CROP DISASTER ASSISTANCE IN UKRAINE: ISSUES, ALTERNATIVES AND CONSEQUENCES

Historically known as a bread basket for millions, Ukraine has a large agriculture sector with almost 40,000 farmers and 16,100 farms producing a variety of products, including cereals, corn, beets, and livestock products. These farmers face multiple perils—such as, drought, excess rain, and freeze—which make their incomes unpredictable and therefore limiting their access to credit. The government of Ukraine (GoU) has an important role in mitigating catastrophic risk in agriculture. That role should be to promote better crop insurance products, by providing the infrastructure to sustain those products and the means to access cost-efficient risk financing instruments (ex. reinsurance). GoU also needs to support farmers' access to insurance and to reinsurance via primary providers in Ukraine rather than subsidizing pure risk premiums. Crop insurance based on a weather index is a feasible product for Ukraine. Such insurance could facilitate a wide array of innovative product developments within the emerging markets of Ukraine. This would allow GoU to move away from subsidized traditional crop insurance programs that have proven to be very difficult and costly to administer in industrialized countries, in large part they tend to reward excessive risk taking by farmers.

However, in order to make weather index insurance available on a larger scale, quality data and more automated weather stations need to be made available. GoU would support the product through a reinsurance pooling facility. The World Bank would provide technical assistance and contingent credit support to facilitate risk retention in Ukraine as well as efficient risk transfer into international markets.[1] This summary first reviews risk in agriculture and the insurance sector, and then it discusses agricultural insurance approaches and recommendations.

RISK PROFILE OF AGRICULTURE

Crop risk in Ukraine is well diversified across the country, facilitating the pooling of risk and retention of a large share of natural risks in the country. Crop-yield data for all 25 oblasts from 1970-2001 including maize, sunflowers, sugar beets, wheat, and barley allow for a rudimentary assessment of risk for Ukraine. While the major agricultural values are concentrated in the center and South of Ukraine, there is a good geographic spread of the value represented by these five crops across Ukraine. The correlation of crop yields between the eastern section of Ukraine and the southern region around Odessa is nearly zero. This type of risk offset presents unique opportunities for structuring risk pooling and risk-swapping arrangements within Ukraine for crop insurance providers.

An initial cost estimate of a crop insurance program that indemnifies yields below 70 percent of the simple five-year average of farm-level yields would require premium levels in excess of 10 percent of sum insured. If we consider a 17.5 percent of the share of the market reported for the first eight months of 2004 (US$1 billion), the estimated premium

[1] In the context of preparing a rural finance project in the Ukraine, a World Bank mission assessed the options for crop disaster assistance options. The team focused on the role of the public sector and the feasibility of "index-based" crop insurance. This report summarizes the mission's findings.

base would be roughly $100 million. Loss ratios in the 300 percent ($US 300million) range are possible in the worst crop years. If the government were to supply a 25 percent premium subsidy, government annual average cost could easily exceed $25 million for only the premium subsidy. More cost would be added to the program given the need for the government to support the reinsurance at some level.

Small farmers access to rural finance can be facilitated with proper crop insurance. Rural credit requires fixed assets as well as equipment and personal guarantees as collateral. Equipment in Ukraine is often old and of limited value, average age of agricultural equipment is about 12 years (2003 – IFC agribusiness survey). Increasingly, rural finance institutions are considering using future harvest gains as collateral. To hedge against crop losses, these lenders tend to require harvest insurance[2]. Currently, the major banks active in agricultural lending, such as Aval with a total of 4600 loans and 30 percent market share, do not lend on the basis of uninsured collateral. The farmer has to produce a proper insurance policy written by a pre-approved insurer to obtain credit. Most banks set up their own insurance companies to provide for their lending insurance needs.

Farmers tend to understand weather risk very well and should understand the particular nature of weather index insurance. Ukraine has a large number of previously state-owned large agricultural industry complexes that have studied weather and yield relationships for a long time and therefore can provide demonstrative effects for surrounding farmers.

INSURANCE SECTOR IN UKRAINE

The insurance sector is divided into three types of activities. The first involves the protection of property and obligations of major international corporations. Often local companies "front" this business for international insurers. The second activity is carried out by domestic companies for domestic clients. For this segment the regulator receives high number of complaints (more than 320 in 2001). Only a fraction of this business is reinsured. The third type of activity is carried out by captive insurers, companies established as subsidiaries or affiliates of other corporations, banks or associated groups. Insurance policies are produced for the parent organization. The supervisory authority estimates that 20 percent of the top 50 companies are captive companies, some of which act as tax optimization schemes (2001-2003).

The premium collected during the first half of 2004 are $US1.6 billion ($US 0.74 billion in 2003). Claims ratios were very low with 5.5 percent in first half of 2004 (10 percent in 2003). Crop insurance is underdeveloped. More then 180 companies received crop insurance licenses (2004), however only around 20 companies offer limited coverage. The former state monopolist, Oranta, now owned to 49 percent by Ukrsotzbank and others, has a large network of agents in the country and collected approximately $US 180 million crop insurance premiums in 2002. Following a severe weather shock in 2002-2003 for the winter and summer season, Oranta Company considerably decreased its crop insurance portfolio. Donetsk-based Aska collected about US $25 million of premiums in 2003, of which less then 10 percent is crop insurance. The market currently offers harvest insurance and input cost insurance policies. Input cost insurance is mostly linked to agricultural credit collateral requirements and is generally limited to very low insured sums. Harvest insurance covers hail, storm, excessive precipitation, freeze, and fire risk. Drought is not covered; however, there are plans to include this risk as well. Two crop insurance pools were founded in 2003. Five and sixteen insurance companies respectively agreed to pool their agricultural risks to improve risk bearing capacity and to obtain access to international reinsurance markets. Crop insurance policy sales have been very limited (around 80 for both pools). Reasons for the low uptake cited by market participants

[2] An IFC survey (2002) of agricultural enterprises in Ukraine revealed that farmers' failure to repay credit was most often attributable to problems related to the sale of produce primarily resulting from low product prices, limited demand, lack of market information, and high interest rates. Only 12 percent cited bad harvests as the reason for their inability to repay their debts. These survey results are motivated by the market problems for grains and good harvests. In 2002/2003 crop failures due to freeze and drought problems would significantly change these farmer perceptions.

were low ability to pay, unclear loss adjustment and underwriting procedures, lack of trust for insurance companies and insufficient information available to farmers. GoU provided ad hoc disaster assistance to farmers in 2003 and 2004, which lowered incentives for farmers to pay for commercial insurance premiums.

Regulatory Framework

The insurance laws and regulations used to disadvantage international reinsurance compared to national and CIS reinsurance and application of the rules resulted in administrative burdens for insurance companies. The regulator favored quality reinsurance to combat "scheme" and "tax minimization" reinsurance mostly done through Moldova, Baltic countries and Russia. Reinsurance tax is three percent for top-rated international reinsurers and 15 percent for not-rated reinsurers located in Russia, Moldova and other countries.

- Insurance and reinsurance are not differentiated in the Law of Insurance, so institutions that obtain the approval for conducting insurance activity in Ukraine can provide both services to the domestic market. The law specifies that insurance shall be carried out in Ukraine only by Ukrainian resident insurers. The regulator has recently announced that insurance and reinsurance activities will soon be separated.
- Reinsurance involving a non resident is not restricted in terms of the amount (percentage) of premium ceded outside of Ukraine, but should comply with the procedures specified in the special norms for that purpose, particularly when fees or premiums ceded to non residents exceed 50 percent of their total amount received from the start of the calendar year. Even though the total amount to be ceded to non-residents is not capped, the amounts of required insurance reserves of the unearned premiums do not decrease for premiums ceded to foreign reinsurance institutions. Ninety percent of these reserves have to be invested inside Ukraine so institutions that cede more than 10 percent of their premium incur the additional financial cost of keeping additional reserves.
- Since 2004 reinsurance regulations do distinguish between low and high rated reinsurers for the purpose of determination of reserve requirements and tax payment as well as the administrative approval of reinsurance treaties.

