reinsurance & direct cost to gov't
5) Make Recommendations

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Farm-level Crop Insurance

- Two types:
  - Named-peril (like hail)
  - Multiple-peril
- Examples exist of financially sustainable named-peril crop insurance for independent perils (e.g., hail or fire).
- **No** examples of financially sustainable multiple-peril crop insurance.

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Multiple Peril Crop Insurance

- All existing multiple-peril crop insurance products are subsidized and/or delivered by governments.
- Financial performance has been poor.
- Extremely expensive
- Essentially these are government social programs for farmers.

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Multiple Peril Crop Insurance: US

- ✓ Government program with up to 50% premium subsidy
- ✓ Sold by private companies who have access to administrative subsidy 24.5% and risk sharing subsidy 14%
- ✓ Farmer pays only about 20-25% of total cost / Expensive to government (> $3 Billion)
- ✓ Private companies use both government and reinsurance market to share risk
- ✓ Extremely political

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U.S. Crop Insurance

- Yield insurance:

$$Indemnity = (trigger\ \ yield - realized\ yield) \times price\ selection \times insured\ acres$$

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U.S. Crop Insurance

- Based on farm (or sub-farm) level units.
- Need.
  - Farm (or sub-farm unit) yield history.
  - Underwriters.
  - Compliance officers.
  - Loss adjusters.

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Multiple Peril Crop Insurance: Canada

- ✓ Government program with up to 50% premium subsidy
- ✓ Sold by provincial governments
- ✓ 14% administrative expenses
- ✓ Government takes all risk : now using international markets to reinsure
- ✓ Have introduced rainfall insurance in both Alberta (4000 policies) and Ontario (fully subscribed)

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Multiple Peril Crop Insurance: Mexico

- ✓Government company (Agroasemex) acts as risk aggregator providing reinsurance to private companies and securing reinsurance in the world market
- ✓Good experience since 1990
- ✓Private companies and agricultural cooperatives sell and service policies
- ✓30% premium subsidy
- ✓Growing pains with high admin cost

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Multiple Peril Crop Insurance: Spain

- ✓Government program with 50% premium subsidy
- ✓Sold by private companies
- ✓Government risk sharing fund
- ✓Many crops
- ✓Expensive to government

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Financial Experience with Multiple Peril Crop Insurance

- Long-run actuarial soundness requires that, on average, costs (indemnities + administrative costs) must be less than premiums.

I = Indemnities

A= Administrative cost

P= Premium

$(I + A) / P < 1$

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Cost Always Exceed Premiums

Country	Time Period	(I + A) / P
Brazil	1975-81	4.57
Costa Rica	1970-89	2.80
Japan	1947-77	2.60
	1985-89	4.56
Mexico	1980-89	3.65
Philippines	1981-89	5.74
USA	1980-89	2.42
	1999	3.67

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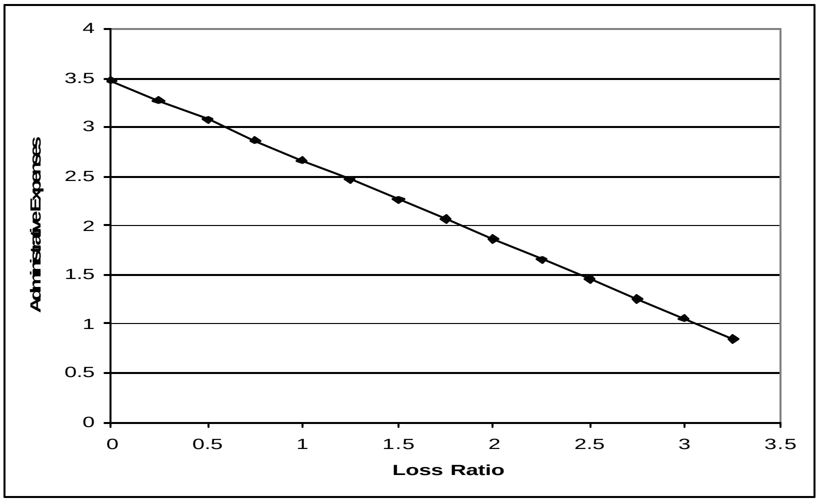
Relationship Between Administrative Cost and Loss Experience



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Basic Message:

Hidden cost will come in the form of either high administrative cost or large loss overruns where Indemnities > premiums

Once the loss overrun cycle begins, the adverse selection and moral hazard increase even more and the insurance program will fail

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Major Challenges

- **Information Problems: Farmers know their business**

1. Adverse selection
2. Moral hazard
3. High monitoring costs

- **Correlated Risk**

Reinsurance for correlated risk can be

1. Limited
2. Expensive
3. Unpredictable

Multiple Peril Crop Insurance

- Will almost certainly have to be subsidized

Must consider the costs.

- How much are governments and/or donors willing to spend?
- Avoiding crowding out private companies
- Avoiding creation of perverse incentives and unintended consequences

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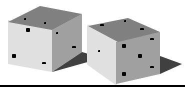
Markets for Different Types of Risk



0% **100%**

No Correlation *In-between risk* Correlation

Farm Level Risk The Big Risk

Supply-side problems: Limits on Capital

- Many agricultural risks are neither completely independent nor completely correlated

  0_________________________________**1**

  Independent correlated

- Insurance companies don't like risks that cannot be pooled (e.g., risks that are not independent).

- Insurance companies don't have pockets deep enough to cover correlated risk

Consider Premium Rating in a Market: Where there is No Government help

Premium Rate =

: Expected loss cost (pure premium)
: Reserve Load
: Catastrophic Load
: Administrative Load (Transaction Costs)
: Rate of return on equity

Bottom line.. Price charged farmer can be 2 times or more than the pure premium

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Basic Message

- Proceed carefully!
- It will take new ways of thinking to leverage limited government financial guarantees to the best end if effective agricultural insurance is to emerge in Romania
- A relatively simple-transparent System will be the key

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Issues

- **<u>How to manage the correlated risk problem</u>**
- Controlling adverse selection / moral hazard
- Who might sell agricultural insurance in Romania?
- What are the best mechanisms to introduce government support?

Where To Begin?

- Let's think of this like building a road through the heart of a major country
- Goal: Super highway / tailored products for farmers
- Clear the way and build the proper foundation first!

Index-Based Insurance Products as a possible beginning

- Indemnities based on an objective, transparent measure that is beyond the farmer's control.
  - Average yield across a region
  - Rainfall
  - Temperature
  - Flood levels
  - Satellite Vegetative cover indexes

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Index-Based Insurance Products

- Example:
  - Farmer purchases an insurance policy that will pay an indemnity if cumulative precipitation measured at a given location is below a specified level over a period of time.
  - Indemnities are **not** based on farmer's yield; they are paid on an independent source of information

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Index-Based Insurance Products

- Advantages:
  - No moral hazard.
  - No adverse selection.
  - Low administrative costs (no individual farm loss adjustments).
  - Easy to understand.
  - Protects against correlated risk

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Index-Based Insurance Products

- Disadvantage:
  - A farmer can have a loss when the index does not trigger a payment (basis risk)
  - Goal: Insure these losses through the private insurance markets

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Weather Index Insurance

- Need:
  - Reliable historical weather data for a given weather station.
  - Secure and objective source of current weather measurements.
- Don't need:
  - Farm yield history.
  - Farm yield for insured crop year.
  - Compliance officers.
  - Loss adjusters to measure farm-level losses.

