Financial Innovations Designed to Mitigate Climate Risks

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Abstract
This research paper aims to build a mechanism suitable for hedging the climatic risks by using financial innovations. The research starts from the premise that the climatic changes during the past years have had a significant impact on the level of agricultural production, cost, prices, and income stability both at the level of agricultural exploitations but also the economic indices at macroeconomic level. Then, following a risk management evaluation, we propose the establishment of a portfolio of indices on the evolution of the meteorological events (rain and temperature). Based on these indices there can be drawn the standardized elements of a contract for derivatives used as alternative mechanisms for the transfer of the agro-climatic risks.
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Keywords
Financial Innovations, Climatic Risk, Selyaninov Index, Derivative Instruments, Climate Change, Hedging

JEL Classification
G23, G32, O14, Q14

Introduction

The climate change represents a major challenge to ensure water resources and crop stability. The 4th Report of the Intergovernmental Committee for Climate Change (ICCC), published in 2007, noted that the single weather events cannot be attributed to a single cause, as the statistical analyses show that the risk of such events to happen is growing due to global warming (Solomon, et al., 2007, p. 310). The global climate change will therefore increase the uncertainty in agricultural production.

At European level, the first political initiative on adaptation to climate change was the “Green Paper”, adopted on 29 June 2007 (Commission of the European Communities, 2007). In April 2009, The European Commission (EC) presented its “White Paper” which had as main objective to establish the framework for action at European level to adapt the climate change (Commission of the European Communities, 2009a). The report “Adapting to climate change: the challenge for the European agriculture and the rural areas” published in 2009 by EC, mentions comprehensive information on the impact of climate change on EU agriculture, examines the needs for adaptation, describes the implications of the Common Agricultural Policy (CAP) and explores possible orientations for future action (Commission of the European Communities, 2009b).

This research paper will focus on analysing risks that are related to weather events and climate change, and have a severe impact on the agricultural sector. Some studies are promoting the idea that it is easier for some developing markets to provide rainfall insurance than traditional crop insurance (Skees, Hazell and Miranda, 1999; Skees, 2000). We discuss about innovations for supplying insurance for climate risks, and propose a basic infrastructure and some financial tools that can be used in order to mitigate the climate risks and support farmers in hedging from agro-climatic risks.

Currently, the agricultural sector is increasingly exposed to both economic and environmental risks, due to the phenomenon of climate change and high volatility in prices. In this context, effective risk management is of major importance for the process of agricultural production. In Europe, knowledge transfer and innovation in agriculture and risk management and natural resources are key priorities for Common Agricultural Policy of EU Member States. Also, "Europe 2020: A European strategy for smart, sustainable and inclusive growth" discusses the efficient use of resources in the context of future climate challenges (European Commission, 2010).

For the most financial innovations, the literature on the issue of evaluation of contracts on agro-climatic indices on climate change is relatively recent. A summary of the theoretical foundations can be found in the work of Jewson (Brix and Ziehmann, 2010). What is remarkable is that each market sector defines its own derivatives evaluation model, as shown in the work of Sloan (Palmer and Burrow, 2002) and Brockett (Wang and Yang, 2005). It also states that although the actuarial valuation models have been successful in the insurance industry on weather derivatives, these are not entirely satisfactory (Sloan, Palmer and Burrow, 2002). With regard to financial models of evaluation, the Black-Scholes is most often mentioned in the literature. However, due to lack of market liquidity of these contracts, the model cannot be successfully applied for derivatives on agro-climatic indices, which is found in the works of Dischel (2002), Cao and Wei (2000) and Davis (2001). In this context, we find in the literature other valuation models with a higher degree of adaptability: *quadratic approaches* with Follmer and Sondermann (1986), Heath (Platen and Schweizer, 2011), Bouleau and Lamberton (1989), as main promoters; *quantile hedging and shortfall minimization*, found in the works of Cvitanić (Pham and Touzi, 1999), and Follmer and Leukert (1999), or the usage of *marginal utility* (Davis, 2001).

Managing risks in agriculture

Too much/little rainfall or too high/low temperatures can have systemic impacts on decision-making, productivity, and market options (Jaffee, Siegel and Andrews, 2010). The climate and weather risks can also affect the quality of products and perturb the flow of grains in an economy. Although such risks have impact mainly geographically and affect only a small number of individual supply chain participants, they can also lead to disruptions in transportation, communication and energy services. But, even if a localized weather-related event can affect farmers from a certain area, other buyers, processors and traders might not be affected, because they can handle the transactions by finding replacements for locally manufactured products with producers from a non-drought areas and/or import goods. So the overall performance of the supply chain could go perform well, while individual farmers (or groups of farmers) are subject to a risk (that can be managed with proper tools).

The risk management is an area of research with a rapid development in recent years. As for the risks in agriculture, they know generally three forms. First, we can discuss the *risk of crop* which refers to the ability to obtain a lower production value considered normal in relation to the factors involved in getting it. This risk is characterized by a high probability of realization (and relatively low losses). Secondly, it is envisaged by the *event risk* which refers to the probability of an event and is characterized by exceptionally high losses, but also a very low frequency (for instance: floods). Third, the agricultural activity is subject to *price risk* and covered traditionally by using derivative contracts (futures and options) on agricultural products.