Supervisory capacity seems to be limited as to reinsurance activity in the country. Reporting standards, on-site supervision, and sanction powers are still inadequate but are in the process of being modernized and enhanced.

Compulsory Crop Insurance proposed by the Government of Ukraine

The new law on insurance promulgated in November 2001 made 43 types (currently 41) of insurance compulsory for certain categories; one of them is crop insurance[3]. Crop insurance is supposed to be compulsory for all activities of state-owned agricultural businesses, as well as for sugar beet and grain for all private businesses. A regulation passed by the cabinet of ministers in July 2002 specifies the coverage and premiums as well as policy wordings of this multiple-peril crop insurance that would pay using a five-year average of farm yields with current prices minus a deductible of 20-40 percent. Premiums are supposed to range between 7 and 9.5 percent for different oblasts. Actuaries report though that these rates are not actuarially sound. Premium subsidies are foreseen in another law, the law on "Stimulation of Agriculture Development, 2001-2004". There are several concerns regarding the introduction of compulsory crop insurance in Ukraine:

- Making crop insurance compulsory for all farmers means every farmer, small and large, has to accept one of a limited number of crop insurance offerings. This situation would open the door to collusion among insurers in order to extract extra profits from

[3] In 2004 NBFIR has initiated amendments to the Law on insurance with the aim of abolishing 32 out of 43 mandatory insurance products

farmers. In order to avoid profiteering or pseudo-insurance contracts, the regulator would have to establish pan-territorial insurance conditions and premium rates, which would in most cases fail to match the true cost of the risk.

- Thus either the official premium is too high, and the farmer would not accept the contract or moral hazard problems will be compounded as even the better farm managers are more prone to change their behavior in ways that increase risk when they are forced to purchase insurance. In other words, forcing farmers to purchase insurance will ultimately lead to a failed system
- Or the premium is too low for the poor farm managers and the insurer would try to avoid offering contracts in the area or even renege on contracts in cases of claims. Since it will be impossible to classify risk and distinguish between the better farm managers versus the poorer farm managers, compulsory insurance will tax the better farm managers and transfer the tax to the poorer farm managers. Such a tax would lead to more inefficiency in the farming economy in Ukraine.
- Another problem is that the insurance sector is not ready to serve the whole country in terms of technical and financial resources. Ultimately the system would result in an overall tax on farming, as insurance companies do not have the proper resources to properly deliver on the collected premiums.
- Finally, there is no real experience with compulsory crop insurance in the world. The U.S. tried a form of compulsory crop insurance in 1995 and abandoned it after one season.

PROMISE OF WEATHER INDEX INSURANCE

Traditional multiple-peril crop insurance that indemnifies losses on individual farm basis is subject to high administrative costs in order to overcome the problems of adverse selection and moral hazard. It also requires significant investment in monitoring farm yields to prevent both higher losses than the initial rating and serious actuarial problems. Furthermore, multiple-peril crop insurance has large correlated risks, so it requires the extra cost of providing reinsurance. These extra costs can be quite high in an emerging economy with little or no experience in providing insurance of this type. These conditions mean that traditional multiple-peril crop insurance is not a workable solution in Ukraine[4]

One form of agricultural insurance that mitigates these added costs is **weather insurance**. Payout is determined by an objective parameter such as the combination of a series of weather-related metrics—for example, millimeters of rain, soil moisture, etc. Weather index insurance is well suited to the agricultural production in regions in Ukraine where there are wide spread crop losses due to drought and frost. The monitoring costs of weather insurance are less as there is no need to perform farm-level loss adjustments and the balance of information about the weather is equally shared by the insured and the insurer (unlike with traditional farm-level insurance where the farmer will always know more about the yield than the insurer). Thus, weather insurance could be a preferred alternative to crop insurance, as it avoids moral hazard problems. Further, the reinsurer is more likely to provide better terms when the insurance is based upon weather events and not farm-level losses.

Evidence from data analysis, qualitative assessments in the field, and interviews with market participants let the team conclude that this product is feasible in Ukraine. Rural credit would drive strong **demand** for crop insurance. The **insurance market** is thin and fragmented, however a few insurers are training people and selling crop insurance, and they are willing to venture into new insurance formulas as they realize the significantly lower expense ratios of the weather based insurance. Crop yields and revenues are very volatile in

[4] Only a few large and commercial farmers would have sustainable access to this type of insurance, for others the added transaction and moral hazard management costs make the product prohibitively expensive.

Ukraine, especially in the drought-prone oblasts to the south. Any type of crop insurance will need to efficiently **transfer the weather risk** portion of these risks to insurance or reinsurance level. Only weather index insurance can provide such an efficient risk transfer mechanism. Weather index insurance needs to conform with the “insurable interest” clause in the insurance law. The **weather insurance infrastructure is good.** The Hydro Meteorological Service runs 187 active meteorological stations with traditional equipment. Since the stations are not automatic, the information is manually aggregated at the oblast level and then transmitted electronically to the central weather service. While these stations are sufficient for weather risk transfer contracts, moral hazard could be addressed by the automation of weather stations, set up of fallback stations by reinsurers, and satellite data use for verification purposes.

PROPOSED NEXT STEPS

The study proposes to proceed in a pilot phase, investment phase and mainstreaming phase. The rationale is that once the **pilot** insurance programs have demonstrated the feasibility of this type of risk transfer from farmer to insurance company to international weather markets, the experience would be replicated in the market and volumes would increase. With higher amounts of risk, **national pooling of risk** and competitive international risk transfer coupled with a contingent loan from the World Bank would dramatically reduce risk financing costs and thereby premiums for farmers. Finally the insurance companies would **mainstream the products** and manage the risk pool themselves without any GoU backstopping.

Pilot Phase

In 2004 the World Bank’s Commodity Risk Management Group and IFC PEP began to assist insurance companies in the development of weather index insurance projects on a pilot basis. The objective is to:

- Further develop statistical and agronomical models to calculate the relationship between yield and weather variables. (See the next section for work on winter wheat and drought risk insurance in Kherson)
- Design risk management models for insurance companies.
- Analyse countrywide risk pooling to determine the correlated exposure and the potential to offset risk exposures inside Ukraine.
- Spring 2005: Launch insurance company led pilot projects, aiming at testing the market viability of the concept. (See next section)

