Can Weather Derivative Contracts Help Mitigating Agricultural Risk? Microeconomic Policy Implications for Romania

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Agriculture remains vulnerable to many sources of weather related risks, especially from extreme temperature and rainfall events. The present study employs a precipitation contract in the lines of a weather derivative contract as an alternative to traditional crop insurance to combat risks due to drought in Romania. The precipitation contract is designed to trigger payments to the insured when rainfall during a period falls below a set trigger amount. The preliminary structure of the contract is designed and tested for seven judets in southeastern Romania. The impact of such contract on the risk management strategy of producers across risk preference levels is also investigated. Based on the analyses some broad policy implications for Romania are drawn. The study uses a combination of insurance design methods along with expected mean variance model to accomplish its objectives. Preliminary results suggest that if sufficient partnerships are forged to share risk, such contracts can prove useful in Romania. Across levels of risk preference, the contracts were found to increase mean profits and reduce coefficient of variance in net returns when compared to a base scenario with no contract. Further research is needed to corroborate these findings. A market-based insurance with minimal government intervention is the key to the development and the success of weather derivative contracts. Risk sharing among farmers, government, private insurance companies, and global reinsurance markets needs to be established. There is also a need for finding ways of trading risk among agroclimatic regions within the nation. Education of groups including farmers, government officials and private insurance companies and marketing of such instruments are essential to have a successful implementation and broad adaptation of these contracts by the buyers and the suppliers.

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Agriculture remains a high-risk prone sector. Combating risk in agriculture has been, and continues to be, one of the major challenges to scientists and policy makers. The inherent biophysical nature of agricultural and livestock systems combined with the various external stimuli (e.g. economic system) makes it vulnerable to various sources of risk. Notable among the risk sources plaguing agriculture include a host of weather related risks. These include extreme rainfall or temperature events as well as natural disasters. Economic losses from weather risks have tended to increase in the past few decades. Examples of damages from such events include catastrophic rains of 1997-98 in sub Saharan Africa leaving more that 10 million people under emergency assistance. Evidence of global climatic change and changing frequencies and severity of high-risk catastrophic events will only aggravate the problem in the future. The efficiency, structure, and performance of agriculture will therefore critically depend on the resources that producers make in managing these risks and on the resilience of the system to adaptation. The crucial role played by agriculture in society culturally, as well as in meeting food and fibre needs, has demanded a steady flow of societal investment to manage agricultural risk.

The most popular avenue to manage risk in the agricultural system has been through the use of multiple peril crop insurance. However, traditional insurance has proven very expensive for many economies including monetary and environmental costs. This has been mainly due to two phenomena referred in the insurance literature as adverse selection and moral hazard. The former concerns the existence of asymmetric information between the insurer and the insured leading to improper classification of risk by the insurer. This might concern producers having more information on their farms than the insurance agency. Past literature on the issue of adverse selection include the works of Quiggin, Karagiannis and Stanton; and Skees and Reed. Moral hazard concerns the inability of the insurance agency to monitor the behavior of the insured. In other words, the insured is said to be indulging on moral hazard causing behavior when he/she changes his behavior in ways that increase the potential likelihood or magnitude of loss thus triggering indemnity payments. Adverse selection and moral hazard make it impossible to provide sustainable insurance and result in a costly cycle of losses. Reduction of these inefficiencies in traditional crop insurance demand the steady investment in monitoring systems incurring higher costs to society.

Other problems with existing insurance involves some intended environmental damages. Keeton, Skees and Long report approximately 15 million new acres being brought into cultivation as a result of subsidized crop insurance in the United States, mostly on lands that would not be normally cultivated. Griffin and Skees have shown that government agricultural support programs have played a significant role in changing land patterns in the United States. The above issues combined with the history of traditional crop insurance make it a very cumbersome avenue for providing risk protection to producers in many developing countries. It is clear that the traditional approach while being costly also demands significant infrastructural facilities lacking in the developing world. Furthermore, without massive government subsidies it is extremely difficult to insure multiple peril risks and natural disaster events. The societal costs in reducing moral hazard and adverse selection problems is exacerbated considering the small farm nature of many developing countries.