Potential Applications

- Weather index insurance can be:
  - Sold directly to farmers (or other potential buyers).
  - Used to reinsure private farm-level yield insurance.
  - Used to reinsure government disaster assistance programs.
  - Sold with farm-level insurance "wrap-around" coverage.

Weather Markets

- Began in the US in 1997: Transactions have totaled over $9 Billion notional risk: 90% or more of that has been energy markets
- The Europeans have now began trading weather /
- The ENRON problems and the problems with the energy sector in the US
- Where are they now?

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Mexico Case Study

- December 2001, Agroasemex was the first emerging economy ever to use weather derivatives to reinsure the Mexican crop insurance program
- Motivation: Obtain a price for the upper layer of reinsurance (the biggest risk) was lower than other alternatives in the market
- Much more activity in Mexico now to use weather measures for disaster payments and insurance

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Morocco Case Study

- A new weather based insurance product is being sold to sunflower and cereal farmers in Meknes.
- The product is a weighted index of rainfall that reflects different levels of rain during the season
- MAMDA will offer the product with a World Bank (International Finance Corporation) and a private sector consortium

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Mongolia Case Study

- Livestock insurance will be offered throughout the country based on our World Bank study of last year
- Innovative approach to provide contingent World Bank loans should a major event on livestock deaths occur (a form of reinsurance)
- Innovative approaches to assure that the use of the index fits into insurance laws

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Summary on Index Insurance

- Index Contracts get the BIG RISK out of the way.. Allow you to move forward
- Lowers both Administrative costs and reinsurance cost
- Many ideas of how to facilitate markets once index insurance is available

Romanian Data

The National Statistics Institute

Judet data for 5 crops 1968-2000 for all 41 Judets in Romania (hectares; total production; yield per hectare)

Issues:

Strengths and Weaknesses

Study finding: These data are correlated with yield data from other sources

Romanian Data

- **National Institute of Meteorology and Hydrology (NIMH)**
- SE Romania
- Daily rainfall and temperature data 1961-2001
- Limited plot and farm yield data from nearby stations

Romania Data

- Special note:

  Thanks to the support from USAID-Romania, 3 Romania professionals from NIMH traveled to the University of Kentucky where they participated in a special course on how to use their data to design weather derivatives. The course material and the products of the effort are available upon request.

Romanian Correlated Risk: Modeling the Insurance Portfolio

- Used data for Judet data from 1968-2000
- Wheat, Barley, Maize, Sunflowers, Soybeans
- Removed the central tendency and put the historic yields into today's value (1st positive trend and then negative after 1990).
- Modeled the spatial (geographic) correlation using the past yields and today's value at risk
- Today's value at risk was a function of the proportional share of the Judet in the past, the current plantings and current prices

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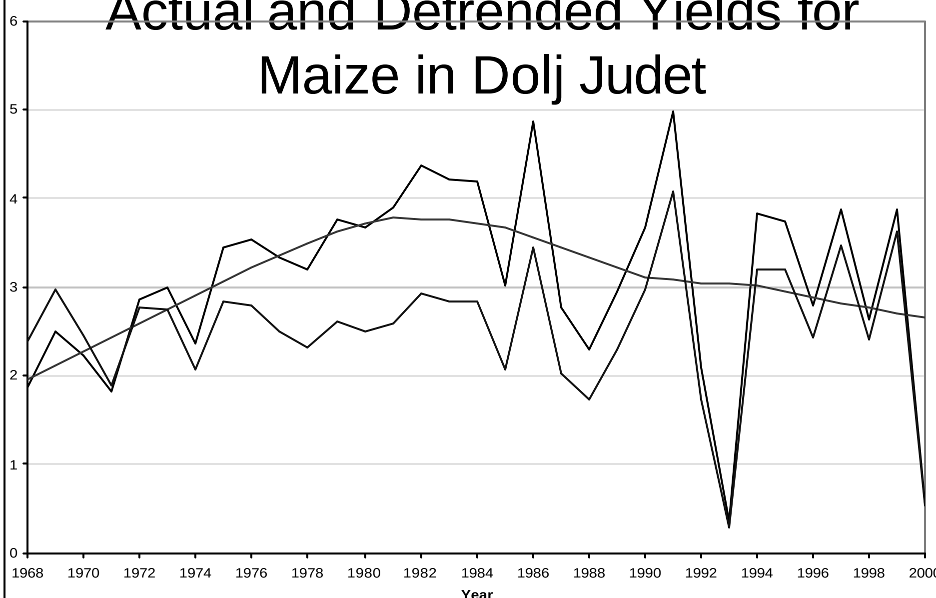
Actual and Detrended Yields for Maize in Dolj Judet



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Estimating Value at Risk

Current Planting = weighted aveage of hectares by judet-crop 1998-2000

Value at Risk =

Current Plantings x Trend Yield x Price

(This is done for every Judet and Crop)

Important note: The value at risk gives the spatial dimension needed. Insurance levels should be pegged to cost of production

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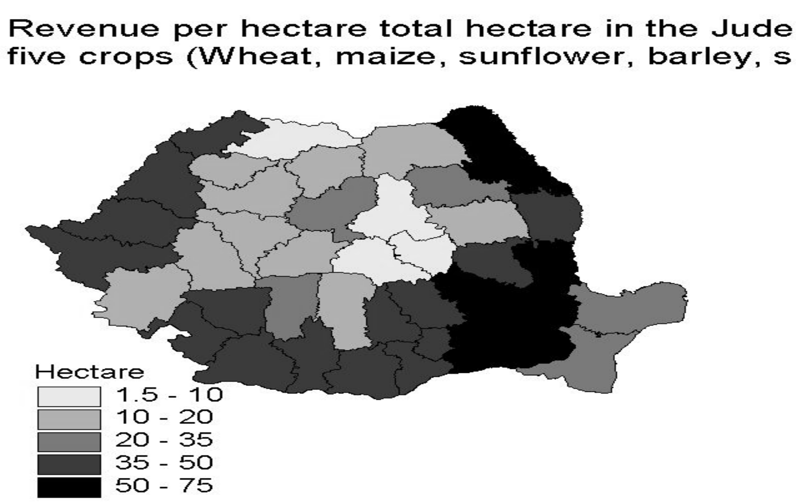
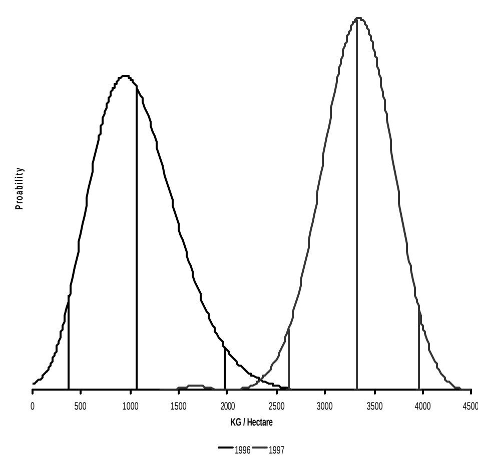


