Several Aspects Regarding Weather and Weather Derivatives

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In recent years, one of the factors that had a significant impact on the economic development was represented by climatic change. At international level, the weather risk management stands for a priority for Governments, insurance companies and companies within the industries affected by the weather variability. Within this article, we try to address a more suitable approach than the insurance policies on the matter of weather risk management by presenting an innovative alternative risk management solution represented by weather derivatives. Furthermore, we focus upon an important economic sector - the agriculture by emphasizing the specific aspects with regard to the employment of weather derivatives.
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1. Rationale

Climatic changes influence more and more the companies due to the major impact the weather factors' volatility has upon their yields. Furthermore, as a direct consequence of the importance of the agricultural sector within the Romanian GDP, the yield variability caused by weather account for a significant part of the Romanian economic evolution. In other words, the weather can have both a direct influence, reflected in agricultural losses, and an indirect impact noticed on the economic growth in case of high dependency on the farming sector.

Consequently, the companies within the sector above mentioned, are in search for new instruments to manage the risk regarding weather. Furthermore, for the specialists within the financial sector, weather turned into the opportunity of some new financial contracts and, as a consequence, into a support asset for the derivatives contracts. The weather derivatives are financial contracts for which the value is linked to the evolution of an index, computed as a function of the parameters of a meteorological phenomenon such as rainfalls, temperature, wind speed, humidity or snow depth.The weather derivatives market has its origins in the deregulation of the energetic industry in the USA. The volatility of weather conditions was always one of the determinants influencing the energy consumption, but after the deregulation, the different participants in the American energetic activity (electric power producers, energy, and heating products), were exposed to temperature variability as a new significant factor of risk regarding the aspects connected to the quantities transacted and with consequence on the financial ones: the local monopolies had to compete on bigger markets and discover new ways for income balancing. Presently, these products are among the most efficient financial instruments regarding weather risk management.

For the farmers, the weather derivatives have emerged in order to permit to those economic activities exposed to the unforeseen weather changes to manage their risks in the same way in which they used the traditional derivatives for the price risk management.

2. Perspective on weather derivatives and insurance policies

Traditionally, the pure risks were managed employing insurances contracts, and the speculative ones, using contracts specific for the derivative markets. In the last years, the border between the two contract types has disappeared through the emergence on the financial markets of new forms of pure risks management solutions, named generically *alternatives risk transfer*. The profiling of these financial instruments pre-

sents a special importance: the increase of risks diversity covered by the accessing the capital markets. Thus, the field of insurances and that of the capital markets are combined for the efficient allocation of the capital in view of covering the present risks[1]. Nonetheless, one should question about the opportunity of using the weather derivates with reference to the existence on the market of the harvest insurances.

A basic difference resides in the fact that the weather derivatives refer to a well specified phenomenon, which can be identified through specific parameters, specified in the contract, and when these ones reach certain values, the agent will be immediately indemnified, regardless the damages concretely suffered. Differently, the harvests insurance policies cover the risks regarding either one or more variables and indemnify only after the assessment of losses caused by the specified variables. Therefore, through the derivatives contracts under discussion the whole procedure of assessing the losses is eliminated, and implicitly the costs are reduced. In other words, there will not be uncertainties in connection to the origination of payment to the economic operators. Obviously, due to the fact that only the price of the weather derivative is linked to the meteorological variable, there can be excluded the inconveniences regarding the information asymmetry (adverse selection and moral hazard).

Furthermore, one should denote the fact that through insurance contracts are covered the risks regarding extreme phenomena, while by derivate contracts are covered the risks regarding the meteorological events which refer to the exposure of one company's incomes to the consequences of the meteorological weather derivatives can be transferred, having a superior degree of liquidity when standardized.

[1] Wang, M., (2001), Financial Derivatives in Corporate Risk Management, Dissertation Presented to the Faculty of Graduate School of the University of Texas at Austin In Partial Fulfillment of the Requirements for the Degree of Doctor in Philosophy, UMI Microform 3036610 ProQuest Information and Learning Company, August 2001

Consequently, the weather risk is a special risk, its features having a great influence upon the technique chosen for the outlining the derivates contracts. First, the meteorological phenomena are not to be found under the direct human influence, such as regulations. Second, there is no effective market regarding weather: you cannot stock it or transfer it (e.g. one cannot negotiate a rainy day).

Starting from these characteristics, one can evidence the fact that the weather derivatives are different from the commodity derivates through the fact that the support asset is not a tradable one. While the commodity derivatives have a spot market, on which the support assets are traded, the weather or more exactly, the meteorological phenomena, as we affirmed, cannot be sold or purchased.