Phase I: Investment Phase

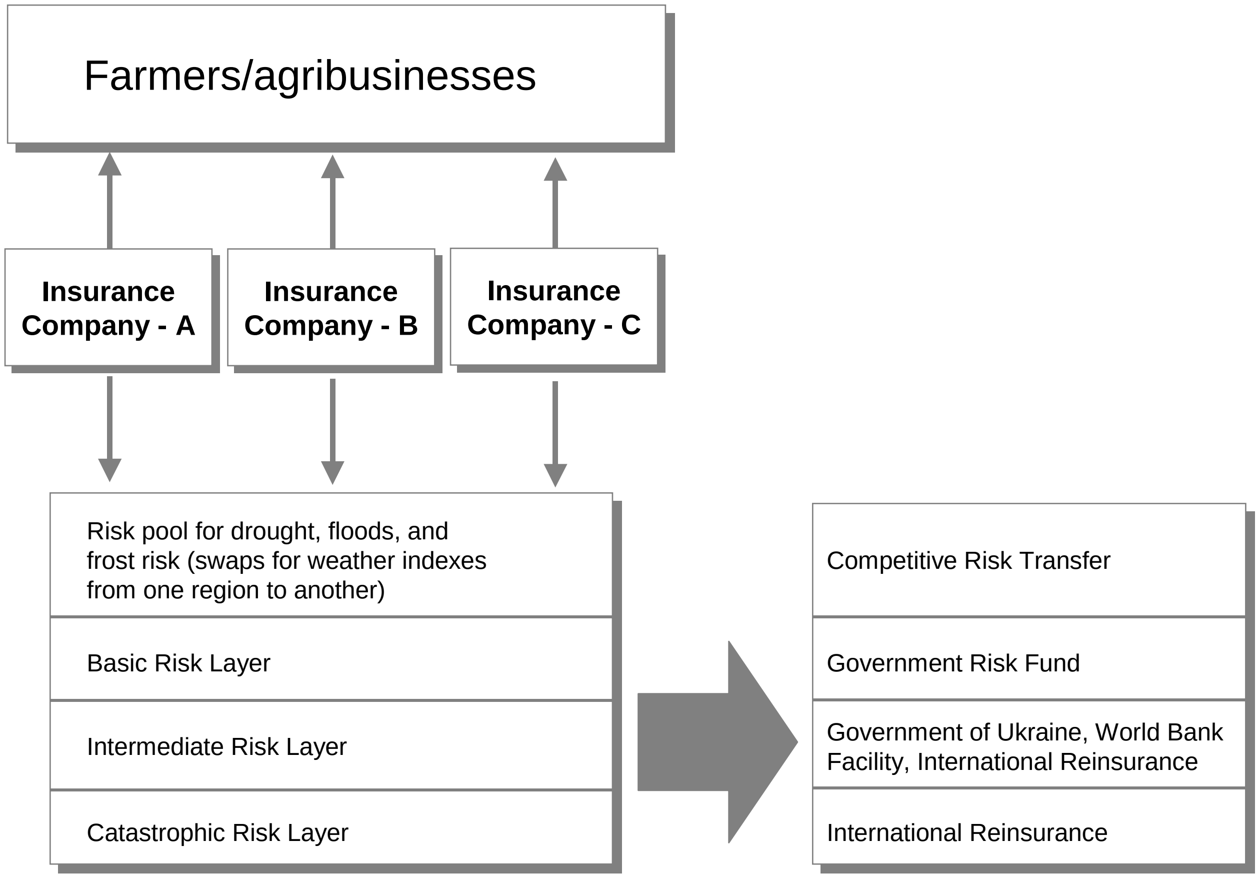
Acquisition and installation of automated stations

- Analysis of the density of the network required for the weather exposure of Ukraine.
- Design adequate maintenance program to ensure the quality of observations across time.

Backstop Facility for Weather Risk Insurance Retention. Ukrainian insurance companies would need international reinsurance for systemic risk types of agricultural insurance. A Ukrainian risk pool (“facility”) would allow for the underwriting of agricultural reinsurance in Ukraine to retain as much risk inside the country as possible based on pre-established underwriting guidelines. This pool would then reinsure itself through a contingent loan by the World Bank or GoU fund capitalized by a World Bank loan. The extreme risk would be reinsured in international reinsurance based on transparent and competitive premium ratemaking principles, that is, once the pool and the GoU fund are depleted, international reinsurers would pay the remaining claims. Through the aggregation and layering of the risk, reinsurers would be interested in reinsuring Ukrainian risk and be forced to price the risk competitively. Individual insurance companies face sometimes insurmountable difficulties to even access international reinsurance markets, let alone obtain competitive prices. Therefore the combination of introducing a transparent index insurance product and an efficient and well-regulated risk pool can overcome this market failure. The graphic shows an example of how the risk of farmers could be aggregated into an insurance company **risk pool** which in turn would transfer risk in layers. The more frequent risk layers would be insured by the GoU risk fund (which could be capitalized by a World Bank Loan). The intermediate risk layers (perhaps, 1 in 20 year events up to 1 in 100 year events) could be transferred to the **GoU/WB Backstop Facility** – for example through a WB contingent loan. The catastrophic risk layer (the one in hundred year event) could be transferred to **international reinsurance** markets.

Phase II: Sustainable private sector-led weather index insurance

Following the successful implementation of a pilot and a full program for two to three years, the insurance sector could be in a position to operate without government supported backstop facilities, and simply continue to pool the risk before transferring it internationally.



WINTER WHEAT INDEXED WEATHER INSURANCE PILOT – KHERSON 2004/2005

The IFC-PEP Agribusiness Development Project in Ukraine has been working in Kherson oblast (southern Ukraine) since March 2001. The farmers and finance institutions indicated that the major risk in crop production in the oblast was weather, namely drought in spring/summer and low temperatures in winter. Trying to address this problem the Project consulted insurance companies and it was established that no company could offer reasonable coverage against drought. While the traditional multi-peril products addressed winter risks, drought was not at all included in the insurance portfolio. The Project also knew that the insurance companies did not have professional staff with the agricultural expertise and that they lacked the sound infrastructure necessary for any type of agricultural products. Consequently the farmers did not trust the insurance companies. High administrative costs and asymmetry of information further compounded these problems rendering the agricultural insurance system ineffective.

In 2001 the World Bank mission introduced the concept of weather index insurance in Ukraine and the IFC-PEP Project saw that it was one of the possible options for developing the crop insurance system in the country. Ukraine is one of the biggest grain and oilseed producers in the world and the agricultural sector is of great importance for the national economy. The concept of weather insurance appeared particularly applicable to the country as Ukraine has a widespread system of 187 weather stations and data of good reputation and reliable quality. There are eight reporting weather stations in the Kherson oblast.

After extensive consultations with the farmers, local authorities and scientists it was agreed that to launch a pilot project and to reach the acceptable volume of contract sales, the weather pilot project had to concentrate on the most important crops to farmers that were susceptible to weather risks. The crops evaluated were winter wheat, spring barley, sunflower and corn. Of these, winter wheat has the biggest area and considerable value at risk (1.5-2 million ton produced in the oblast annually with an approximate crop value of 200 million USD) in addition most of this crop is cultivated without irrigation. In addition, the finance institutions recently started to accept standing crops of grain as security for agricultural loans, though they were worried about not having sound insurance protection.

Considering all the information on the oblast - its climate, crop production, the general situation and tendencies in rural finance - the World Bank together with IFC-PEP Agribusiness Development Project agreed to run a pilot project to test the weather-based index insurance concept in the Kherson oblast.. In 2004, the partners proposed several insurance companies to participate in this initiative. One company, Credo Classic, developed the weather index products based on different weather stations throughout the oblast, with support from the World Bank and IFC-PEP, and launched a small pilot in spring 2005, selling drought protection products to winter wheat farmers in Kherson.

DEVELOPING A WINTER WHEAT PILOT PROGRAM IN KHERSON

The four technical steps essential for developing a successful index-based weather insurance pilot program are:

a. Identify the significant weather exposure of winter wheat farmers in the Kherson oblast;

b. Quantify the financial impact of these adverse weather conditions on their revenues and/or input/production costs;

c. Structure an insurance contract that pays out when adverse weather conditions occur;

d. Execute the contracts in optimal form to reinsure the risk in the international markets.