There exist a number of alternatives for traditional crop insurance including weather derivative contracts (WDC). WDC provide a mechanism for cross hedging against variability in farms, when its revenues or costs are sufficiently correlated with the underlying weather event. For example, a weather derivative contract could be designed to help producers manage drought risk by making a payment when precipitation in a given period goes below a certain agreed level. The World Bank has been introducing index based contracts in several developing countries including Morocco, Mexico, Ukraine, Mongolia and Romania (Skees, Varangis and Larson). The central focus of this paper is to provide evidence that such index contracts can be efficiently employed as a viable risk management strategy by producers. The above goal is achieved by examining the impact of a precipitation derivative contract for Romania. The objectives of the paper include:

1. To develop and Price a precipitation contract for selected judets in Romania
2. Investigate the impact of the precipitation contract on farm level risk management decisions
3. Derive agricultural policy implication of WDC in Romania.

The paper is divided into 5 sections. Section I presents an overview of the WDC, Section II provides a background on Romanian agriculture and existing insurance structure, Section III includes the methods followed by Section IV which presents the results and discussion. Section V provides the conclusion.

Section I. Weather Derivative Contracts

The emergence of weather derivative contract signifies a new and low cost option for handling risk in many sectors including agriculture. For many economies in transition and developing World, these contract merit serious consideration (Hazell; Skees, Hazell and Miranda). The following section describes the merits and limitation in the use of such derivative contract in brief.

Index contract provide many potential advantages to traditional crop insurance as practiced in many countries. These include: absence of moral hazard and adverse selection. Under these types of contract the indemnity is not based on an individuals yield making it is impossible to indulge in moral hazard causing behavior. Also the potential for misclassification of the producers risk category does not arise considering index contracts are based on widely available transparent information i.e. the weather event. The contracts also boast of low administrative costs as they do not require any under writing or inspections of individual farms. There also exists wide opportunities for reinsurance to transfer risks of widespread crop losses. Under this scenario, it can be used as a mechanism to reinsure the portfolios of insurance companies for farm insurance policies.

One important limitation under these type of contract concerns what is called as basis risk. This depends on the extent to which the insured's losses are positively correlated with the index. Basis risk could result in the insured experience a loss and does not receive an insurance payment sufficient to cover the loss or when a payment greater than the loss is made available. This occurs because the indemnities under the contract are triggered by the weather event and not actual producer yields. Other limitations under weather contract include the need for accurate and secure measurement and dissemination of weather data to all parties involved. The difference in the contract designs from traditional insurance also demands investment in education and human resource building among partners in the program as well as marketing. Effective arrangements for forging reinsurance are also needed to establish a sustainable weather derivative contract.

Section II. Background on Romanian Agriculture

Agriculture is an important sector of Romanian economy such that, in 2000, 15% of GDP came from agriculture and agriculture sector employed 40% of the labor force[1]. It is important to pay close attention to natural disasters and their impact on agriculture. For example, in 2000, Romania suffered an extreme drought conditions that affected over 90 percent of the agricultural land surface, destroying mainly Corn and sunflower crops and resulting with US$1 billion in economic losses. The Romanian National Commission for Statistics reported that frequent, severe drought in Romania affected 3.9 million hectares in 1992 and 7.1 million hectares in 1997, which is almost one half of the 14.7 million-hectare agricultural land in Romania. Since 1992, extreme weather events like drought in the south, heavy rain and floods in the northwest, hail, and storms, caused an economic loss of US$310 million per year, on average.

Romania has a traditional crop insurance in place with several private companies offering insurance for fire, hail, flood and freeze. However, like in many other developing countries, participation rate is very low in Romania. Currently, less 10

[1] http://www.cia.gov/cia/publications/factbook/geos/ro.html

percent of the agricultural land is insured, mainly purchased by large commercial farmers. A new legislation is being initiated for the establishment of a catastrophe fund to help producers cover their losses.

Natural events not only affect the agriculture but also the growth of the whole economy. Natural disasters like drought are not insurable in a classis sense since the drought affects a large number of farms at the same time. The challenge is to provide an instrument to mitigate risk resulting from major weather events like droughts, floods and freezes while minimizing the cost to farmer and the society. However, there are alternative options available. Weather derivative contract based on rainfall is chosen in this paper, mainly because farm performance is usually highly correlated to rainfall, and drought is itself a highly uncertain event.

Section III. Methods

The research methodology to accomplish the set objectives first involves the conduction a simplistic preliminary investigation on design of a precipitation contract for selected judets in Romania. The aim of this exercise is to arrive at a set of premium rates and indemnity payments to provide an idea of WDC structure in Romania. The impact of the contract on farm decision making is achieved through the use of quadratic programming techniques incorporating profit and risk considerations of the producer. Analyses on the farm model will aid in making broad recommendation on the potential of WDC for Romania. In the following section each of these components are elaborated.

