

USE OF WEATHER DERIVATIVES IN AGRICULTURE

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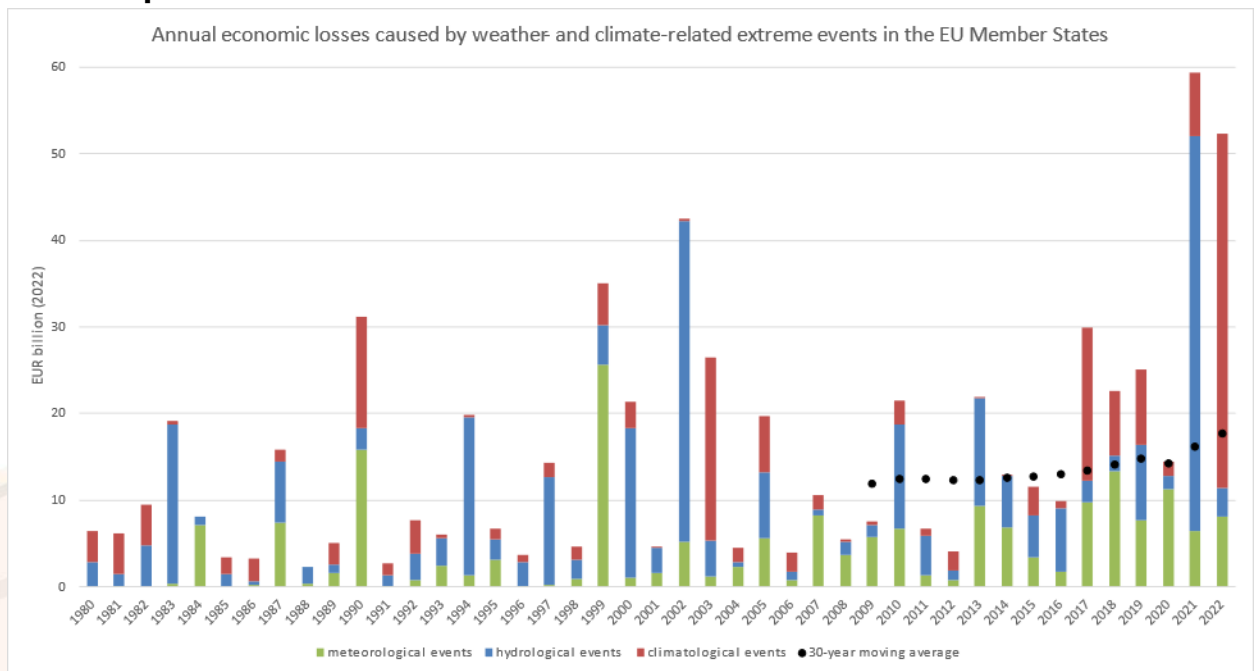
Abstract: *Recent innovations in capital markets suggest the possibility of addressing agricultural risk factors by issuing derivatives on weather elements. Such instruments appear particularly attractive, as asymmetric information and loss adjustment issues do not affect them. This article describes the concept, functioning and application of weather derivatives.*

Keywords: *Weather risk, weather derivative, weather insurance, index-based weather insurance, option contract.*

Due to the effect of human's economic and social living activities, our planet is suffering obvious change, for which, the climate warming is the key characteristic. The changed climate results in glacier melting and rising of sea level, bad extreme weather, reduction of grain output, and species extinction. The changing climate also brings huge losses to all industries, such as natural disasters of hail, draught, and flood directly affecting the output of grain, energy industry, transport industry, and construction industry. Weather often has a significant impact on agricultural production. Climate change has increased the frequency and intensity of catastrophic weather events that can caused serious financial damages to the farmers. Actually, it is to be expected that weather fluctuations will increase in the future due to climate change. Weather and its changes have driven a demand for weather risk management.

Weather risk refers to the phenomenon that people's life, production, and operation, or certain commodity's production cost and market demand fluctuate due to nondisaster weather events as rainfall volume, temperature, humidity, and snowfall volume, which further result in uncertain changes to cash flow and gain of economic entity. The weather changes have very important effect on the economic activities of industries of agriculture, transportation, construction, and tourism. With the social and economic development, the demand on weather risk management of these industries would become more and more urgent. One of the most obvious applications of weather risk management products, be it weather insurance or weather derivatives, is in agriculture and farming. Weather impacts many aspects of the agricultural supply and demand chain. From the supply side, weather risk management can help control both production or yield risk and quality risk.