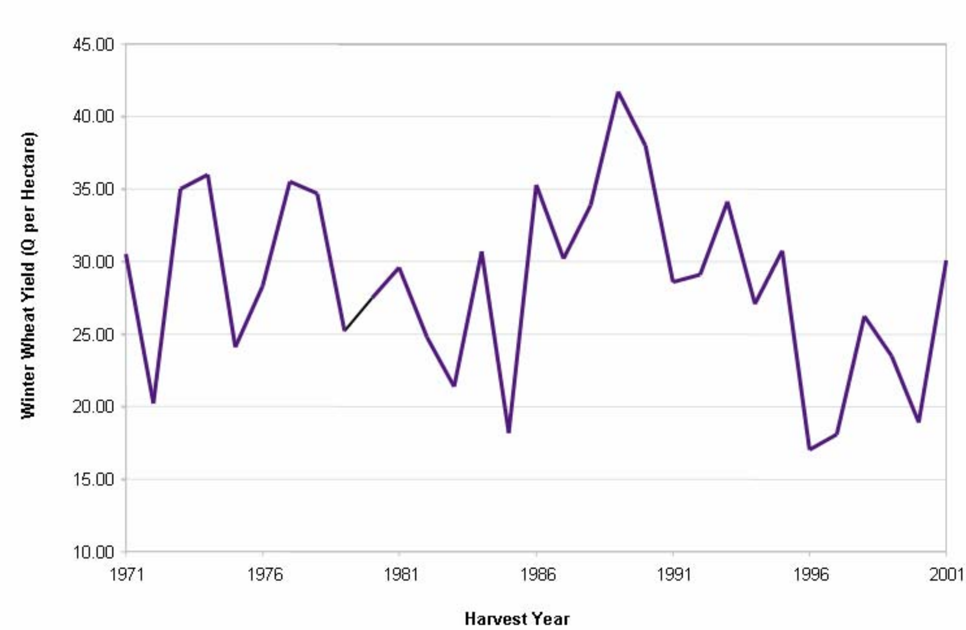
IDENTIFYING THE WEATHER EXPOSURE

The Kherson Oblast

The Kherson oblast is situated in the southern steppe of Ukraine. The climate of the southern steppe belongs to the Atlantic continental climate and is distinguished for its drastic continentality and dryness vis-à-vis other zones of Ukraine. Winter wheat is one of the dominant grain crops in the region and the main grain crop in the country. The life cycle of winter wheat consists of the following phenological stages: germination, sprouting, bushing, leaf-tube formation, earing, flowering and ripening (milk, wax and full ripeness). Each development phase is connected to morphological changes in the plant physiology and has its own weather requirements for optimum growth and maturity. However, in many cases agroclimatic resources of the Kherson oblast fall short of these requirements.

A cursory glance at winter wheat yield data for the Kherson oblast shows that there is significant interannual variability in yield in the region (Figure 1), which reflects the agroclimatic risk inherent to the oblast. Informal interviews with winter wheat farmers in the region indicate the greatest perceived risk for wheat production is drought followed, in order of importance, by frost, storm/hail and finally fire. Pest attack is considered a manageable risk by most farmers. Hence, it is clear there is potential for an index-based weather insurance pilot in the region.

Figure 1 Winter Wheat Yield for the Kherson Oblast, 1971-2001[5]



[5] Source: Authors' figure using yield data from the Kherson Oblast Department of Agriculture, Kherson, Ukraine.

Designing the Index

The normal process for designing an index-based weather insurance contract involves looking at a measurable weather index that is correlated to yield rather than the yield itself. After gathering the weather data, an index can be designed by: *i)* looking at how the weather variables have or have not influenced yield over time; *ii)* discussing key weather factors with experts such as agro-meteorologists and farmers; and/or *iii)* referring to crop models which use weather variables as inputs for yield estimates. A good index must account for the susceptibility of crops to weather factors during different stages of development, the biological and physiological characteristics of the crop and the properties of the soil. If a sufficient degree of correlation is established between the weather index and yield, a farmer or an agricultural producer can insure his production risk by purchasing a contract that pays in the case that the specified weather event occurs (or does not occur). These weather based insurance instruments provide financial protection for the farmer against uncertain revenues that result from weather related yield volatility.

It is generally accepted that the reported yield data, available from the Ukrainian Statistics Office, differs significantly from actual yields collected by farmers throughout the country. There are significant political and economic incentives for both farmers and officials to under- or over- report production and planting data, particularly since independence in the early 1990s. Hence historical yield data for Kherson is unreliable for the purposes of index construction as it does not faithfully represent the actual production in the rayons (sub-regions) of the oblast. Therefore methods *ii)* and *iii)* must be used to design an effective weather risk management instrument. To this end, a report[6] was commissioned by the World Bank's Commodity Risk Management Group (CRMG) and ICF-PEP from the Ukrainian Hydrometeorological Centre (UHC) in Kiev to assess the agroclimatic conditions and weather risks for growing winter wheat in the Kherson oblast. In the absence of reliable yield data, the results from the report based on the UHC's oblast-specific crop model and expert assessment, were used as the basis for constructing an appropriate weather index for winter wheat in Kherson.

Identified Weather Risks

According to the UHC report[7] the most significant weather risks for the growing of winter wheat in the Kherson oblast are:

- Winterkill during the crop's hibernation period from December to March; and
- Moisture stress during the vegetative growth period from mid-April to June.

Winter wheat yields at harvest depend to a great extent on how well the plants survive the winter and the hibernation period. On the territory of Kherson winter wheat winter crops mostly die as a result of air and therefore soil temperatures falling below a critical level for one day or longer. These winterkill events cause damage and death of the plants' tillering node. Snow cover considerably improves conditions of winter wheat hibernation, as the difference between air and soil temperature varies from 0.5 to 1.1°C per each centimeter of snow cover. In other words, with sufficient snow cover winterkill will not occur even with very low air temperatures. However, snow cover on the territory of the oblast is normally unstable. According to the UHC in some years, stable snow cover does not appear at all, snow cover is rarely of a height sufficient to protect crops from severe frost. Hence complete winter wheat crop failure due to winterkill is a potential risk in the southern steppe zone of Ukraine – the crop usually dies in years with no snow cover or where the stable snow cover appears late in winter, such as in 2003.

The other main limiting factor for high winter wheat yields in the Kherson oblast is moisture. Lack of moisture in the soil and air during the vegetative growth period are the main causes of low winter wheat yields. In particular all five rayons of the oblast are subject to frequent

[6] Private Communication: *"Agroclimatic Conditions and Assessment of Weather Risks for Growing Winter Wheat in Kherson Oblast"*, T. Adamenko, July 2004, Ukrainian Hydrometeorological Centre, Kiev.

[7] As above.

droughts: the probability of a severe and medium drought (defined subsequently) during the vegetative period in the region is 15-20 percent and 40-50 percent respectively. The first critical period in which winter wheat yield formation is highly susceptible to moisture stress is the leaf-tube formation to earing phase. According to the climatic conditions of the region this period lasts from April 15 till May 25. The water requirements for winter wheat during this stage when compared to the climatic conditions for this period for the oblast are estimated to be 80 percent of optimum by the UHC. In the most recent years, in 50 percent of cases moisture conditions during this period were close to optimum (1998, 1999, 2001), in the other 50 percent of cases they were insufficient (in 2000, 2002, 2003). The second critical period for winter wheat is earing to milk ripeness**,** the kernel formation phase, which lasts from May 22 to June 14 on average but can extend later into June. Lack of moisture during this period directly decreases the number of kernels in an ear and leads to excessive drying of the ears. The water requirements for winter wheat during this stage when compared to the climatic conditions for this period for the oblast are estimated to be 90 percent of optimum by the UHC.

These findings indicate that two products must be available in order to sufficiently protect winter wheat farmers purchasing weather insurance in the Kherson oblast. For the growing season 2004/2005 winterkill insurance, based on traditional methods of loss adjustment, was offered in the oblast by several insurance companies. This is a welcomed development by the farmers however drought protection was still not available. Therefore an index to capture drought risk from mid-April to June wasdesigned in order to address the disparity between the products currently offered and identified production risks faced by the farmers. An example of how such a product could be structured is outlined in the following sections.