Modeling Risk

- 33 years of yield data for Judet and the 5 crops / missing data were replaced using special spatial correlation procedures
- The normalized data could then be used to determine the risk profile for Romania
- An estimate of the value produced is made using the backcast yields from 1968-2000

Simulating Farm Yields

- Special procedures developed for the US reinsurance market are used to simulate farm yields draws around the Judet yields
- Very important to give more insights into potential yield risk issues



Designing Different Yield Programs

- Given the Judet adjusted yields and the simulated farm yields, it is now possible to model any number of insurance programs
- **Focus:**

  A Judet Area Yield program that triggers on frequency values (1 in 5; 1 in 7; 1 in 10)

  More appropriate way to think of disaster

  Multiple Peril Crop Insurance that triggers payments at 60 or 70% of the average yield

Estimating Loss Cost

- Liability = maximum possible indemnity.
- Loss Cost (LC) = indemnities / liability.
- Premium rate = premiums / liability.
- Break-even premium rate = E(LC)

Important point: Once we have the LC history, any level of insurance liability can be modeled

Two Programs for Analysis

- Area Yield Trigger based on 1 in 5 year events (we did a special kernel fit of the distribution to determine this yield)

  If Judet yield < Trigger Yield then

  Indemnity = (Trigger Yield – Actual Yield) x Value per Hectare x Hectares
- Multiple Peril Design has the same loss function but trigger yield is 70% of the average farm yield and actual yield is the simulated farm yield (we have 300 draws for every Judet-crop)

Average Cost of Three Products

	Pure Risk	Loaded Rates
AYP 1 in 5	3.0%	4.7%
MPCI @ 70%	6.5%	14.2%
MPCI @ 60%	3.8%	8.6%

Assumed Total Cost @ US $ 1 Billion Insured

AYP 1 in 5	$ 47 Million
MPCI @ 70%	$142 Million
MPCI @ 60%	$ 86 Million

Example of Disaster Program Payments per Hectare for Calarasi Judet

- Maize in 2000: Realized Yield = 1.23 ton
  Trigger Yield = 2.63 ton

  Maize price = US $ 91 per ton

  Assumed cost of production @ 60% of value making 1 ton of insurance = $54.60

Indemnity calculation = (2.63-1.23) x $54.60

Payment = $76.40

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Example of Disaster Program Payments per Hectare for Calarasi Judet

	Wheat	Barley	Maize	Sunflower	Soybeans
Expected Yield ->	3.30	3.30	3.09	1.15	1.64
Trigger Yield ->	2.76	2.78	2.63	1.05	1.25
2000	$ -	$ -	$76.39	$ 28.84	$ 87.74
1999	$ -	$ -	$ -	$ -	$ -
1998	$ -	$ -	$ -	$ -	$ -
1997	$ -	$ -	$ -	$ -	$ -
1996	$78.19	$11.59	$ 7.65	$ -	$ -
1995	$ -	$ -	$ -	$ -	$ -
1994	$26.73	$25.41	$ -	$ -	$ -
1993	$ -	$ 5.98	$ -	$ -	$ -
1992	$ -	$ -	$ -	$ -	$ -
1991	$ -	$ -	$ -	$ 6.37	$ -
1990	$ -	$ -	$ -	$ -	$ 9.00

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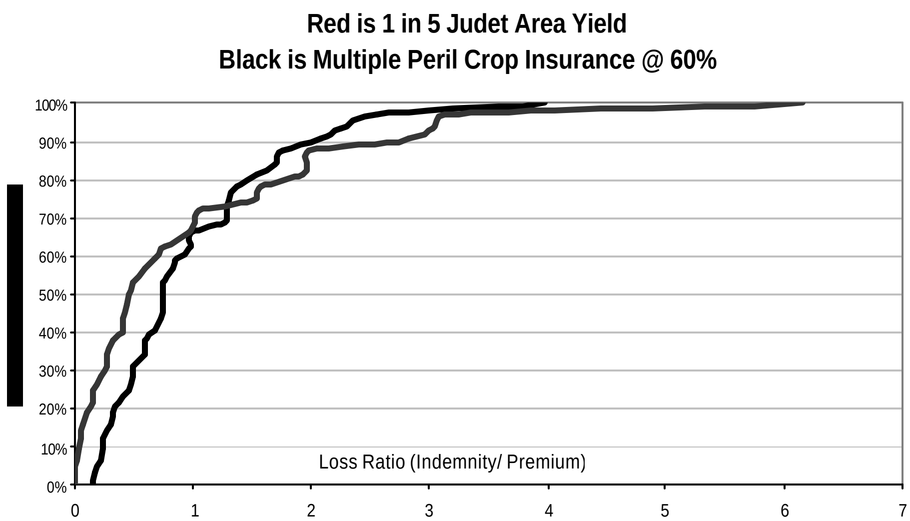
The Romanian Crop Loss Function: Pure Risk ONLY



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Basic Principles

- Need new ways to handle catastrophic risk
- Some level of very clear gov’t involvement in providing disaster payments based on a better definition of disaster
- Gov’t should not handle individual risk
- Once you create an index for handling the big risk, we can change the shape of the loss function! Opening the door for private sector innovations

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Moving toward strategies

- ✓Use Judet yield estimates to trigger 1 in 5 year payments.
- ✓Gov't offer this program at a base level with limits on liability using variable cost of production.
- ✓Gov't reinsure their program with weather indexes; contingent loans; traditional reinsurance

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Moving toward strategies

- ✓Gov't allow private companies to sell the base product; they must register the insurable risk and handle the limits when they sell the product
- ✓Private companies now can add more private products to the base product

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What Motivates our Model?

- Equity in transfers in way that DOES not favor high risk regions and farmers
- Transparency
- Eliminates adverse selection & Moral Hazard
- Takes advantage of what gov't can do best
- Gov't Should not try to fix individual risk.. Taking care of sector risk may be needed
- This addresses cognitive failure also: farmers forget the worst years and are unwilling to pay the full cost of catastrophe insurance
- Changes the shape of the loss function!