Precipitation contract for seven judets representing the main crop producing regions in Romania are considered in the study. These seven judets comprising of Braila, Buzau, Calarasi, Constanta, Galati, Ialomita and Tulcea, located in the southeast part of

Romania, form the sample for the study. Later a microeconomic farm model is developed for one of the judets as an example to demonstrate the impact of precipitation insurance on producer optimal decisions. Figure 1. presents a map of the seven judets considered for the study.

Precipitation insurance contracts involves risk sharing by multiple partners and requires a few prerequisites and data requirements. These include:

1. Data measured and reported by a third party
2. Time series of meteorological data must at least cover the last 25 years
3. Quality of time series must be analyzed and
    i. Missing data must be documented
    ii. Changes to the location of measurement (relocation of measuring instruments or changes to environment affecting measurements) must be documented.
    iii. Changes to method of measurement and reporting of the data must be document, and
    iv. Changes/replacements of measuring instruments must be documented.

Existing meteorological infrastructure in Romania suggest that weather data can satisfy the above requirements. Furthermore, recent developments in Romania including greater use of remote sensing and advanced Doppler systems increase the accuracy, transparency and confidence of data for global insurance partners. Thirty two years of annual rainfall data for the seven judets was collected from the National Institute of Meteorological and Hydrology (NIMH) for the period covering from 1969 to 2002.

The critical components in the precipitation contract design involve setting the indemnity payments and the premium costs of the program. Indemnity refers to the payments made to the holder of the contract when events as specified in the contract trigger a payment. A host of indemnity designs exist in literature (See Martin, Barnett and Coble). The precipitation contract envisaged here is designed to trigger a payment when rainfall in the said time period fall short of a certain set strike rainfall amount. The design employed in the study uses the European precipitation put proposed by Skees and Zeuli with an indemnity function of the form:

$$\text{Indemnity} = \begin{bmatrix} 0, \text{ if } X \geq \text{strike}; \\ (\text{Strike-X/strike}), \text{ if } X < \text{strike} \end{bmatrix} \quad * \text{ liability}$$

Where,

X is the actual rainfall

Strike is the trigger rainfall amount

Liability establishes the maximum possible indemnity. The liabilities are usually set based on the total value at risk of the produce.

The pure premium is calculated using the following formula

Pure Premium = (average indemnity payments/ liability)*100

The above formulation for calculating the pure premium is based on the pure loss cost history and does not cover for the transaction costs or risk preference of partners. Reinsurance firms usually load the pure premium based on the variance of the loss costs.

For the purposes of this study, a 33% load was imposed on the standard deviations of indemnity payments per liability. Using the above procedure, preliminary estimates for indemnity payments, pure premium rates, loaded premium rates for the seven judets were arrived at given strike and liability.

The above procedure was slightly modified for establishing the contract design for the farm level model. This was done considering the unique agronomic growth stages for crops produced as well as knowledge of the value at risk for the representative farm. Corn and Wheat, which represent major crops in Romania, are included in the farm model. Corn is planted in the spring (April-May) and harvested in September- October and Wheat cropping period spans from October and July. Adequate rainfall during the critical periods of crop growth is a crucial factor in determining yields of the above crops. Based on the above fact the precipitation contract was designed to cover only for crtical periods of crop growth. Specifically, the contract was designed to trigger a payment when the monthly rainfall in a critical month fell short of a set strike for that crop. The critical months for corn spanned from April to August and for Wheat from October to November in the fall followed by May and April in spring. The strike was set as 85% of the average rainfall during critical months for the above crops. For example, the average rainfall during critical months for corn and wheat were 46 mm and 36 mm respectively. Accordingly a strike of 39 mm for corn and 31 mm for wheat were established. The average farm yield in the selected judet was considered as a good proxy for the value at risk and used to establish liability estimate by crop. Once the strike and liability are given, indemnity payments and premiums can be formulated. It is again important to recall that the precipitation contract was designed to consider only the critical periods of crop growth and not the whole cropping season.