Within the farm sector the risks have, in general three forms:

First, we can discuss about the harvest risk that refers to the probability of obtaining an inferior yield to the values considered as normal when considering the factors involved for its obtaining.

Second, it is held in view, the event risk that refers to the probability of realizing an exceptional event and it is characterized by great losses and by relatively small frequency of occurrence (e.g. the floods).

Third, the agricultural activity is submitted to the price risk, which is covered traditionally by use of commodity derivatives contracts. These ones offer protection against the price risk, but elude the covering of the volume risks.

The weather risk is considered a volume risk, or a quantity one, rather than a price risk. Although the instruments of price risk management are largely available, they have a limited applicability for the management of volume risks. In order to manage the weather risk, there were developed the weather derivatives and we could state that they represent important instruments.

Accordingly, they are not used for covering the price risk of the support asset, but implemented as a substitute for covering the volume

risks, which could be represented by an income reduction due to a winter with higher or lower temperatures than normal.

3. Weather and weather derivatives

The agriculture sector is always subjected to changes regarding the weather condition, fact which determines that an important part of the economy to stand under the sign of uncertainty, and the economic operators in this sector to not be able to appreciate exactly the production level.

These aspects can be seen in the variations of the contributions brought by the farm sector in the economy of a country due mainly to the evolution of the weather condition and to the cyclical character of the harvests.

The exposure to weather can be defined as the sensitivity of revenues to the variability of weather. In order to outline a weather derivative contract for the farm sector, there must be a strong correlation between it and the meteorological phenomenon chosen as asset as the same variable influences differently upon the soil, the harvests or the different phases met during the crop development. In addition, the meteorological event must be characterized by measurable parameters while the historical data regarding its evolution should be available.

Thus, the main element which must be carefully managed in the profiling of these financial contracts refers to the existence of a genuine relationship between the weather variable and the farm production, such that the weather derivatives should explain a great part of the production's variability.[1]

[1] Stoppa, A. (PROCOM, Italy), Hess, U.(The World Bank); (2003) Design and Use of Weather Derivatives in Agricultural Policies: the Case of Rainfall Index Insurance in Morocco; International Conference Agricultural policy reform and the WTO: where are we heading? Capri (Italy), June 23-26, p. 4

Agriculture is directly linked to the weather: the level of the production fluctuates as result of the changes regarding the meteorological conditions, and among the meteorological phenomena most frequently mentioned in connection to the volatility within the farm sector are temperature and rainfalls. But the establishing of a indisputable pattern of the connection between harvests and the two variables is hard to identify, as the crop type and its localization seem to account to a great extent for it.

The essential element of a contract is represented by the support asset and the method of measuring its parameters. With respect to this aspect, the location is extremely important; it specifies the place where the index is measured, given by the location of the weather station.

The best- known weather derivatives are those based on temperature changes. This aspect can be explained by the fact that temperature can be measured daily. In USA, for example, temperature has most often calculated by help of the indexes represented by HDD (Heating Degree Days) and CDD (Cooling Degree Days). These represent the average of highest and lowest temperature of day measured in Fahrenheit degrees, at a certain weather station. A degree day is the variation measure of the average temperature from the value of 65ºF. HDD measures the lowering of the daily temperature in comparison with a standard of 65ºF, while CDD measures the increase of a daily temperature in comparison with 65ºF.

HDD of a day is defined as HDD=max (0, 65ºF -A)

CDD of a day is defined as CDD=max (0, A-65ºF).

Thus it can be ensured a protection regarding risks of chillier summers or of warmer winters than the average. The futures contracts under discussion are firm engagements of selling or buying of the value of the HDD/CDD index at a future specified date. These contracts are with monthly due, being permanently listed as seven consecutive futures contracts. Moreover, the total value of the contract is not transferred, the loss or gain being transferred to the operator. The most of-

ten used futures contract is that offered by CME (Chicago Mercantile Exchange). This was introduced in 1999 on the electronic platform of the Globex stock exchange. The monetary value of the index is settled as being the value of the index multiplied by 100 USD.

In Europe, LIFFE has created Monthly and Winter Season, having as *asset* the average of the daily temperatures in a month for three locations: Berlin, London and Paris. Opposite to the monthly index, the winter one is an average of the daily temperatures for a specified period of time: November 1- March 31.