The most unpredictable risk from the agricultural activity is the food price risk and instability which are subjects that were comprised by food policy debates over years and there is a good reason for that. Volatility of prices of staple foods such as maize, rice and wheat, can have severe economic, social and political consequences (Timmer, 1995). Price volatility can lead to very inefficient agricultural production decisions, particularly when credit and risk markets are poorly developed (Newberry and Stiglitz, 1981; Myers, 1988; Williams and Wright, 1991; Myers, 1992). The volatility of food prices can lead to macroeconomic shocks and political unrest, discouraging long-term investment and sustaining a slow growth.

Food prices can become extremely unstable and risky as a result of climatic events, world price fluctuations, an inelastic supply and demand response in domestic markets, and high transportation costs (World Bank, 2005). Climate cycles and global climate change increase the exposure of developing countries to droughts, floods and other extreme weather events that increase the risk of sharp fluctuations in food production (Tobey, Reilly and Kane, 1992).

Until the 80s, the traditional political response to volatile food prices in developing countries was the state's intervention. Governments were responsible for the flow of the bought and sold food, controlled food prices and limited domestic and foreign trade, usually by cereals marketing organizations. Although such interventions have reduced, in many cases, the price volatility, they have imposed economic costs (Schiff and Valdes, 1992). Apart from the high costs that can often be observed when public institutions take on marketing functions, direct government intervention is often vulnerable to rent-seeking and the unequal distribution of benefits (McPherson, 2002). Over time, these interventions have led to changes in national price levels (which often fall below the limit price), high treasury costs, and large income transfers (often from the poor to the rich; Jayne and Rukuni, 1993).

The governments' intervention in the food sector until the 1980s was considered a major barrier in the growth and development of the developing countries' food sectors (World Bank, 1994; World Bank, 2000; Dorward, et al., 2004). The reformation of this sector begun by governments' involvement in promoting the reform of food marketing and price policies aimed towards offering incentives for farmers by maintaining stable prices. Moreover, the markets have begun to open to the private sector. All these have been the subject of numerous debates (Barrett, 1999; Reardon, et al., 1999; World Bank, 2000; Dorward, et al., 2004). Even if food market reforms were introduced in many developing countries, they were done only partially, and the success of these reforms lies in maintaining the food price stability and low levels of risks.

Innovations for supplying insurance for climate risks

The understanding of the weather risks and the exposure to such risks have undergone a growth in complexity which has meant the passing from a traditional approach to following and controlling of risks and the crisis management to an integrative approach which has as its main objective the proactive management of such risks. Therefore, the traditional techniques for risk management, developed from the theory of utility and the portfolio theory (Markowitz, 1952; Sharpe, 1964; Lintner, 1965), and the following development of the financial markets by creating derivatives, set by the models of Black and Sholes (Black and Scholes, 1973) and the theory of rational option pricing (Merton, 1973) and the coming of the standards for risk measurement such as Value at Risk (RiskMetrics Group, 1996) we arrive nowadays to a more and more integrative approach both in practice and especially in research. Also, the developments at the institutional level, such as Weather Risk Management Association (WRMA) have led to the standardization and the development of specific markets for weather risk management.

Due to its nature, the research in the field of climatic risks through derivatives is complex, having a particular meaning both for economy, and for social and ecologic climate, and has some tendencies to clear up the main research path. Therefore, the research directions in the field of financial innovations aimed to mitigate climate risks have to encompass:

(I) *The study and the underlining of the particularities of the weather risks and their impact*. The specific literature in the financial and insurance field focuses on risk and its management (Dischel, 2002; Geman, 1999). A current research issue is represented by the opportunity of using weather derivatives under the existence of a crop insurance market. The failure of private insurance markets in offering crop insurance contracts is documented in the literature by Glauber, Collins and Barry (2002). The difference between the classic insurance of harvests and those through derivatives is that weather derivatives are based on a well-defined phenomenon, which can be identified through specific parameters stipulated in the contract. In the case these parameters reach certain values, the insurance company will compensate the agent who has used them to cover specific risk regardless of the damage suffered. In contrast, the insurance policies on crops cover the risks of one or more variables and they are compensated only after assessing the loss caused by the variables in question. Through contracts on agro-climatic indices the whole process of loss evaluation is eliminated, and thus it reduces the costs. In other words, there will be no uncertainty related to payment to the insuree. In comparison with the insurance policies which cannot be transferred, the weather derivatives have a higher degree of liquidity and can be easily transferred.

(II) *The drought-agriculture relationship*. For example, in 2002, in Romania, as part of a research project funded by the National Programme for Environment, Energy and Resources (MENER) the first national synthesis of the risk of drought in areas with forest was developed based on combined experience in monitoring and forecasting this phenomenon in forest districts of Romania. The researches developed under European-funded projects after 2005 have contributed to the foundation of the climate-agriculture relationship in the context of current trends (observed) and future evolution of climate and associated extremes, aiming to quantify the economic impact of climate change on agricultural productivity, monitor the water scarcity and water resources, and identify adaptation measures.