The Selyaninov Hydrothermal Ratio Index[8] (SHRI)

There are two types of agricultural drought: air drought and soil drought. Air drought describes conditions where precipitation is low and high air temperature persists against the background of low relative air humidity (less than 30 percent). It leads to unfavorable conditions for plant vegetation and drastically reduces crop yields. Soil drought describes the excessive dryness of soil, resulting in a scarce supply of moisture ultimately leading to premature fading and death of crops. Soil drought is characterized by the lack of soil moisture available for crop growth and development. Air drought, which is characterized by long rainless period, high air temperature and low air humidity is often characterized by using the Selyaninov Hydrothermal Ratio (SHR). For the vegetative growth period for winter wheat in Kherson, April 15^{th} – June 30^{th}, the SHR is defined as follows:

$$SHR = \Sigma_{15\ April\text{-}June}\ Daily\ Rainfall\ /\ 0.1 * \Sigma_{15\ April\text{-}June}\ Average\ Daily\ Temperature$$

and holds for periods when daily averages temperatures are consistently above +10 deg C. This period begins from April 15^{th} on average in the Kherson oblast. The SHR does not always serve as a reliable criterion of agricultural drought because it does not take soil moisture into account, but as this is not an observed variable in general and rainfall and a average temperature are, it is the only objective indicator that can be used to capture drought risk during the vegetative period.

Conditions for obtaining the best harvest are when SHR = 1.0-1.4. When the SHR is greater than or equal to 1.6 plant yields will be depressed by excessive moisture. When the SHR is less than or equal to 0.6, plants are depressed by drought conditions. In general the isoline SHR = 0.5 coincides with regions of semi-desert climate conditions. Results

[8] Information on SHR taken from *"Agroclimatic Conditions and Assessment of Weather Risks for Growing Winter Wheat in Kherson Oblast",* T. Adamenko, July 2004, Ukrainian Hydrometeorological Centre, Kiev (Private Communication)

from the UHC's crop model[9] suggest that the impact of SHR during the vegetative growth stage April 15th – June 30th on yields can be defined as follows:

SHR	Description	Yield Loss
1.6	Excessive Humidity	30 percent+
1.3-1.6	Damp	-
1.2-1.0	Sufficient Humidity	-
0.9-0.7	Dry	-
< 0.7	Drought Conditions	-
0.5-0.6	Medium Drought	20 percent
0.4-0.5	Severe Drought	20-50 percent
< 0.4	Extreme Drought	50 percent +

Therefore the SHR can be used as an index to monitor the impact of air drought on winter wheat crop yields.

Quantifying the Impact of Weather

Once weather indices to capture the impact of adverse weather conditions on winter wheat yield have been developed it is straightforward to calculate the financial impact of these events for farmers. In order to calibrate an indexed-based weather insurance contract to the financial losses experienced by a farmer as a result of weather, there are two aspects that need to be quantified:

a. The limit, also called the sum insured, of the contract i.e. the **maximum** protection required per risk period;

b. The tick size i.e. the farmer's weather exposure per unit of the defined index.

There are two possible levels for weather insurance protection that can identify the appropriate limit for a weather insurance contract:

c. To cover the farmer's production and input costs;

d. To protect his expected revenue from the sale of the crop at harvest.

The former is more appropriate for catastrophic weather risks earlier in the growing season, such as winterkill, where the farmer has an opportunity to re-sow another crop for summer harvest if his winter wheat crop is completely destroyed. The latter is more appropriate for weather risks later in the growing season, where there no opportunity for re-sowing yet where yield can vary significantly from the expected levels, for example as a result of April-June drought. Indeed, informal interviews with farmers in the oblast indicated that farmers are less concerned with winterkill risk than with drought risk, despite that fact is it can potentially case complete damage, because of the re-sowing potential.

Winter wheat farmers spend a maximum of 1000 UAH per hectare in on production and inputs costs during the entire growing season of the crop. The limit of a mid-April to June drought insurance contract to cover production and input costs should by set at 1000 UAH per hectare insured. For example, in the event of total crop failure as a result of a very extreme drought (e.g. a SHR < 0.15 event) the farmer would be indemnified for 1000 UAH per hectare insured to compensate for the loss of the investment. The tick size of the insurance contract can be determined from the information in the UHC report and are summarized in the following table:

[9] Data from *"Agroclimatic Conditions and Assessment of Weather Risks for Growing Winter Wheat in Kherson Oblast"*, T. Adamenko, July 2004, Ukrainian Hydrometeorological Centre, Kiev (Private Communication)

SHR	Payout per Hectare	SHR	Payout per Hectare
0.6-0.61	200 UAH (20 percent loss)	0.3-0.26	700 UAH (70 percent loss)
0.5-0.46	300 UAH (30 percent loss)	0.25-0.21	800 UAH (80 percent loss)
0.45-0.41	400 UAH (40 percent loss)	0.2-0.16	900 UAH (90 percent loss)
0.4-0.36	500 UAH (50 percent loss)	< 0.15	1000 UAH (100 percent loss)
0.35-0.31	600 UAH (60 percent loss)		

For example in the event of a partial crop failure as a result of a bad drought (e.g. a SHR = 0.39 event) the farmer would be indemnified for 500 UAH per hectare insured to compensate for the 50 percent loss in yield and hence his investment. In the event of an extreme drought (e.g. a SHR = 0.2 event) the farmer would be indemnified for 900 UAH per hectare insured to compensate for the 90 percent loss in yield.

Calculating the limit and tick size for a contract to protect a farmer's revenue is a little more difficult as harvest-time commodity prices are not known in advance when the insurance is purchased. Furthermore, commodity prices also often vary in response to extreme production shocks and it is often difficult to quantify the production (weather)-price correlation, particularly in emerging commodity markets where prices are not always stable. However estimates for the harvest-time price can be made e.g. last year's harvest-price or the five-year average September price from the local commodities exchange could be used as a best estimate, or the Government minimum support price could be used as a lower-bound for the selling price. For example if a fair estimate of the September price is 700 UAH per tonne and if a farmer's expected yield is 3.5 tonnes per hectare, then he expects to make approximately 2450 UAH per hectare less his production costs at harvest, that is 1450 UAH per hectare profit. Therefore in order to protect this profit, a farmer could buy a weather insurance contract in March for a sum insured of 1450 UAH per hectare. However this approach is more appropriate for large commercial farmers who either have fixed-price delivery obligations or those who have access to price hedging instruments in the market to manage their exposure to movements in the selling price. It is assumed that most farmers will be buying weather insurance contracts to cover their production and input costs.

STRUCTURING A WEATHER INSURANCE CONTRACT

The Sum Insured

The limit of the insurance contract is negotiable with the farmer however it cannot exceed a maximum estimated by the potential insured loss to the farmer as outlined in the previous section. For example, if production/input costs are 1000 UAH per hectare at the end of the growing season a farmer cannot insure himself for 2000 UAH per hectare to cover these costs. Furthermore the farmer cannot buy winter wheat insurance for more hectares than he farms. An upper limit on the risk volume per client should be set at the total area of the crop planted multiplied by the expected selling price, determined as mentioned above by either last year's selling price according to records, the 5 year average or the Government's minimum support price. The insurer can ask for a copy of the State Statistics Agriculture Report No 29 that all the farmers should provide to the Statistics Service. This document is also used for allocating government subsidies to farmers and can be used as a basis to consider index contracts valid and sufficient for the Regulator from supervisory point of view. The farmer and insurer should be liable for correctness of the reported hectarage of the crop.