The best-known weather – based index for the farming sector is GDD (Growing Degree Days).Its value is determined as a maximum function between 0 and the difference between an average of the maximum and minimum value in a day and a threshold temperature. For a certain period these daily values are added up and linked to the farm production. The growing degree days are measuring plants development in a season and take into consideration the fact that plants are directly connected to a certain temperature in the germination and development phases, depending on the crop type.

Before the introduction of the weather derivatives, the farm companies could manage exclusively the price risk by use of commodity derivatives. In agriculture, the risks regarding the rainfalls level are very important: after a period characterized by hard drought, the farmers are reducing the areas cultivated if they expect more reduced rainfalls than the normal level. On the other hand, abundant rainfalls can affect at their turn the harvest through the manifestation of some specific maladies. In the case of rainfalls, the most proper calculation structure for the indexes would be that under the form of determining the averages of rainfalls in certain zones. The wind speed could be at its turn a support asset for agriculture, the indexes being calculated in a manner alike the previous ones. Another reference asset could be considered the number of shiny days. It is well-known the fact that the lack of sun

during some phase regarding the development of wine cultures influences the grapes quality.

The financial structure of the weather options is similar to the financial options. First, we can mention the exercise price, which represents the limit level for the payment commencement for the protection buyer. Second, other important elements are represented by the weather station where the reference indexes are determined, the parameters, and implicitly the calculation method. In addition, there must be specified the value to be paid per index unit and the maximum value which the seller is obliged to pay to the buyer.

One of the weather risks often met in the case of farm crops is that referring to the extreme volatility of the temperatures. When one considers that harvests will be affected by extremely high temperatures, one can opt for a CDD index call option. From the contract stipulation until its maturity the CDD will be calculated daily and these values will be summed up. If the registered daily temperatures are extremely high, the differences between the average of the maximum temperature and that of the minimum temperature in a day and the fixed value (65ºF) the CDD index will be characterized by high values. If we consider the asset as being the index calculated this way, it results that its value is compared at maturity to the exercise price specified in the option contract. If, the exercise price is lower than the index value, then the buyer will be indemnified.

If one considers the covering of extremely low temperatures risk, one can opt for the purchase of a put option on an index of HDD type. This way, for the specified period the HDD will be calculated daily and these values will be summed up until maturity. Obviously, if the daily temperatures registered are extremely low, the differences between the fixed value (65ºF) and the average of the maximum and minimum temperatures in a day will have low values. If one considers as asset the index, it results that its value is compared at maturity to

the exercise price specified in the option contract. If the exercise price is higher than the index value, then the buyer will be indemnified.

As one can notice, modelling the weather derivatives seems to be intricate for the sector in discussion. If in the majority of industries a contract can be outlined for a certain period to cover against a single risk, as far as the farm sector is concerned, certain meteorological phenomena can have an influence at the same time: for the summer period, certain crops can be affected both by drought and by abundant rainfalls.

Drought represents a factor with a strong impact upon farm production as much as the new global climate context favours the emergence and the maintaining of this phenomenon.

A recent paper[1] presents as support asset for the weather contracts the level of soil humidity. This is modified by the type of soil and by the geographical characteristics of the zone where it is calculated, by the climate changes in that particular zone and by the human interference. One of the major advantages of this resides in the fact that it can be used to cover diverse risks as are those of floods, drought, or rainfalls. For the call options on the soil humidity index (Water Table Index) it is proposed a model through which the premium is paid by the operator at contract's start. When the difference between the WTI index and the exercise price is positive, the option seller pays an amount equal to this difference multiplied with a tick value. For the put option, the mechanism is alike, except the relationship between the index value and the exercise price in case of exercising the option under discussion.

[1] Agarwal, A.(2002), A new approach &model for weather derivative instrument based on water table for floods, droughts, and rainfalls; Finance India; Sep 2002; 16,3; ABI/INFORM Global, pg. 877

4. Positive aspects and inconveniences

A first special characteristic of the weather derivatives is represented by the exact settlement of the event leading to the indemnity payment. As it was remarked, these contracts have the advantage of eliminating the moral hazard: due to the fact that losses/gains are calculated exclusively on the basis of the physical parameters of the event specified in the contract, there is no possibility that the farm agent who is covering crops through these contracts should report losses superior to those effectively suffered. This element is concretized into a strong motivation for the introduction of these financial contracts on the derivatives market.