The next step in the methodology involves designing the economic framework for decision making by the producer. The mathematical formulation the farm level model is as presented below:

Max $Y - \phi\, \sigma^2_y$

Subject to the following constraints

1). $\Sigma_E X_E \leq LAND$

2). $\Sigma_E LAB_{E,} X_E \leq LABOR$

3). $\Sigma_E EXPYLD_{E,YR} X_{E,} - SALES_{E,YR} = 0$ $\forall$ E,YR

4). $-(INDEMINITYPAY_{YR,M,E} * BUYRAIN_E) + RAINYLD_{Y,M} = 0$ $\forall$ YR,M,E

5) $-(\Sigma_E PURCH_E * X_E) + INPURCH_E = 0$

6). $-(BUYRAIN_E * PREM_E) - \Sigma_E IP_{E,} INPURCH_E$

$- \Sigma_E P_E\ SALES_{E,YR} + \Sigma_M RAINDYLD_{YR,M} + Y_{YR} = 0$ $\forall$ YR

7). $\Sigma_{YR} 1/N\ Y_{YR} - Y = 0$

Where activities include:

1. Y = Mean expected net returns above variable costs across years
2. Y_{YR} = Net returns above variable cost by years (net returns)
3. X_E = Production of enterprise E in hectares.
4. $SALES_{E,YR}$ = bushels of crop produce from crop enterprise E, sold by year
5. $INPURCH_E$ = Purchase of inputs by crop enterprise E
6. $BUYRAIN_E$= decision to buy units of precipitation contracts by crop enterprise E

Constraints include:

1. Land resource constraint
2. Labor resource limitations
3. Sales balances by crop and year
4. Rainfall contract balances
5. Input purchases by crop
6. Profit balances by year
7. Expected mean profit balance

Coefficients include:

1. ϕ = Pratt risk aversion coefficient
2. P_E = Price of crop output for crop enterprise E in dollars per ton
3. YR= Number of years
4. IP_E = Cost of input for crop enterprise E
5. $EXPYLD_{E,YR}$ = Expected yield of crop enterprise E by year YR.
6. LAB_E = Labor requirements for production of crop enterprise E
7. $PREM_E$ = Premium payments for crop enterprise E

Indices include:

1. C = Crop
2. E = Enterprise
3. YR = Year
4. M= Month

The objective function maximizes the certainty equivalent of net returns or the net returns above variable costs (NRVC) less the product of Pratt risk aversion function coefficient and the variance of net returns (σ^2_y). The Pratt risk aversion function coefficient, formulated using methods by McCarl and Bessler, measures the risk aversion of the hypothetical grain producer. Here, the producer is assumed to maximize the lower limit from a confidence interval of normally distributed net returns. The risk aversion parameters were selected by increasing the Z score from 50 percent, which depicts that of the risk neutral situation (ϕ=0). A general expression for calculating the risk aversion parameter is given below.

$$\phi = 2Z_\alpha / S_y$$

Where ϕ = risk aversion coefficient

Z_α = Standardized normal Z value of α level of significance

S_y = Relevant standard deviation from the risk neutral profit maximizing base case scenario.

The objective function is constrained by a set of resource constraints 1-6. Constraint (1) defines a land resource limitation. The farm is restricted to operate on 50 hectares of cultivable land. This was derived in consultation from experts from Romania. Constraint (2) defines the labor constraint by crop. The labor hours was calculated by multiplying the number of workable field days by 12 working hours a day assuming 2.56 persons worled on the farm. Constraint (3) is a balancing constraint, which ensures that sales from a certain crop enterprise E is restricted by the expected yield per hectare of that enterprise. Thirty two years of farm data from 1970 to 2001 for the selected crops of wheat and corn were used for the study. The raw yield data had to be adjusted for positive trend in yields due to advances in technology and input application through the decades.

Transition pressure from 1980 to early 1990s led to drastic fall in application of inputs in Romania. The yield data were detrended using the following equation:

$$\text{Detrended Yield}_E = (\text{Actual Yield}_{YR,E} / \text{Trend Yield}_{YR,E}) * \text{Trend Yield2001}_E$$

Figure 2. presents the actual and trended yields for the selected judet by crop. Constraint (4) defines the indemnity payments balances accruing as a result of the precipitation option being exercised. $BUYRAIN_E$ defines a boolean decision to purchase precipitation insurance by crop. Constraint (5) defines the total purchases of input for crop production by crop enterprise. These are estimated using per hectare input requirement, total hectares under production. Constraint (6) defines the mean net returns by year. Crop prices for estimating the farm profits for 2000 in US ($) per ton were $106 for wheat and $90 for corn from the OECD publication " Review of Agricultural Policies: Romania." Constraint (7) estimates the mean net revenues above variable costs in the farm.