Contract Specifications

In addition to defining the index, the buyer/seller information (names, crop and hectarage insured), limit and tick-size, an index-based weather insurance contract must also include the following information:

- Location – the weather station at which the weather variables used to construct the index are measured and recorded;
- Calculation period – the risk protection period of the contract;

- Strike – the index level at which weather protection is triggered;
- Premium – the cost of the insurance per hectare insured;

Location & Calculation Period

Index-based insurance contracts must be written on the nearest UHC weather station to the farmer's land in order to provide the best possible coverage for the farmer client. Indeed, the extent of the UHC weather observing network may be a limiting factor for the applicability of this type of insurance in regions that do not have a UHC station. The correlation coefficients for the interannual variation in cumulative rainfall, cumulative average temperature and SHR for April 15 – June 30 for five weather stations in the oblast respectively from 1973-2002 are given in the tables below.

It is clear temperature exhibits less spatial variability than rainfall. A very loose rule-of-thumb is that farmers living within a 30km radius of the weather stations are able to purchase weather insurance for that station.

The calculation period described the effective dates of the risk protection period during which relevant weather parameters to construct the index will be measuring at the location. For example, the calculation period for the SHR drought insurance contract is 15th April – 30th June to cover the leaf-tubing to kernel formation growth period of winter wheat. Final settlement of the weather insurance contracts typically occur up to 45 days after the end of the calculation period, once the collected weather data has been cross checked and quality controlled by the UHC.

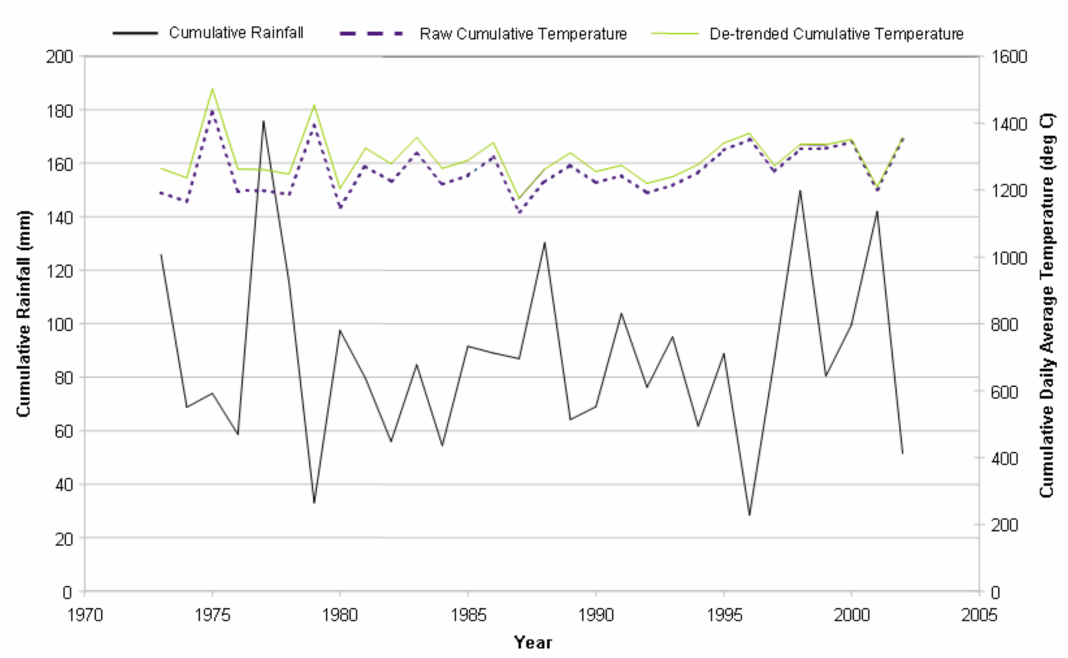
Station Name	Behtery	Genichesk	Kherson	N Kahowka	N Sirogozy	Station Location
April 15 – June 30 Cumulative Rainfall Correlation Coefficients (1973-2002)						
Behtery	1					46`15`` N 32`18`` E
Genichesk	0.72	1				46`10`` N 34`49`` E
Kherson	0.74	0.59	1			46`38`` N 32`34`` E
N Kahowka	0.70	0.41	0.65	1		46`49`` N 33`29`` E
N Sirogozy	0.35	0.54	0.39	0.50	1	46`51`` N 34`24`` E
April 15 – June 30 Cumulative Temperature Correlation Coefficients (1973-2002)						
Behtery	1					46`15`` N 32`18`` E
Genichesk	0.93	1				46`10`` N 34`49`` E
Kherson	0.98	0.93	1			46`38`` N 32`34`` E
N Kahowka	0.98	0.95	0.99	1		46`49`` N 33`29`` E
N Sirogozy	0.95	0.95	0.98	0.98	1	46`51`` N 34`24`` E
April 15 – June 30 SHR Correlation Coefficients (1973-2002)						
Behtery	1					46`15`` N 32`18`` E
Genichesk	0.69	1				46`10`` N 34`49`` E
Kherson	0.74	0.59	1			46`38`` N 32`34`` E
N Kahowka	0.74	0.44	0.68	1		46`49`` N 33`29`` E
N Sirogozy	0.38	0.58	0.42	0.50	1	46`51`` N 34`24`` E

Strike & Premium

The strike determines the level of risk retention of the farmer and is the key to pricing. A strike very close to the mean of the index indicates a low level of risk retention by the farmer and a contract that will pay out with high probability, implying a large premium to the farmer. A strike further way from the mean reduces the probability of a payout and hence the premium of the contract as the farmer is retaining the more frequent, near-the-mean risk himself and transferring less to the insurance company selling the protection. In general, insurance is appropriate for risks that happen with a frequency at least less than one in five years and generally around the one in ten year level or less. For example, in the case of April-June drought, the strike can be set at SHR level given in the previous table appropriate for the weather station under considered.

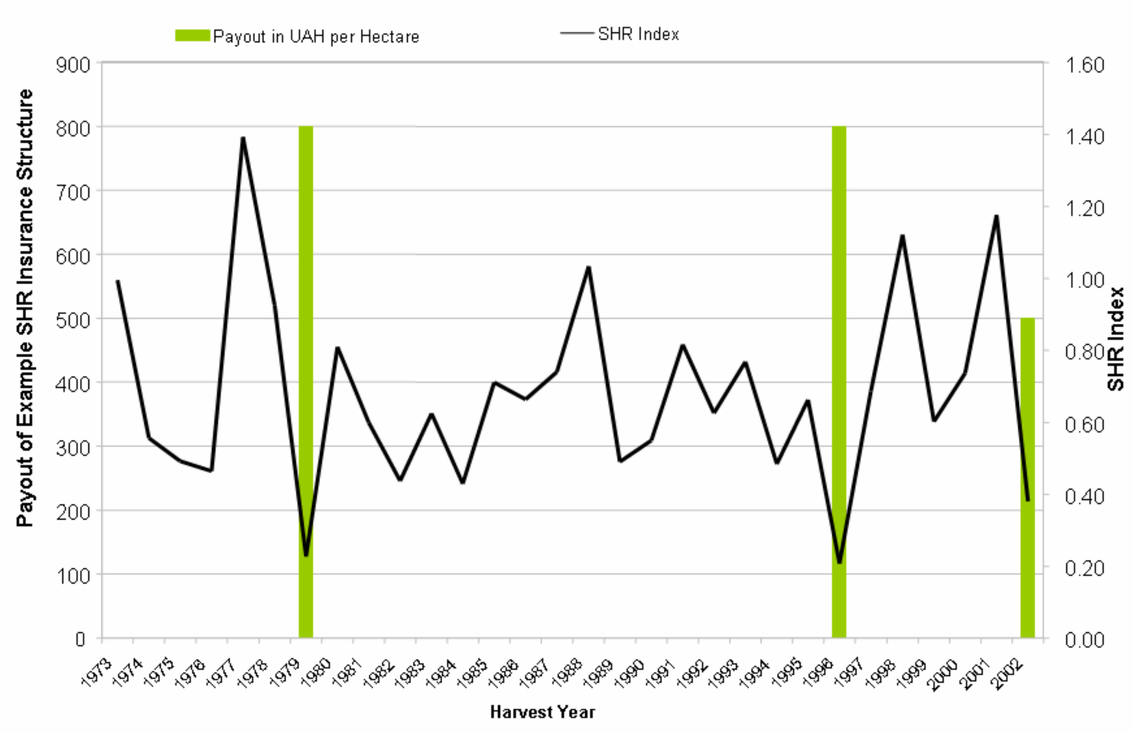
The premium of an index-based weather insurance contract is determined actuarially, that is by conducting a rigorous analysis of the historical weather in order to understand the statistical properties and distribution of the defined weather index and payouts of the insurance contract. Such an analysis includes: *a)* cleaning and quality controlling the data, i.e. using statistical methods to in-fill missing data and/or to account for significant changes, if any, as a result of instrumentation or station location changes; *b)* checking the cleaned data for significant trends and de-trending to current levels if appropriate—this is particularly pertinent for temperature data which in general exhibits a strong warming trend in the northern hemisphere and; *c)* performing a statistical analysis on the cleaned and de-trended data and/or a Monte Carlo simulation using a model calibrated by the data to determine the distribution of the defined weather index and payouts of the insurance contract. By determining the frequency and severity of specified weather events an appropriate premium can be calculated. A pricing example for winter wheat drought risk is given below for Behtery weather station.