From the point of view of the protection seller, the adverse selection is eliminated: this refers to the fact that agricultural companies have more information connected to their production and to the associated yield losses than the insurance company. As a result, the insurance company will compensate this lack of equilibrium in information settling an average risk premium (higher for those with reduced risk and smaller for those with high risk). As consequence, those farmers with very high risks will choose to buy protection.

In addition, revenues stabilization can be realized, mainly in the case of seasonal crops, which are correlated to the weather condition. What one must consider is that in the case of farm sector its relationship to the time is special: in the case of crops, the frequency, periodicity and the values reached by the different meteorological aspect influence differently the different types of crops.

In addition, the contracts under discussion represent a special interest for the participants from the financial markets, explained by the fact that these are assets with a low correlation with the economic or political events. Thus, it is given the possibility for improving the risk-return ratio for a portfolio. This aspect can be noticed in the case of the weather derivatives due to the advantage above mentioned: that is

the low degree of correlation between these financial contracts and other assets in a portfolio.

In other words, farmers can reduce losses caused by the meteorological phenomena, the insurance companies can cover their exposure regarding the demands for indemnities linked to the weather, and the portfolio managers can include these instruments in order to benefit from the risk diversification. Therefore, securitization of the weather risk allows investors to combine the weather derivatives with the traditional classes of assets.

The main inconveniency of the weather derivatives is represented by the location risk, transposed into the fact that the parameters of the support asset (temperature, humidity, wind speed), are measured in locations established, which could be different of those in which the events take place and for which cover is necessary.

In addition, events like rainfalls, winds, have a local character; as result, there can be significant differences between the effective losses and the indemnities of the derivative contracts. The future of the weather derivative contracts depends on the size of this risk. In other words, farmers must cover themselves through a derivate contract, which calculates the parameters of the index at a weather station, in the proximity of the agricultural zone submitted to risks.

Consequently, through the transaction of the weather derivates, the farmers could be affected due to the fact that these contracts are stipulated in a different place than the area where their crop id influenced by weather. The size risk is linked to the correlation between the loss of company and the sector's losing. The smaller this correlation, the higher is the risk of location. One solution could be represented by the creation of regional indexes.

5. Perspectives regarding the weather derivatives

For the introduction and the successfully management of these contracts, it is essential the realization of independent data collection centres regarding weather variables, in order to ensure the market transparency and to give a feeling of trust in connection with financial instruments. Moreover, it is necessary a historical data basis in order to evaluate these assets. In addition, we cannot imagine a market in which the participants should trust without the development of some evaluation patterns, taking the form of models and techniques. Of great relevance for the enrichment of the weather derivatives market, one should consider the realization of a data system regarding the meteorological phenomena: the high cost and their weak quality could be impediments for the market's liquidity.

As farm sector is differently influenced by weather risks in comparison with other sectors, a single crop being affected by more factors in a different manner (humidity, temperature or rainfalls) the most appropriate solution would be that of outlining weather derivatives having as support asset a complex of the involved factors. In addition, one should notice that, in each country, there should be outlined contracts especially designed for the thar area, in connection with the relevant crops of the zone and with their reaction to the meteorological phenomena.

An important element linked to the weather derivatives refers to their transparency. This must be ensured by putting at the disposal of those who trade on these markets, the relevant information, linked to the indexes determination: the location (the meteorological station) where are being transacted the contract's parameters, the modality of calculation and the frequency.

Although it is mentioned that the weather risk can be transferred within the market to speculators, one can also consider the case of targeting the risk towards those companies in sectors with divergent risks as regards the same meteorological event.

An important perspective with could refer to the possibility of simultaneously covering the risks in the hydro energetic sector and the agricultural one. As the companies in the hydro-energetic industry depend from point of view of gains both on the temperature, and on rainfalls, there can be outlined contracts to encompass the two types of meteorological phenomena. In addition, taking into account the fact that risks regarding rainfalls and temperature in agriculture are compensated with those in the industry mentioned above, one can consider the possibility of ensuring of a minimum degree of liquidity.

Furthermore, taking into account the existence of indexes regarding the global heating, there can be outlined weather derivatives for agriculture with respect to this risk. Recent studies[1] appreciate a possible link between the global heating and the floods generated by rivers' overflow. As result, if more studies of the kind could demonstrate an exact connection between the global heating and the evolution of the parameters, characteristic for the weather condition phenomena, the above- mentioned indexes could be used as a support asset.

A special relation is that between the pollution level, deforestations and the variations of the meteorological phenomena, which are affecting the crops: under the conditions of demonstrating a significant correlation, the weather is not an asset totally independent from the human nature anymore. Under these conditions, in the zones with a high level of natural equilibrium degradation, the covering through the derivative weather contracts and the accessing of the capital market could prove the adequate solution.