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Demonstrating How the Loss Function Changes

- Consider someday when a private sector MPCI policy could be sold that would pay for any farm level losses that are not paid for by the government disaster policy
- Set the MPCI policy level at 60% of the farm level loss
- Indemnity function

  = Max (AYP 1 in 5, MPCI 60%)

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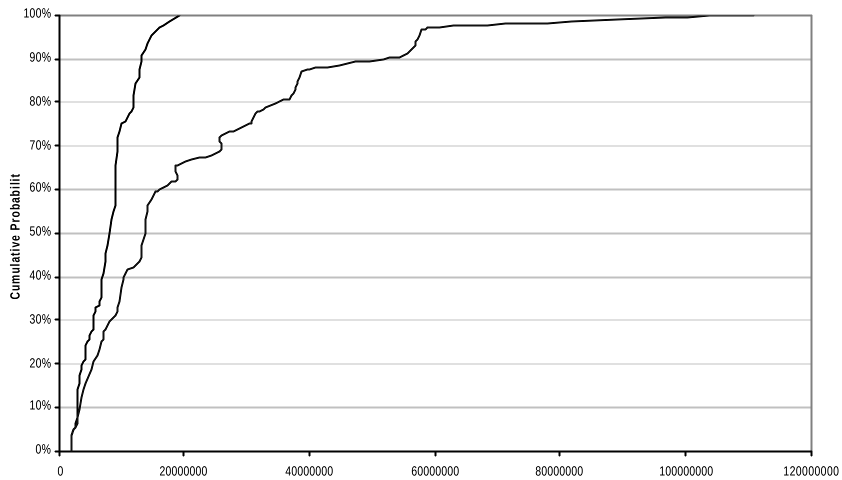
Changing the Loss Function

Blue is Loss Function for Unsupported MPCI at 60%
Black is Loss Function for Residual MPCI Product at 60%



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Government Based Insurance Component: The 1 in 5 Year AYP Area Yield Plan

- Issues:

  Must cover the catastrophic risk for this

  What are the difference in rates?

  Should it be sold to farmers? provided as a standing disaster program? Can an outside source perform the services needed?

  How can private companies use this policy?

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Gov't Area Yield Policy

- 1 in 5 year trigger
- Allow farmers to insure only cost of production (assumed to be 60% of the value at risk)
- Value at risk total =US $1.5 Billion x.6
- Value insured = $750 Million
- 3% pure risk = $22.5 Million

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Average Pure Risk By Top 10 Judets

Judet	Mkt Share	Rate
Calarasi	7.3%	2.9%
Constanta	7.0%	2.3%
Timis	6.2%	2.7%
Ialomita	5.9%	2.1%
Dolj	5.7%	5.1%
Teleorman	5.4%	3.9%
Braila	5.2%	2.3%
Olt	4.8%	4.5%
Arad	4.4%	2.6%
Buzau	3.8%	3.2%

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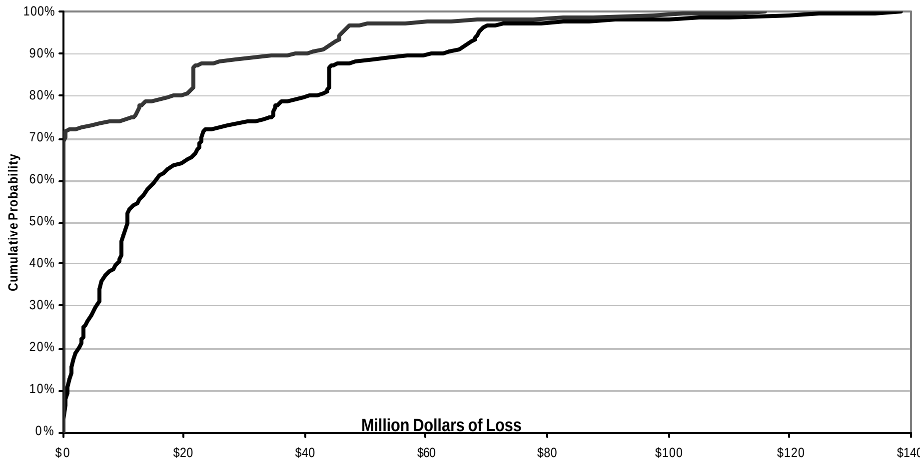
Loss Function of Gov't Program

Black is the Loss Function
Red is Required After Using $22.5 Premium



Reinsurance Needs

- Average loss overruns after $22.5 Million Premium = $10.3 Million
- To obtain a stop loss in the traditional reinsurance market it might cost 2x the expected payout or $20.6 Million
- Reinsurers will be reluctant to reinsure the Gov't program given the moral hazard of the government developing the yield statistics: *Weather Data can be used*

Reinsurance Needs

- Using weather data
- ✓ some weather data were available from USDA other areas in Romania
- ✓ a simple average of summer rainfall was examined, this analysis strongly suggests that a rainfall reinsurance could be used to remove some of the catastrophe risk
- ✓ Other weather indexes such as temperature; winter snow; dry falls should be examined

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Reinsurance Needs

- Contingent loans may take be used to handle the basis risk of catastrophe losses that are not paid by the weather reinsurance program
- Conclusion: It is possible to finance via:

1) Farmer premiums at the pure rate
2) Weather reinsurance
3) Traditional reinsurance
4) Contingent loans from USAID / World Bank others

Key: Layering out the risk to the most efficient sources

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Weather Indexes

- Professionals at INMH have quality data and good knowledge of the weather events that impact crop yields
- Our analysis for maize demonstrates a simple summer rainfall insurance contract would add value; it may also be useful to couple this contract with an excess heat contract that would pay when maximum temp exceed 32 during the critical growing period
- Given our model of combining weather instruments with the base area yield product, it is possible for private companies to write weather insurance in Romania: Again the base product removes the correlated risk.

Models in the Study Area

- From 1986-2000 strong predictions of the trend adjusted Judet yields using the following variables:

  1) <u>Cumulative rain from May-August</u>

  (If rain exceeds 20 mm for the day the level is reset to 20 mm for that day)

  2) <u>Frequency of days with</u>
  max temp>32 from June 1-Aug 31

Determining Farmer Demand

- Observations:

✓ Carefully designed focus groups can successfully discover the weather events that are of most concern to farmers.