Section IV. Results and Discussion

The results and discussion are sectioned to answer the three major questions behind this research. The first sections provide the preliminary insurance structure across the selected seven judets. This is followed by analyses into the microeconomic farm level model and the impact of the precipitation contract on risk management. The third section provides some broad recommendation for agricultural risk management in Romania and potential for weather based derivative contracts.

a. ***Regional estimates for a precipitation contract***

The regional estimates to provide a preliminary idea of potential of precipitation contract in selected judets in Romania was estimates using a strike of 200 mm of annual precipitation across judets. This was arrived at as 85% of the average annual precipitation in across the seven judets in the study. A value of $100,000 was used as the liability for each of these judets. The liability establishes a ceiling for indemnity payments at one time to the insured. While a more complex procedure involving separate strike by judets and actual estimation of the value at risk could have been carried out, the illustrative nature of the exercise and data requirements constrained the effort. Based on the above figures a tick of $500 (i.e. 100,000/200) is set for the precipitation design. This would mean that the contract would pay the insured $500 for the total value of the insured liability for each mm of annual precipitation below the strike. The summary of annual rainfall in the seven judets is presented in Table 1. Regional estimates for the contract design are presented under Table 2. It is obvious that the seven judets in southeastern Romania provide a range of estimates. This indicates a range of under lying risk scenarios embedded in the system.

The pure premium rates across the seven judets extended from a value as low as 1% premium rate for Buzau to a high value of 12% for Tulcea. The pure premium rate is arrived at by dividing the average indemnity payments by the total liability and expressed in percenatges. Existence of such range in risk event, as long as they are not correlated, can mean efficient risk sharing across agroclimatic regions in a country. While the proximity of these judets and the similarity in cropping patterns are limitation for such sharing within a country, these may be an advantage for economies with greater geographic diversity and varied agroclimatic zones like China or India. The loaded premium rates, as mentioned earlier, include a 33% simple load to the pure premium. The mean average payment across all seven judets was $ 6,322 with arrange from $3,057 in Buzau to $17,293 in Tulcea. There were some substantial payments made during the sample period with an average maximum payment of $43,126 made across the seven judets. Total premium is the product of the premium rates and the liability. Both the unloaded as well as the loaded estimates of the premium are presented. The unloaded premiums equal the average indemnity payments indicating that the loss ratio is zero in the long run satisfying an important criterion for a viable insurance program. The loaded premium rates extended from $3,057 in Buzau to $17,293 in Tulcea for the set liability amount. The indication is that precipitation contract of some nature could be implemented in Romania if partner ships are established between the producers, government and global insurance agencies. Considering a high loaded premium rates, it would be idle if the pure premium is passed on to the producer and some amount of the load is shared between the other partners especially the local government. Further discussion on this issue is carried put elsewhere in the paper.

b. ***Impact of Precipitation Contract on Farm Risk Management***

A 50 hectare farm in Tulcea was selected as representative for investigating the impact of the precipitation contract on risk management. Two scenarios representing a BASE case without the precipitation contract and a RAIN case including a precipitation contract by crop are analyzed. As mentioned under methods, a slightly modified version of the contract design was employed for the farm level yield data. The farm level economic model was run for the above two scenarios across 10 different of risk preference levels. However, three levels risk significance: slight risk aversion (Z = 55%), moderate risk aversion (Z = 60%) and high risk aversion (Z =65%) along with a risk neutral case (Z = 50%) will alone be discussed.

i. BASE Case

Base case risk neutral mean net returns was $1,741 accompanied with a C.V. of 207. The range of mean profits extended from maximum profits of $7,028 to minimum profits of -$7,141. Increase in risk aversion lead to lower mean NRVC as well as C.V. in net returns. The underlying economic rationale being that risk averse producers are willing to accept a lower mean return if it reduces the variance in net returns. This is exhibited by low risk averse producers accepting mean net returns of 1,377 for lower C.V. of 174%. A similar trend continued across risk aversion levels with high risk averse producers receiving mean net returns of only $459 for a C.V. of 174%. Economic figures across risk aversion levels suggest that producers have limited avenues to manage risk under the model setup. Inclusion of alternative production practices (range of planting dates, plant populations, varieties ect.) would allow better risk management avenues for the producer. Across risk aversion producer do not seem to gain any reduction in C.V. for accepting lower mean net returns. A good idea of the extent of profit maximization can be had by computing the ratio of mean net return for a risk preference level and mean net return for corresponding risk neutral level. These figures are presented under percentage profit maximization in Table 3. They indicate that while low and moderate risk averse producers maximize 79% and 40% of profit maximization potential respectively, high risk averse producers only manage to maximize 26% of risk neutral profits. This suggests substantial loss of mean net returns per unit lowering the C.V. Table 3. presents a summary of economic numbers from the various scenarios across risk preference levels. Figure 3. presents the expected mean- standard deviation frontier across risk preference levels across scenarios.