Moreover, under these conditions one can consider the creation of some ecological yields, or the reduction of the influence of the products from the chemical industry upon the soil (implicitly the reduction

[1] Submitted by: Linnerooth-Bayer, J.,IIASA, Mace, M.J., FIELD, Verheyen,R., University of Hamburg, with support (Sec III) from Compton, K, IIASA: (2003) Insurance –Related actions and Risks Assessment in the Context of the UNFCCC, Background Paper for UNFCCC workshops Commissioned by the UBFCCC Secretariat: May 2003.

of the pollution degree especially when accompanied by water infiltrations from the soil)[1], we can assume that in case of influence of certain meteorological phenomena, the crops could be affected by certain specific diseases. In this case, the risk regarding the negative variation of the production, and implicitly of incomes, can be managed by investing in weather derivatives.

An extreme, that should not be omitted, is that linked to the potential pollution of the environment due to floods, affecting the zones where are stored the natural fertilizers coming from the livestock farms[2] A special case regarding weather risk is that referring to the livestock[3], if one considers the fact that these are negatively influenced by the meteorological extremes (e.g. the relationship between the temperature and the average daily milk production). In this case, we could discuss about an in-chain risk: first, one can consider the risk of higher costs regarding the acquisition of the farm products (when the producer of these products is not insured with reference to the weather risk); second, one can consider the weather risk with reference to his own production.

Therefore, in the farm sector, we can discuss about a chain of risks and losses, generated, mainly, by the same meteorological phenomenon, with negative influences, both on the producers and on the final buyer.

References

[1] Skees, J., (2002): The Potential Role of Weather Markets for US Agriculture; The Climate Report, Vol. 2, N0 4, Fall 2001 available at www.guaranteedweather.com.
[2] *Idem*
[3] *Idem*

Agarwal, A. (2002), "A new approach & model for weather derivative instrument based on water table for floods, droughts and rainfalls", *Finance India*, Sep. 2002, 16, 3; ABI/INFORM Global.

Brocket, P.L., Wang, M., Yang, C. (2005), "Weather, derivatives and weather risk management", *Risk Management and Insurance Review*, Spring 2005, 8, 1; ABI/INFORM Global.

Buckley, N., Hamilton, A., Harding, J., la Roche, N., Ross, N., Sands, E., Skelding, R., Watford, N., Whitlow, H.; "European Weather Derivatives"; General Insurance Convention 2002/Nick Ross (Chairman), 08 Oct. 02; available at http://www.actuaries.org.uk/files/pdf/giro2002/Ross.pdf

Garcia, A.F., Sturzenegger, F., "Master of Science in Banking and Finance – MBF Master's Thesis *Hedging Corporate Revenues with Weather Derivatives: A Case Study*"*;* Universite de Lausanne, Ecole des Hautes Etudes Commerciales HEC – 2001.

Geman, H., Leonardi, M.P. (2005), "Alternative Approaches to Weather Derivatives Pricing"; *Managerial Finance*, 2005; 31, 6; ABI/INFORM Global.

Moody, Michael J. (2006), *Weather Risk Management*; Rough Notes; May 2006; 149, 5; ABI/INFORM Global.

Ray, R. (2004), "Weather derivatives: Global hedging against the weather", *Derivatives Use, Trading & Regulation;* 2004; 9, 4; ABI/INFORM Global.

Skees, J. (2002), "The Potential Role of Weather Markets for U.S. Agriculture"*; The Climate Report*, Vol. 2, No. 4, Fall 2001, available at www.guaranteedweather.com.

Stewart, R.T. (2002), "Derivatives Instruments Written on Non-Tradable Assets: The Case of Weather Derivatives"*;* ProQuest Information and Learning, 300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA, UMI Microfilm 3045136, 2002.

Stoppa, A. (PROCOM, Italy), Hess, U. (The World Bank); (2003) "Design and Use of Weather Derivatives in Agricultural Policies: the Case of Rainfall Index Insurance in Morocco"*; International Conference Agricultural Policy Reform and the WTO: Where are we heading?*, Capri (Italy), June 23-26.

Wang, M. (2001), "Financial Derivatives in Corporate Risk Management"; Dissertation Thesis Presented to the Faculty of the Graduate School of the University of Texas at Austin; The University of Texas at Austin; August 2001, available at http://wwwlib.umi.com/cr/utexas/fullcit?p3036610

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