✓ Once the proper weather events are identified, it is relatively straightforward to design weather index insurance products to match the concerns

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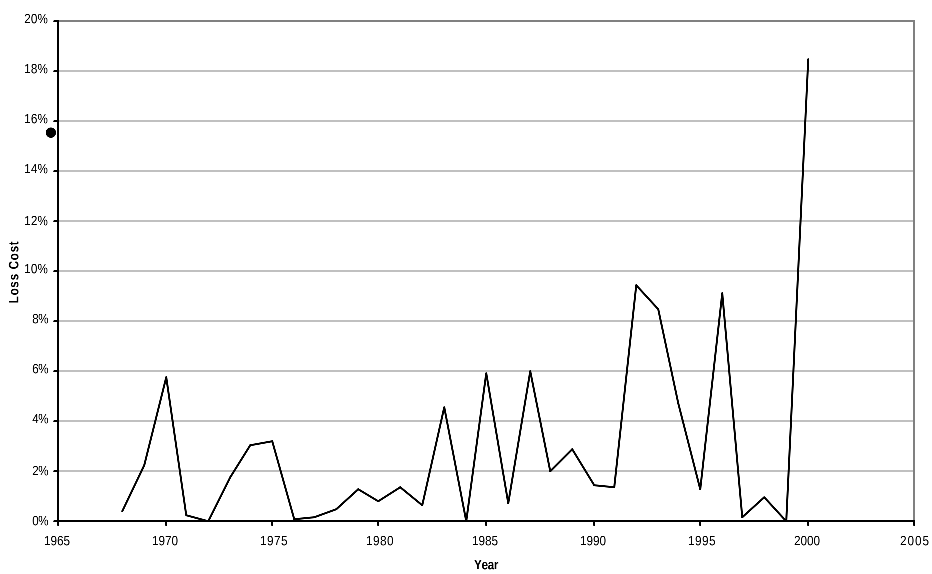
Loss Cost Trend for Area Yield Plan 1 in 5



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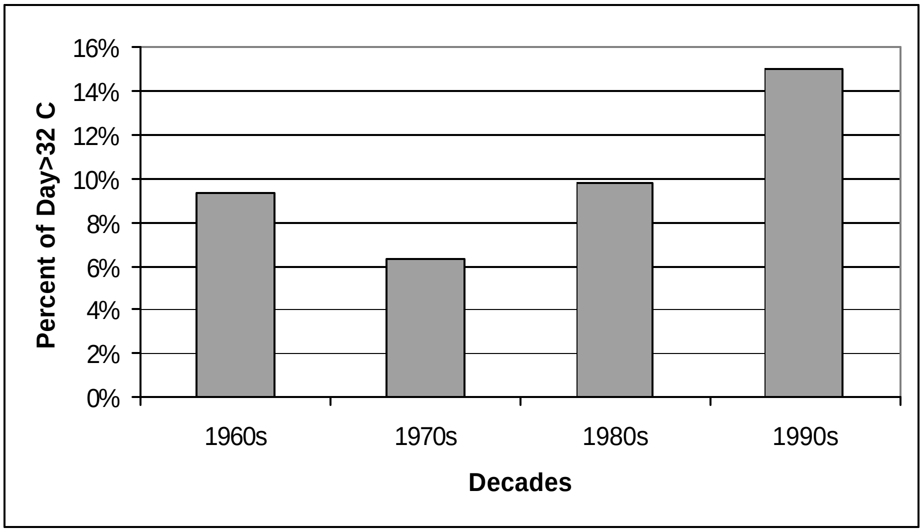
Percent of days with max temp> 32 degrees C from June1-Aug 31



Trends

- Max Temp > 32 degrees C
- Frequency from June 1 to Aug 31
- Recent trends are a concern
- Question: Is this is cycle or something more permanent?
- I will visit with professionals from INMH on these issues on Wed

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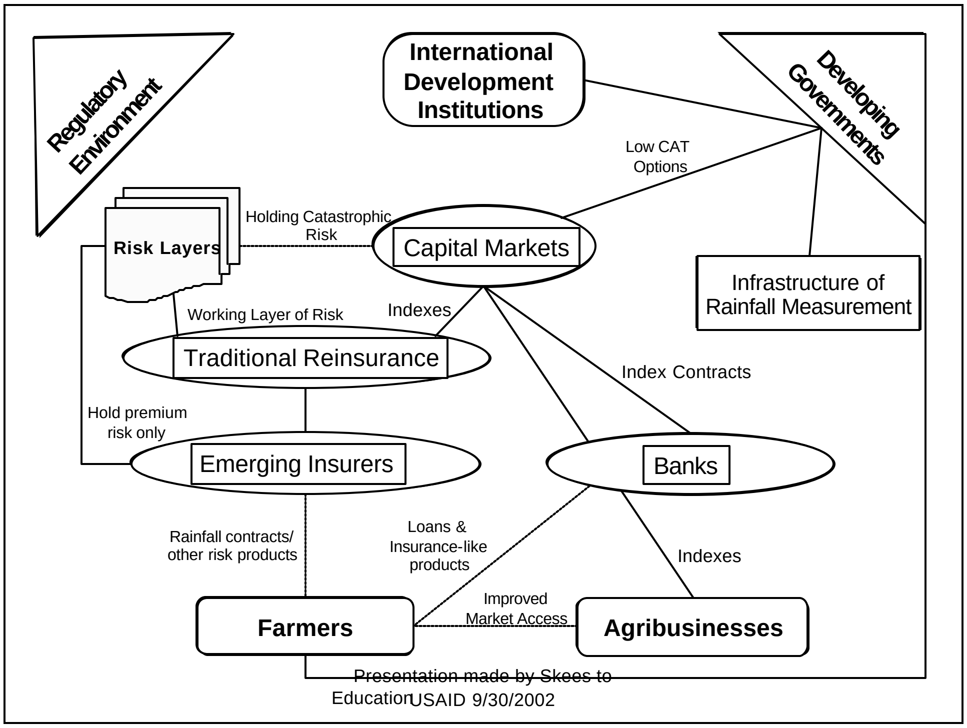
International Development Institutions
Regulatory Environment
Developing Governments
Low CAT Options
Holding Catastrophic Risk
Risk Layers
Capital Markets
Infrastructure of Rainfall Measurement
Working Layer of Risk
Indexes
Traditional Reinsurance
Index Contracts
Hold premium risk only
Emerging Insurers
Banks
Rainfall contracts/ other risk products
Loans & Insurance-like products
Indexes
Improved Market Access
Farmers
Agribusinesses
Education
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Designing Weather Contracts to Serve as Agricultural Insurance in Developing Countries

Jerry R. Skees, University of Kentucky
Barry J. Barnett, University of Georgia

Perils and Risks

- Peril: An event that causes losses.
- Risk: Uncertainty concerning the occurrence of a given peril or the associated magnitude of loss.

Why is Risk a Problem?

- People tend to be risk-averse.
- Risk reduces incentives for investment and thus retards economic growth.
  - Reluctance to invest if one must accept the full risk of a potential loss.
  - Idle “emergency funds.”

Risk Characteristics

- Probability?
- Magnitude?
- Correlated with other risks?
- Widespread or localized?
  - Systemic or spatially correlated risk.
  - Idiosyncratic or independent risk.

Risk Characteristics

Independent — Correlated

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Independent or Correlated Risk?

- Automobile accidents.
- Drought.
- Earthquake.
- Low prices.
- Currency exchange rates.
- House fire.
- Insect infestation.

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Risk Management Methods

- Loss control (taking steps to reduce the likelihood and/or magnitude of loss).
- Retention (self-insurance).
- Risk Transfer with Pooling (insurance).
- Risk Transfer without Pooling (non-insurance contingent-claims contracts).
- These methods are not mutually exclusive.
- These methods are all costly!