Figure 2 Cumulative Rainfall and Average Temperature for Behtery Weather Station for April 15- June 30 for the period 1973-2002[10]



[10] Source: Authors' figure using weather data from Ukrainian Hydrometeorological Centre, Kiev.

Figure 3 SHR Index for Behtery Weather Station, 1973-2002[11]



[11] Source: Authors

Example: Pricing drought risk as measured by the SHR Index

In Behtery, droughts of varying intensity happen quite frequently. Figure 2 shows the cumulative average temperature and cumulative daily rainfall measured at the Behtrery station from 15 April – 30 June 1973-2002. The temperature data exhibits strong trends, hence the data must be detrended in order make the historical data consistent with the recent warmer and conditions, which may make severe drought events more frequent in Bethery now than 30 years ago. The weather data from the UHC is of high quality and does not need to be cleaned or quality controlled prior to analysis. The data is detrended by fitting and removing a best-fit linear trend to the cumulative average temperature and rainfall totals respectively for 15 April – 30 June. Figure 3 shows the corresponding SHR index: medium droughts (SHR < 0.6) have occurred nine times in the past 30 years and severe droughts (SHR < 0.4) two times. The driest conditions occurred in 1996 with SHR = 0.21.

The payout of a SHR index insurance contract at Behtery is determined by the following equation:

$$\text{Payout} = \min(\,M, \max(0, K - SHR)*X\,)$$

where M is the maximum payout of the contract per hectare, K is the strike, SHR is the SHR index measured during the calculation period and X is the tick size, determined by the tick size structure given in above. To calculate the premium for the insurance contract one must determine the following parameters for a given strike:

a. The expected loss of the contract, *E(SHR),* i.e. the average payout of the insurance structure each year;

b. The standard deviation of the payouts of the contract, $\sigma(SHR)$, i.e. a measure of the variability of the insurance contract payouts;

c. The x^{th}-percentile of the payouts, i.e. a measure of the value-at-risk (VaR) of the contract for the seller, $VaR_X(SHR)$. For example, the 99 percent VaR represents the economic loss that is expected to be exceeded with 1 percent probability at the end of the calculation period of the contract.

These three parameters quantify the expected (1) and variable (2,3) payouts of the insurance contract and must be determined from the historical weather data, either by using the 30 SHR values from the 30 years of detrended data (given in Figure 3) or by using the data to calibrate a Monte Carlo simulation model to generate thousands of possible SHR realizations in order to fill-out the distribution of payouts and to determine better estimates of *E(SHR),* $\sigma(SHR)$ and $VaR_{99}(SHR)$. A complete description of the various methods for determining these payout statistics are beyond the scope of this paper, but it is clear that *E(SHR),* $\sigma(SHR)$ and $VaR_{99}(SHR)$ will vary with the strike. The historical payouts for a SHR index insurance contract with a strike level of SHR = 0.4 are given in Figure 3.

The price of an insurance contract is then determined by the risk preferences of the insurance company, that is how they measure the cost of risk with respect to return for the purposes of pricing, risk management and capital allocation[12]. As a result this is the most subjective aspect to the risk pricing process as it is largely driven by the business imperatives and risk appetite of the insurance company, however it is clear that the insurance company will charge *E(SHR)* plus an additional risk margin for taking the weather risk from the farmer, i.e.

$$\text{Premium} = E(SHR) + \text{Risk Margin}$$

From a farmer's perspective, he essentially already holds the cost of *E(SHR)* in his business plan – it is the average annual cost (loss) associated with weather risk when farming winter wheat in Behtery. In other words without insurance the farmer can expect to lose this amount *on average* each year, therefore the premium he essentially pays for weather insurance is the risk margin charged by the insurance company. Some examples of the

[12] Henderson, R., Chapter 10, Banks, E., Ed., 2002, "Weather Risk Management: Markets, Products and Applications", Palgrave, New York. For a full discussion on pricing weather risk readers are referred to this book and particularly Chapter 10. This section on pricing is based on Mr. Henderson's discussion on pricing weather risk.

more commonly used methods for measuring risk and hence determining the risk margin of a risk taker include the Sharpe Ratio and the Return of VaR method – both measure expected excess return in terms of some measure of risk and hence determine the "cost of risk" for the insurance contract seller[13].

Sharpe Ratio,

$$\alpha = [\text{ Premium - E(SHR) }] / \sigma(\text{SHR})$$

$$\text{Premium} = \text{E(SHR)} + \alpha\sigma(\text{SHR})$$

Return on VaR (99 percent),

$$\beta = [\text{ Premium - E(SHR) }] / \text{VaR}_{95}(\text{SHR})$$

$$\textbf{Premium} = \text{E(SHR)} + \beta\ \text{VaR}_{99}(\text{SHR})$$

The Sharpe Ratio uses standard deviation as the underlying measure of risk and therefore α represents the "cost of standard deviation" as determined by the seller's risk preferences. One of the benefits equating risk with standard deviation is that it is an easy parameter to estimate, however it is a symmetric measure of risk capturing the mean width of the payout distribution[14] and it is clear from Figure 3 that the payout distribution is not symmetric but has long tail. The Return on VaR method uses VaR (99 percent) as the underlying measure of risk and therefore β represents the "cost of VaR". The advantage of VaR_{99} is that it is computed from the loss side of the payout distribution, where loss is defined as underperformance with respect to the expected payout, *E(SHR),* and therefore captures the potential loss to the seller[15] and is more appropriate for catastrophic crop failure risk such as extreme drought. However VaR_{99} is a harder parameter to estimate particularly for strike levels set far away from the mean. Therefore the worst-case recorded historically can often be used as a cross check for VaR.

A reasonable estimate for α, β given prices in the weather market are α = *25 percent* and β = *5 percent*. For a strike level of SHR = 0.4, by taking the simple 30-year average of payouts in Figure 3, *E(SHR)* = 70 UAH, σ*(SHR)* = 220 UAH and VaR_{99} = 800 UAH Therefore an appropriate premium to charge a farmer for an insurance contract with a strike level of SHR = 0.4 at Behtery weather station is between 110-125 UAH per hectare.