The cropping strategy employed under risk neutrality involved the cultivation of corn on all available land. Marginal values on additional hectare of land were $34.82. This means that an additional hectare of land would contribute $34.82 to the profits. With increase in risk aversion, two significant cropping decisions were optimal. First involved the entry of whet into the production decision. For example under slight risk aversion 38 hectares were devoted to wheat along with 10 hectares under corn. In general, wheat represents a more stable crop leading to its preference among risk averse producers. The second decision involved the exit of land as a means of managing risk. As mentioned earlier, the absence of sufficient avenues for risk management under the setup necessitated risk averse producers to utilize land exit as a strategy to reduce losses. Results from the RAIN scenario are discussed next in comparison to the BASE case.

ii. RAIN Case

Risk neutral producers under the RAIN scenario had mean net returns of $2,832 accompanied with a C.V. of 127%. This represents substantial increase in the net returns along with a decrease in C.V. compared to a similar level under the BASE scenario. Specifically mean net returns increased in the order of 62% with reduction in C.V. of 39%. Range of profits extended from $8,069 to -$6,042 along with a standard deviation of 3,598. This represents a positive shift in the range of mean profits compared to the BASE case. With risk aversion, decreases in mean net returns were accompanied with lower C.V. Unlike the BASE case, efficient reduction of the C.V. for tradeoff in Mean net returns was observed under the scenario. Across all levels of risk aversion, producers did much better than similar levels under the BASE case in terms of profit maximization as well as C.V. reduction. For example, Low levels of risk aversion led to mean net returns of $2,472 along with a C.V. of 97%. Figures under the percentage profit maximization under the scenario indicate that producers are able to maximize a greater percentage of risk neutral mean net returns. For example, high risk averse producers were able to maximize 55% of risk neutral profits compared to 26% under BASE case. The economic figures indicate that the purchase of the precipitation contract has major impact on reducing the C.V. of net returns and in managing risk. The crop production strategy across risk preference levels under the RAIN scenario mirrored those under the BASE case and will not be further discussed. The precipitation contract was purchased under all levels of risk preferences in the scenario.

c. Policy Implications

Index contracts lower the cost to farmer and to society if incentives are established for government and insurance companies. Rural groups and small-scale farm operations could purchase these contracts when the cost is lowered. One unknown to index-based insurance is the fact that the demand for these types of instruments is not easy to predict. Small farmers may resist adopting a new instrument, if how it works and how they would benefit from such program are not made clear to them. This brings up the importance of human resource development. Education of farmers, insurance companies and government agencies is crucial at the beginning of the program. Marketing of such contracts while reaching large number of small size farm operations is important as well.

Designing a contract is important, however, at the same time, questions of how risk is shared among farmers, government and private insurance companies and how risk can be traded between agroclimatic regions before going to the global reinsurance markets must be answered based on the conditions in Romanian agriculture and economy. Any government trying to help farmers to survive should not make decisions based on political reasons but based on society's welfare in general. Government is needed to put the infrastructure in place, to create marketing plans for when, where and whom to sell these contracts to, and to give credibility to the program. In the end, government intervention should disappear and the market would decide how this program develop and reach to groups involved in and affected by agriculture.

All of the issues mentioned above should be taken care of to provide room for WDC to take off and be successful in reducing losses to farmers and the economy due to natural disasters.

Section V. Conclusions

Based on results from farm level analyses and the strong need for mitigating risk from natural disasters, weather-based derivative contracts seem to be a good alternative for Romanian agriculture. Traditional crop insurance like multiple peril at the farm level is not the most efficient tool of reducing risk in agriculture. As mentioned earlier, moral hazard, adverse selection and high monitoring and administrative costs are major problems with these programs. In order to eliminate these problems and to provide an instrument to help farmers reduce risk caused by extreme weather events, there is a need for alternative instruments. We believe that weather-based index contracts would fill this void.

WDC allows governments to use limited resources to tackle weather-related risks in agriculture in an efficient and low cost manner. It also would retain risk within Romania before going to the expensive, global reinsurance market, if it is employed correctly. Natural disasters will continue to affect countries like Romania. It is our wish that the system will be in place to utilize weather-based derivative contracts to reduce risk and lower cost of such disasters.