Why Accept Risk Transfers?

- Profit: risk-averse individuals are willing to pay more than the expected value of loss to avoid the financial consequences of a potential peril.

Risk Transfer With Pooling

- The Law of Large Numbers implies that for a group of individuals each faced with similar ***independent*** loss events, the mean of the individual variances is always greater than the variance around the mean loss of the group.
- Pooling actually reduces overall risk exposure and thus the aggregate cost of managing risk.
- Can occur at insurance or reinsurance level.

Risk Transfer Without Pooling

- Even if loss risks are ***not independent,*** mutually beneficial risk transfers can occur between those who are more risk-averse and those who are less risk averse.

Insurance

- A legal contract whereby risks are transferred from one party to another in exchange for a premium.
- The purchaser of an insurance policy is willing to accept a small loss with certainty (the premium) rather than face the risk of a much larger loss.

Insurance

- Insurance contracts must specify:
  - What peril(s) are being covered.
  - A threshold which will trigger the payment of an insurance indemnity.
  - The maximum possible indemnity payment (dollars of protection).
  - How the indemnity will be calculated.
- Not all risks are insurable!

Insurability Conditions

- Large number of ***similar***, independent, loss exposure units.
  - Can the insurer accurately classify potential policyholders according to their risk exposure? (Underwriting)
  - The problem of hidden information.

Hidden Information

- If potential policyholders have "hidden information" about their risk exposure, then they will be misclassified.
- Some high risk individuals will be incorrectly placed in low risk classifications. They will be inclined to purchase the insurance.
- Some low risk individuals will be incorrectly placed in high risk classifications. They will be disinclined to purchase the insurance.

Hidden Information

- A disproportionate number of policyholders will be those who have been misclassified to their benefit (adverse selection).
- When high payouts occur, the insurer will raise premium rates for everyone.
- This only compounds the problem because those who were accurately classified will be less likely to continue purchasing insurance.

Insurability Conditions

- Large number of similar, ***independent***, loss exposure units.
  - If losses are correlated, pooling will not reduce overall risk exposure.
  - Widespread losses can bankrupt the insurer and leave policyholders with no insurance protection.

Insurability Conditions

- Determinable and measurable loss.
  - Can an objective third party determine:
    - Whether the loss was caused by an insured peril?
    - Whether the loss exceeds the threshold (i.e., whether an indemnity payment has been triggered)?
    - The magnitude of loss?
  - One can't insure what can't be measured!

Insurability Conditions

- Unintentional loss.
  - Indemnities should be paid only for random, unpreventable, losses.
  - Can an insured individual engage in "hidden actions" that would increase the likelihood of loss?
  - Can an insured individual engage in "hidden actions" that would increase the magnitude of loss?

Hidden Action

- Hidden action (moral hazard) can be fraud. It can also be simple carelessness as a result of having insurance protection.
- Deductibles and co-payments can reduce incentives for hidden action.
- Pervasive hidden action will increase insurance indemnities. The insurer will typically respond by increasing premiums for all. Those not practicing hidden action are then likely to quit purchasing insurance.

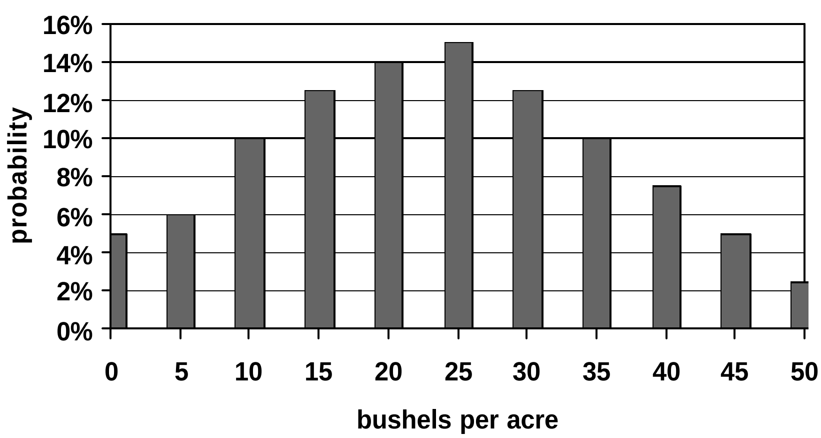
Insurability Conditions

- Calculable chance of loss.
  - The same premium rate (based on average expected payout) is charged to everyone within a given risk classification.
  - To develop premium rates the insurer must be able to accurately estimate the frequency and magnitude of losses.

Setting Premiums: An Example

- Assume a pool of identical soybean producers.
- Assume an insurance policy that protects soybean producers against yields less than 10 bushels per acre.
- For simplicity, assume that both premiums and indemnities are paid in soybeans rather than dollars.

Distribution of Yields



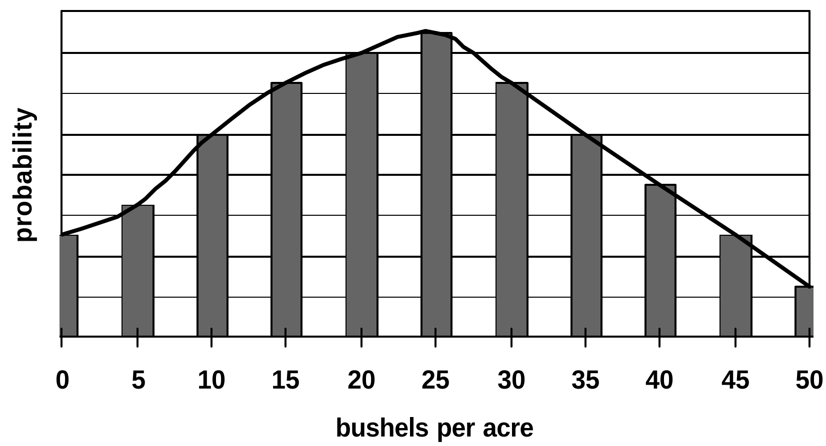
Expected Indemnity

- 6% of the time the insurer will have to pay a 5 bushel per acre indemnity.
- 5% of the time the insurer will have to pay a 10 bushel per acre indemnity.
- Expected Indemnity = Break-Even Premium = (6% * 5 bushels) + (5% * 10 bushels) = 0.80 bushels per acre.

Break-Even Premium

- Of course, in reality, yields do not occur in discrete 5 bushel per acre increments, instead they are continuous.