3.3 Insurance Contract Example

An example of a SHR based weather insurance contract for winter wheat in Kherson is given below.

REINSURANCE OF A WEATHER INSURANCE PORTFOLIO

The benefit of indexed-based weather insurance contracts is that given the objective nature of the underlying index such contracts can be easily reinsured by players in the international weather market. A local insurance company can choose to reinsure the entire portfolio of contracts sold, which in turn may determine the price of the contracts to the farmer, or only a portion of the portfolio to cap the maximum exposure the insurance company to drought in Kherson.

Furthermore, a company running a sales campaign will obviously hope to sell a substantial volume of insurance contracts written on several weather stations within the Kherson oblast. It is clear from the previous section that there is some diversity in weather conditions within the Kherson oblast. Therefore the overall position of the company's weather insurance portfolio as well as the availability of possible hedging contracts, e.g. selling excess rainfall contracts for April-June for vegetable farmers in the region, may also impact and reduce the price of the insurance to individual farmers. The reason being a well-diversified book of contracts will reduce the relative σ and VaR_{99} parameters and hence the of the overall risk position of the portfolio.

THE 2005 PILOT IN KHERSON

According to Ukrainian legislation, in order to be able to introduce a new product, such as index-based weather insurance, to the market the participating company (or companies) must design and register the rules of insurance with the state regulatory body. Although the law on insurance – the leading document regulating the insurance industry – does not specifically reference "index" insurance, other legislative documents introduce index-based products in relation to agricultural applications, for example relating to agricultural insurance and state finance support of the agricultural sector.

[13] As above.

[14] As above.

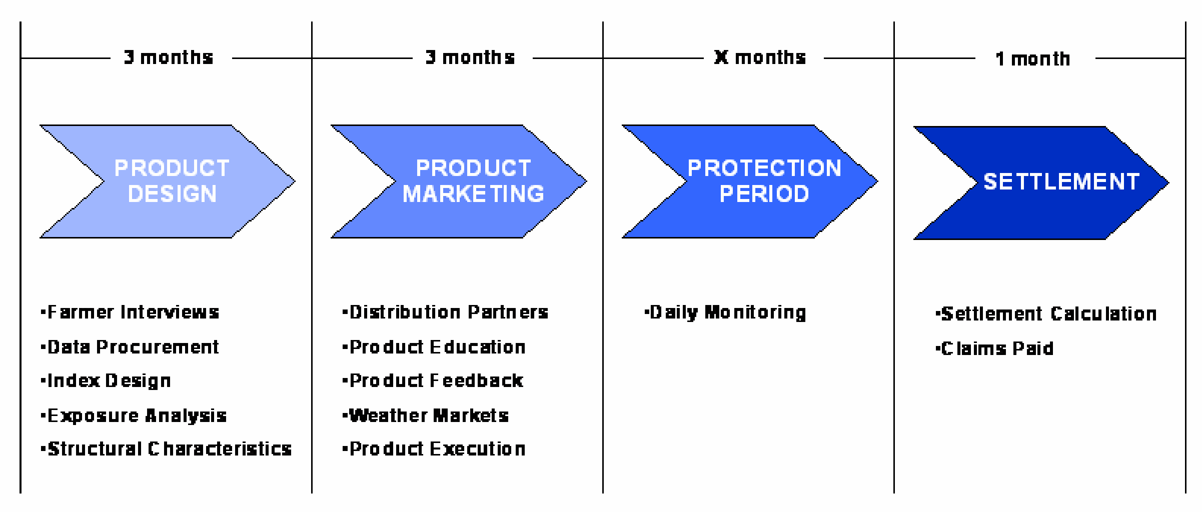
[15] As above.

As a result there is no direct legislative barrier prohibiting the use of index-based products in Ukraine and in April 2004 the regulator agreed to register rules of insurance that permit the development of different types of index-based insurance products for agribusiness applications.

The insurance company partner, Kiev-based Credo Classic, working with IFC-PEP and CRMG submitted the necessary package of documents to the regulator in Kiev, in doing so drafting and registering the rules of insurance for index-based weather insurance products with the regulating body. The rules of insurance were accepted at the beginning of April 2005, clearing the way for the first weather insurance pilot in Ukraine. The regulator confirmed that given the nature of the product the insurer is not required to carry out field checks and loss adjustments, despite the potential of basis risk. The regulator further stated that the insured area must not be greater than the seeded area and, for the purpose of this product, a farmer report declaring the seeded area should be sufficient proof of the maximum possible area for insurance.

The weather insurance contract designs and marketing materials for the proposed pilot program in Kherson were finalized following the State Regulator approved the rules of weather index insurance for agricultural applications. IFC-PEP worked with the insurance partner in Kherson oblast to target groups – including farmers, agribusinesses and financial institutions – who may benefit from the new insurance products through feedback and workshop sessions. Only two weather insurance contracts were sold during the brief marketing period, primarily due to the timing of the pilot and late regulatory approval. The protection period for the first pilot finished in July 2005. The results of the small first pilot will be communicated to the public to raise awareness about index insurance and the pilot experience: the concept and methodologies developed will be made publicly available. At the present time the insurance company leading the pilot in Kherson is already providing consultations to other markets players in Ukraine on designing index-based products in-house and drafting the rules of insurance for these new products.

Buyer:	Farmer Z 1 Wheat Street, Bethery, Kherson, UA
Seller:	ABC Insurance Company
Hectares of Winter Wheat Insured:	100 Hectares
Calculation Period:	15th April 2005 – 30th June 2005 (inclusive)
Location:	Behtery WMO 12345
Index, SHR:	**SHR = Index 1 / (Index 2 * Scaling Factor)** Where: **Index 1** = Cumulative Capped Daily Rainfall measured during the Calculation Period at Location. Measuring Unit: mm **Index 2** = Cumulative Daily Average Temperature measured during the Calculation Period at Location. Measuring Unit: Degrees Celsius **Scaling Factor** = 0.1
Capped Daily Rainfall	Capped Daily Rainfall = min(50, Daily Rainfall Total) Measuring Unit: mm
Strike, K:	0.4
Maximum Payout, M:	1000 UAH per Hectare Insured
Settlement Calculation:	If the **Index SHR** is greater than the **Strike K** no payment is made. If the **Index SHR** is less than or equal to the **Strike K** the **Buyer** receives a payout **X** per hectare insured from the **Seller** according to the following **Settlement Calculation**: **If 0.36 < max(K – SHR, 0) < 0.41, X = 500 UAH** **If 0.31 < max(K – SHR, 0) < 0.36, X = 600 UAH** **If 0.26 < max(K – SHR, 0) < 0.31, X = 700 UAH** **If 0.21 < max(K – SHR, 0) < 0.26, X = 800 UAH** **If 0.16 < max(K – SHR, 0) < 0.21, X = 900 UAH** **If max(K – SHR, 0) < 0.16, X = 1000 UAH**
Maximum Settlement:	The maximum payment that can be made from the **Seller** to the **Buyer** is 100,000 UAH.
Premium:	The **Buyer** will pay the **Seller** a premium of 12,000 UAH for the weather protection outlined above.
Settlement Data:	Ukrainian Hydrometeorological Centre, Kiev
Settlement Date:	Within 45 days of the end of the **Calculation Period**.


3 months
3 months
X months
1 month
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PRODUCT MARKETING
PROTECTION PERIOD
SETTLEMENT
•Farmer Interviews
•Data Procurement
•Index Design
•Exposure Analysis
•Structural Characteristics
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