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Table 1. Summary of rainfall statistic across judets in Southeastern Romania

	Mean Annual Rainfall (mm)	Rainfall Standard deviation (mm)	C.V. of Rainfall (%)
Braila	249.53	69.97	28.04
Buzau	309.96	86.01	27.75
Calarasi	245.45	78.85	32.13
Constanta	209.29	68.73	32.84
Galati	258.87	89.13	34.43
Ialomita	254.15	79.48	31.27
Tulcea	193.82	57.9	29.87

Table 2. Regional estimates for selected judets in Romania for precipitation contract

	Braila	Buzau	Calarasi	Constanta	Galati	Ialomita	Tulcea
Unloaded premium rate (%)	5	1	6	10	5	5	12
Loaded premium rate (%)	8	3	11	15	8	8	17
Average indemnity payments ($)	4,810	1,222	5,927	10,212	4,891	4,901	12,290
Unloaded Premium ($)	4,810	1,222	5,921	10,212	4,891	4,901	12,290
Loaded Premium ($)	8,159	3,057	10,751	15,004	8,262	8,277	17,293
Maximum payment($)	37,825	31,300	51,000	49,540	39,500	37,817	54,900
Minimum Payments($)	0	0	0	0	0	0	0

Table 2. Summary of Net Returns and Management Strategy Results by Risk Attitude across Scenarios

Section I. BASE Case

	Risk Significance Level*			
Component	Risk	Slight Risk	Moderate Risk	High Risk
Mean ($)	1,741	1,377	689	459
Max ($)	7,028	4,964	2,482	1,655
Min ($)	-7,141	-5,359	-2,680	-1,786
Std. Dev. ($)	3,605	2,393	1,197	798
C.V.(%)	207	174	174	174
% of Profit Max.	100	79	40	26
Wheat hectares		38	19	13
Corn hectares	50	10	5	3

Section II. RAIN case

Component	Risk Neutral	Slight Risk	Moderate Risk	High Risk
Mean ($)	2,832	2,472	1,784	1,554
Max ($)	8,069	6,079	3,597	2,769
Min ($)	-6,042	-4,277	-1,597	-704
Std. Dev. ($)	3,598	2,394	1,197	798
C.V.(%)	127	97	67	51
% of Profit Max.	100	87	63	55
Wheat hectares		38	19	13
Corn hectares	50	10	5	3
Purchase of corn precipitation contract	yes	yes	yes	yes
Purchase of wheat precipitation contract	yes	yes	yes	yes

* Risk Neutral: Z = 50% Slight Risk: Z = 60% Moderate Risk: Z = 65% High Risk: Z= 75%