Distribution of Yields



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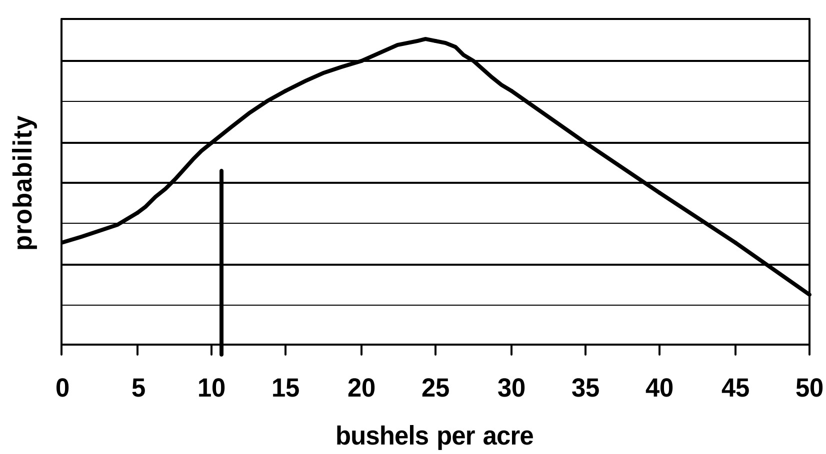
Distribution of Index



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Loss Cost

- Liability = maximum possible indemnity.
- Loss Cost (LC) = indemnities / liability.
- Premium rate = premiums / liability.
- Break-even premium rate = E(LC).
- How to estimate E(LC)?

Expected Loss Cost

- If, for a given underwriting pool, the loss distribution can be assumed stable; and if there are sufficient historical data; then E(LC) can be estimated as the mean historical loss cost.
- Common practice for many lines of insurance (e.g., automobile insurance).

Expected Loss Cost

- What if the loss distribution is not stable (e.g., terrorism or climate change)?
- What if the insurance coverage has not been available for a long period of time?
- What if there is “ambiguity” about the nature of the loss distribution (e.g., earthquakes, hurricanes, widespread drought)?

Catastrophic Loss Events

- When catastrophic (low-probability, high-magnitude) losses are possible, it becomes extremely difficult to estimate E(LC).
- Thus, premium rates vary widely across time and across insurance sellers.

Reinsurance

- Insurance purchased by an insurance company. Provides protection against the risk of having to make unusually large indemnity payments.
- The more systemic or correlated the underlying risk, the more important that the insurer acquire reinsurance.
- Transactions costs!

Reinsurance

- Because of the difficulty in estimating E(LC) for catastrophic risks, reinsurance companies “load” premium rates.
- These loads vary over time. After a catastrophic event (e.g., Hurricane Andrew), the loads increase dramatically.

Government Role?

- Insurance for catastrophic losses tends to be very expensive. Sometimes, it is simply not available.
- For this reason, some have argued that governments should protect citizens against catastrophic losses.

Government Roles

- Most governments provide *ex post* assistance to disaster victims.
- Some directly provide insurance protection against catastrophic losses (flood insurance, FDIC, etc.).
- Some provide reinsurance against catastrophic losses (crop insurance).

Disaster Assistance

- Essentially, free insurance.
  - “Crowds-out” insurance market.
  - Inefficient: no price signals about extent of risk exposure); scarce resources are misallocated.
  - Inconsistent: across both space and time; subject to political influence.
  - Inequitable: taxpayers are forced to pay for the risk-taking behavior of a few.

Government Reinsurance

- U.S. crop insurance program.
  - Various yield and revenue insurance products.
  - Policies sold and serviced by private insurance companies.
  - Reinsurance, premium subsidies, and administrative cost reimbursements provided by federal government.

U.S. Crop Insurance

- Yield insurance:
- Revenue insurance:

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U.S. Crop Insurance

- Based on farm (or sub-farm) level units.
- Need.
  - Farm (or sub-farm unit) yield history.
  - Underwriters.
  - Compliance officers.
  - Loss adjusters.

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U.S. Crop Insurance

- Problems.
  - Adverse selection.
  - Moral hazard.
  - High transactions costs.
  - Rent-seeking.
- High cost to taxpayers.
- Planting decisions are distorted.

Options

- Dr. Maynard.

Area Yield Insurance

Where yields are measured at county-level.

Area Yield Insurance

- Essentially, an option on county yield.
- Indemnity does not depend on farm-level yield!
- No moral hazard.
- No adverse selection.
- Low transactions costs.
- Geographic basis risk!

Area Yield Insurance

- Need:
  - County yield history.
  - Independent party to measure county yield for insured crop year.
- Don't need:
  - Farm yield history.
  - Farm yield for insured crop year.
  - Compliance officers.
  - Loss adjusters to measure farm-level losses.

Geographic Basis Risk

- The farm may experience a yield loss when the county does not.
- Area yield insurance will not provide effective risk protection unless the farm yield is highly positively correlated with the county yield.

Empirical Evidence

- Area yield insurance is not appropriate for all crops and regions.
- Will only work well in relatively homogeneous production regions.
- Recent research by Barnett, Hu, Black, and Skees indicates that in some situations, area yield insurance provides risk protection that is superior to farm-level yield insurance.

Potential Applications

- Area yield insurance can be:
  - Sold directly to farmers (or other potential buyers).
  - Used to reinsure private farm-level yield insurance.
  - Used to reinsure government disaster assistance programs.
  - Sold with farm-level insurance “wrap-around” coverage.

Limitations of Area Yield Insurance

- Area yield data are not collected for all crops and all regions.
- Insufficient time-series of area yield data for a given region.
- Historical area yield data are not reliable.
- Current year area yield estimate is subject to manipulation (by farmers, politicians, etc.).

Alternatives to Area Yields

- Is there an objective *index* that is highly positively correlated with area yields and farm yields?
- Weather variables:
  - Rainfall.
  - Temperatures.

Index Products

- Weather index derivatives are now widely used by energy sectors in U.S., Europe, and Japan.
- Property and casualty insurance sectors use index derivatives based on wind speed, Richter scale measurements, etc.

Weather Index Insurance

- Can be constructed many ways. A simple example to protect against insufficient rainfall would be:

Weather Index Insurance

- Essentially, an option on specified weather variable measured at a given weather station.
- Indemnity does not depend on farm-level yield!
- No moral hazard.
- No adverse selection.
- Low transactions costs.
- Geographic basis risk!

Weather Index Insurance

- Need:
  - Reliable historical weather data for a given weather station.
  - Secure and objective source of current weather measurements.
- Don't need:
  - Farm yield history.
  - Farm yield for insured crop year.
  - Compliance officers.
  - Loss adjusters to measure farm-level losses.

Potential Applications

- Weather index insurance can be:
  - Sold directly to farmers (or other potential buyers).
  - Used to reinsure private farm-level yield insurance.
  - Used to reinsure government disaster assistance programs.
  - Sold with farm-level insurance “wrap-around” coverage.

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Where from here?