(III) *Setting agro-climatic indices and launching derivative contracts used to support the risk management.* The scientific literature has paid particular attention to derivative contracts on indices and agro-climatic indices in agriculture (Skees, 2000; Skees, et al., 2001; Martin, et al., 2001; Dischel, 2002; Vedenov and Barnett, 2004). As far as the contracts introduced into developing countries (India, Morocco, Ukraine), some efforts were done to research (data availability, construction and testing of econometric models) and implement new financial structures. In our specialized literature, for Romania, some research was done by Hurduzeu and Constantin (2008), and Kevorchian, Hurduzeu and Gavrilescu (2012). The indices used can be the Selyaninov index as it will be described in the next subsection. The derivative contracts having as asset the indices are financial products (futures contracts) characterized by standardization, traded on on-line auction with permanent negotiation in perfect transparency.

The Selyaninov index as a risk management tool

In general, the financial instruments such as the derivatives on agro-climatic factors are intended to cover with low risk the events with a high probability of achievement in comparison with the weather insurance which cover high risk with low probability.

Selyaninov suggested that the sum of temperatures, that is, the product of mean air temperature for a period when it exceeds a specified value (often 10°C) times the duration of this period, be used as a characteristic of potential evaporation. An index proportional to the ratio of precipitation to the sum of temperatures was called the hydrothermal coefficient by Selyaninov (Budyko, 1974, p. 333).

The Selyaninov index (introduced in 1930) is given by the following relationship:

$$k = \frac{p}{t/10} \qquad (1)$$

where p is the sum of rainfall (mm) during those months when mean temperatures are above 10°C and t is the sum of daily mean temperatures above 0°C for the same period (Vogt and Somma, 2000, p. 336).

An index of Selyaninov type can be calculated under the following formula:

$$SHR_{grain} = \frac{{}_{15\,April}^{30\,June} Daily\ rainfall}{0.1 * {}_{15\,April}^{30\,June} Daily\ mean\ temperatures} \qquad (2)$$

This index (based on data from the past 20 years, for example) will meet certain values for each crop and for each studied area (if the Romanian Plain will be studied, counties from this area can be taken into consideration), as well as having an interval of the optimal value, which requires adequate rainfall and temperatures favourable to crops and therefore, a small exposure of farmers to climate risk. The exit from interval means risks that are higher as the distance is wider and more significant.

After constructing the Selyaninov index, futures contracts will be developed for each subject crop taking into account (such as corn, canola, wheat, sunflower, barley) and for each of the areas concerned. The substantiation of the contracts will be based on key environmental variables recorded at weather stations representative for the analysed area of culture. To profile contractual formulas, it should be taken into consideration the following parameters: (i) location - represented by the meteorological station where the data were collected in order to build the index, (ii) the period of calculation - the index represents the period of protection, (iii) level of exercise - represented by the index for which protection is triggered, (iv) the prime - the cost of insurance for each hectare, (v) prices, (vi) active months, (vii) tick – the trading steps, (viii) last trading day, (ix) the last day of execution.

The data collected on climatic factors will be analysed in terms of trend. Subsequently, these data will be made on a statistical analysis and Monte Carlo simulations to determine the distribution of agro-climatic indices and related financial hedges. Depending on the frequency and severity of weather events included in the indices will be calculated first contracts, representing a fixed amount per hectare, the function for calculating the amount offered if weather phenomena parameters exceed certain limits (captured in the agro-climatic indices previously created).

Therefore, using these risk management tools finds its rationale in the need to address the obvious advantage of the farmer's specific problems, complex and especially current for the agriculture, while contributing to the alignment in the management of agro-climatic risks.

Conclusion

The recent innovations in the capital markets can provide solutions to hedging from natural disaster and climate risks by enabling the bearers of the risks to share the exposure to such event with market investors (Skees, et al., 2002). By evaluating the relationship between land use and global environmental changes, there can be made improvements to environmental policies and strategies, for managing environmental risk, and for the health of the population in the studied areas. It will also provide useful scientific information for territorial planning activities, by identifying and mapping potential areas with agro-climatic risks. By pursuing a research that will use the futures contracts and will calculate the Selyaninov index mentioned in the above, the results may be useful for the work of agricultural improvement, development of genotypes with resistance to current and future climate changes, ensuring sustainable exploitation of natural resources (climate, water and soil). Data can also be gathered on ways to improve farming efficiency through the developed measures and adaptation options.

In general, one can say that stimulating the economic activities leads to the creation of new jobs, with consistent social impact on the overall employment, and the acquisition of knowledge and continuous training. Positive social impact is felt on all the target groups; the upstream and downstream activities will be stimulated, which will further create new jobs. In this way, the economic and social impacts are intertwined.

An optimal management of agro-climatic risks through the solutions developed in this research generates social beneficial effects, mainly in disadvantaged areas of a country. At a national level, this research can also contributes to capacity development for institutional cooperation, developing economies' resilience against climate risks, and consolidating the ability of preventing and reacting to disasters, according to the objectives of Europe 2020.

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