Figure 1. Map of the locale

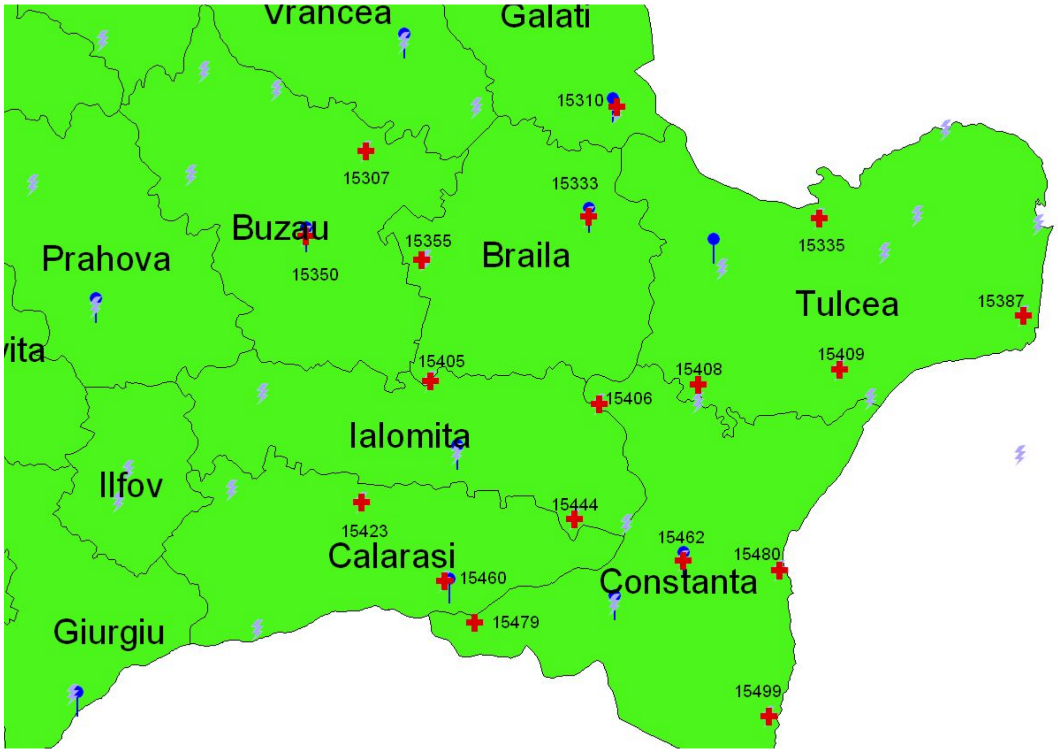

Figure 2. Actual and Detrended yields by crop for Tulcea across years

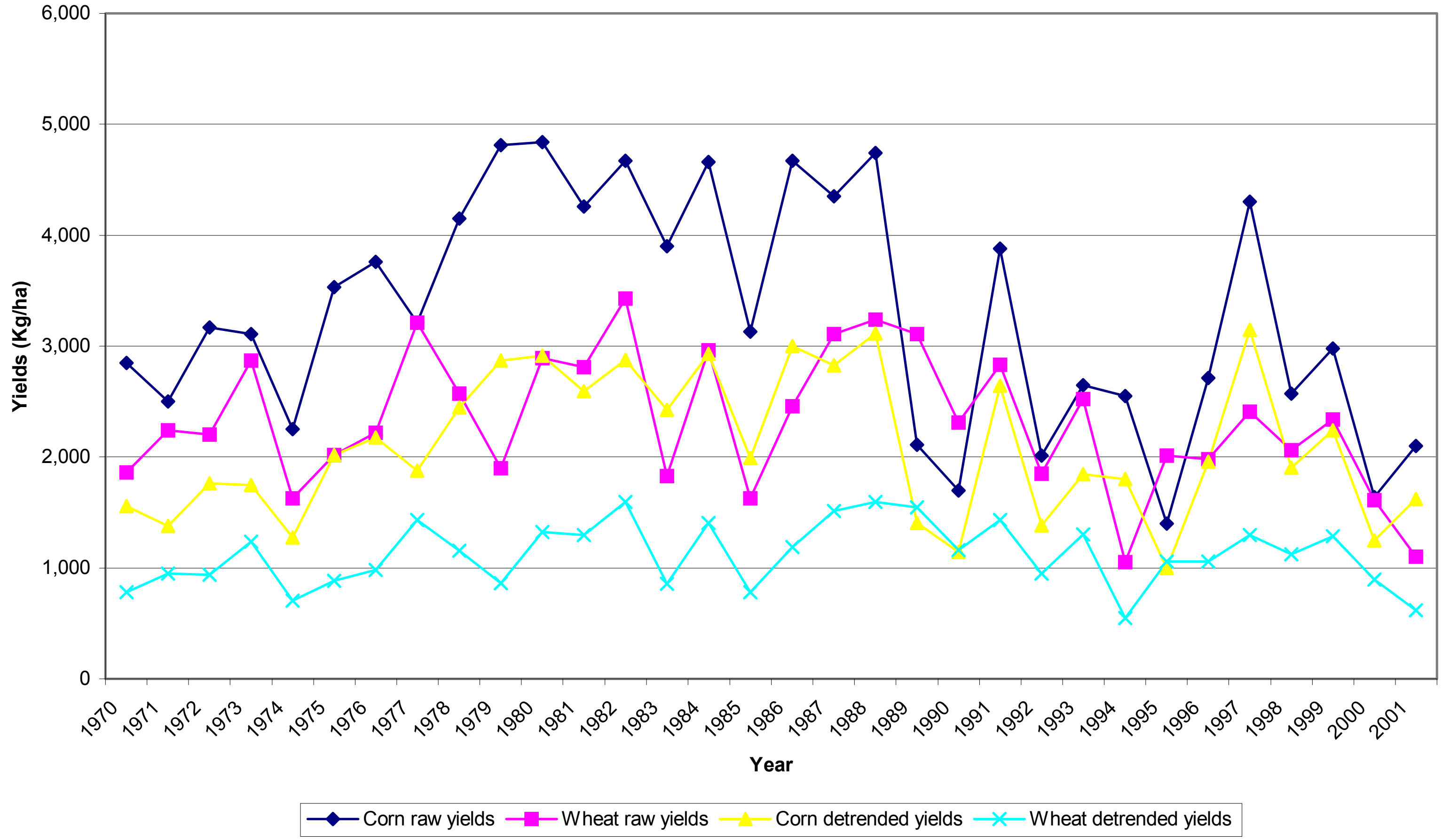

Figure 3. E.S. Frontier across Scenarios