- Developing an effective derivative for hedging crop yields
- Pricing a derivative insurance contract
- Mitigating Basis Risk!
- The role for government

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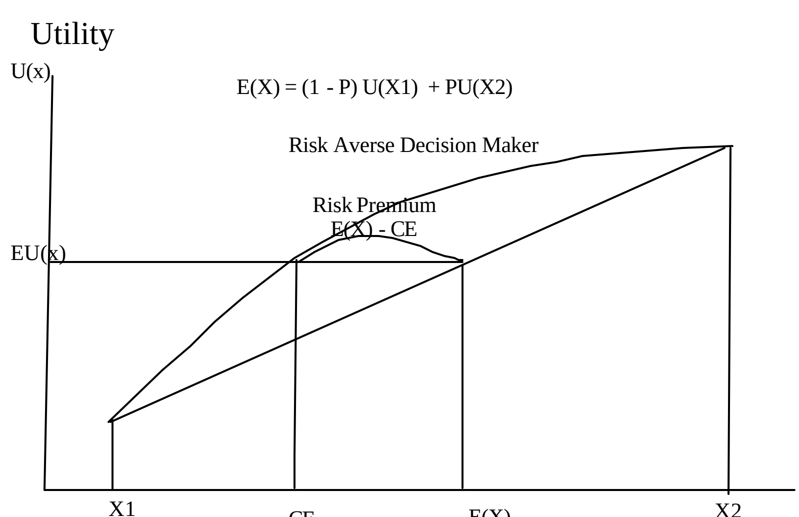
Risk-Aversion

- If, when given a choice, an individual chooses a given level of income with certainty rather than a risky proposition with a higher expected level of income, the individual is said to be risk-averse.

Risk-Aversion



Diversification

- Simple principle: when one asset is experiencing low returns another asset is making up for it with higher returns.
- In a two asset portfolio you need to know the expected return for each asset, the variance of returns for each asset, and the covariance of returns between the two assets to understand impacts of diversification.

Portfolio Expected Return

- Consider a portfolio of two assets:

Where w_1 and w_2 are the fractions of the overall portfolio invested in each of the two assets.

Portfolio Expected Return

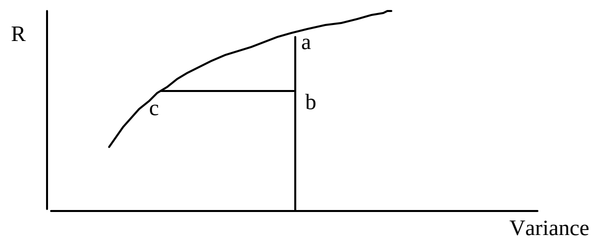
- More generally:

Where *n* is the number of assets in the portfolio.

Portfolio Variance

Or more generally:

Efficient Portfolios



- Portfolios a and b have the same risk.
- Portfolios c and b have the same return.
- Portfolios a and c are *Efficient* portfolios.
- Portfolio b is *Inefficient.*

Extensions of Portfolio Theory

- A portfolio may include financial assets (e.g., stocks or bonds). It may also include physical assets (e.g., buildings or crops), insurance policies, or futures and/or options contracts.
- The literature on optimal insurance purchasing and optimal hedging is just an extension of portfolio theory.
- All are based on the statistical concepts of expected return, variance, and covariance.

Capital Asset Pricing Model

- Given common assumptions:

Where R_i is the return on asset, *i;* R_M is the return on the overall market; and $R_{risk\ free}$ is the return on a risk free asset (e.g., treasury bills).

Capital Asset Pricing Model

- Rearranging terms:
- Statistically, beta is just:

Capital Asset Pricing Model

- Thus, beta measures the risk associated with asset *i* relative to the systemic risk inherent in the overall market.
- With sufficient historical data, one can use regression procedures to estimate beta.
- If beta is close to one, the expected return on the asset is highly correlated with expected returns in the overall market. If beta is zero, the return on the asset is independent of market returns.

Optimal Hedging

- Given common assumptions:

Where the subscripts C and F indicate local cash market and futures market prices, respectively, and the superscripts indicate different points in time.

Price relationships are usually stochastic

- Relative to initial date, total gain from hedge
  $= (P_C^2 – P_C^1)\ n_C - (P_F^2 – P_F^1)\ n_F$,
  where n_C = cash units and n_F = futures units

- divide by n_C to get per unit gain
  $= ?P_C – ß\ ?P_F$
  ($ß = n_F/n_C$ = hedge ratio)
- variance of per unit gain
  $= s^2(?P_C) + ß^2 s^2(?P_F) - 2\ ß\ s(?P_C ,?P_F)$

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Deriving optimal hedge ratio (cont.)

- variance of per unit gain
  $= s^2(?P_C) + ß^2 s^2(?P_F) - 2\ ß\ s(?P_C ,?P_F)$
- choose ß to minimize variance (risk)
  $2\ ß\ s^2(?P_F) – 2\ s(?P_C ,?P_F) = 0$
- $ß = s(?P_C ,?P_F) / s^2(?P_F)$
- in matrix notation,
  $ß = (?P_F^T ?P_F)^{-1}\ ?P_F^T ?P_C$

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Estimating optimal hedge ratio

- Hedge ratio is OLS estimate from regression:
  ?P_C = a + ß ?P_F + e
- Hedge is fully effective if P_C and ?P_F are perfectly correlated (no basis risk)
- Use adjusted R-squared to measure hedging effectiveness in the stochastic case

Optimal Hedging

- Here beta measures the price risk associated with the cash market relative to the price risk in the futures market.
- To minimize exposure to price risk, the individual would hedge beta percent of his/her crop.

Area Yield Insurance

- Given common assumptions:

Where y is the area yield, y_i is the farm yield, and the tilde indicates a realization of the random variable.

Area Yield Insurance

- Here beta measures the farm yield risk relative to the area yield risk.
- If beta is close to one, the farm yield is highly correlated with the area yield. If beta is zero the farm yield is independent of the area yield.
- Area yield insurance will provide adequate farm yield risk protection only for farms with reasonably high betas.

Weather Index Insurance

- Given common assumptions:
- Where w is some random weather variable.
- Weather index insurance will provide adequate risk protection only for farms with reasonably high betas.

Corn Percent Variance Reduction

		GRP		MPCI	
State	Number of farms	Cov = 90% and scale = 100%	Optimal coverage and scale 70%= cov. =90% 90%= scale =150%	65% cov	75% cov
Illinois	11,364	49.0	54.6	31.0	45.5
Minnesota	11,189	56.0	58.8	44.9	57.1
Iowa	31,506	43.5	48.7	30.6	44.3
Texas	665	35.7	40.2	40.1	50.0
Michigan	220	5.4	5.4	23.4	35.5

Sugar Beet Percent Variance Reduction

		GRP		MPCI	
Co-op	Number of farms	Cov = 90% and scale = 100%	Optimal coverage and scale 70%= cov. =90% 90%= scale =150%	65% cov	75% cov
Southern Minn	296	48.0	53.3	29.3	42.7
Min-Dak	519	11.5	13.1	31.1	42.6
American Crystal	2,337	17.6	23.5	17.6	29.4