Graph 1¹



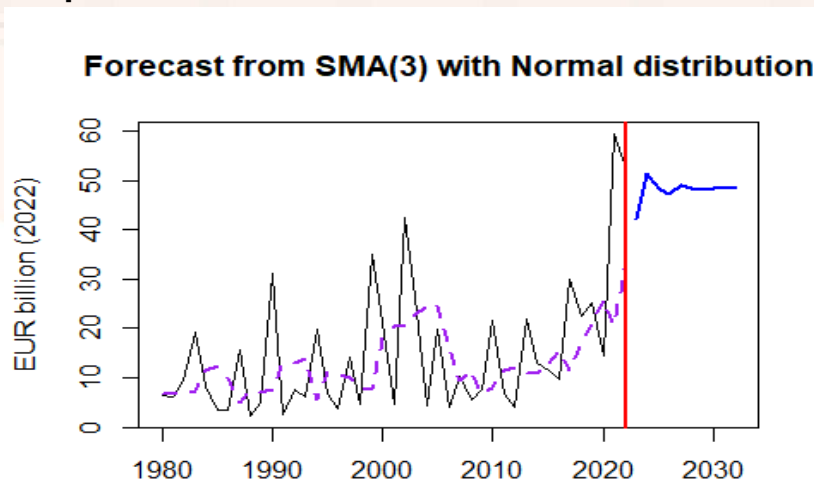
We analysed these indicators in R studio. We found out that MA Smoothing model for these indicators is the best model and built this equation:

$$\hat{X} = F_t + \varepsilon_t = \frac{x_t + x_{t+1} + x_{t+2}}{3} - 0.13684 \cdot \varepsilon_{t-1} - 0.29690 \cdot \varepsilon_{t-2} + W_t$$

If we predict with this model, Annual economic losses caused by weather- and climate-related extreme events in the EU Member States will reach 42.05667, 51.25222, 48.52296 billion euros in 2023, 2024, 2025, respectively.

You can visualize this model with following graphics and by this understand the impact of the weather on economy.

Graph 2



¹ <https://www.eea.europa.eu/en/analysis/indicators/economic-losses-from-climate-related>

Market of weather derivatives started from North America in 1997. In order to avoid bad effect of nonanticipated weather change, Enron and Koch Energy signed the first batch of weather derivatives contract in the world, which indicated the formal start-up of weather derivatives market. Since its foundation, the development speed of weather derivatives market is amazing. And the trading scale, types, and participants increase every year. Especially, it is prosperously developed in European and American securities market. Investors can not only perform hedging by purchasing various kinds of weather risk products from capital market, but also acquire profits by various kinds of trading and changes of weather. The weather factor and payment variable in the weather derivatives contract are flexible and easy for operation. Enterprises may disperse the possible weather risks by purchasing proper weather derivatives, thus to realize the purpose of risk transfer.

The weather derivatives market is one of financial markets having most potential. As a kind of financial derivatives instrument innovation, it is the output of optimized capital market and highly developed market economy. With the further development of market, the weather derivatives market attracts more and more attention from European and Asia-Pacific Region countries, such as Great Britain, France, Germany, Switzerland, and Japan, etc. It is becoming globalization day by day. And with the further deepening of economic globalization and financial integration tendency, the prospect of the weather derivatives would surely attract people's attention.²

Technology plays a key role in production risk in farming. The introduction of new crop varieties and production techniques offers the potential for improved efficiency, however agriculture is also affected by many uncontrollable events that are often related to weather – including excessive or insufficient rainfall, hail, extreme temperatures, insects and diseases – that can severely impact yields and production levels. Countless examples can be given on the impact of cold temperatures on deciduous fruit, deficit rainfall on wheat, excess rainfall on potato yields and even temperature stress on cattle and thus dairy production. In 2001 California's wine revenue fell by over \$200 million, which was largely attributed to frost damage of wine grapes in April of that year. In 2003, 64% of Ukraine's winter wheat crop was destroyed due to winterkill temperatures and 40-50% of northeastern England's oil rapeseed crop was lost to due excessive rain at harvest in August 2004.

Weather can also impact the quality, if not the absolute production levels, of a crop. An example can be taken from the brewing industry. A large brewery needs a specific quality of barley for its production of beer and contracts land for barley production in order to have direct access to the quality of barley it needs. The key

² "Function of Weather Derivatives in Risk Management" article by Xinyuan Zhang

risk to the quality of the barley produced occurs once the plant is mature where excessive rain and humidity will cause the seed to lose weight and discolor. In years where the crop quality is insufficient, the barley can be used for animal feed or alcohol at a lower market value, but the brewery will still need to purchase the barley at market prices incurring an additional cost to the brewery – a cost that can be insured against by the purchase of an appropriate weather risk management product.

On the demand side, weather also impacts related agricultural products through the use of pesticides, fertilizers and herbicides. Agricultural chemical producers, for example, can use weather risk management instruments to hedge against the costs associated with fluctuations in the demand for chemicals by farm operators. Increases in pesticide sales are often related to weather conditions, particularly accumulated Growing Degree Days, that impact the gestation period and hence the birth rate of pests. Cotton boll weevil, which costs cotton producers in the U.S. \$300 million a year, is an example of a weather sensitive pest whose numbers differ from year to year largely due to the severity of the winter. In extremely cold winters weevil numbers drop significantly, directly affecting the net earnings of an agrochemical company. Chemical producers could hedge their earnings volatility through fluctuations in pesticide sales by purchasing a weather risk management instrument specifically indexed to the phenology of pests their products target.

Index-based weather insurance is a relatively new product and the use of weather risk management products in the agricultural sector is still in its infancy, with very few publicized transactions in the U.S. and Europe. However there have been a number of agricultural transactions outside of the main weather market trading hubs, most notably in Canada (Ontario – maize; Alberta – forage), Argentina (Sancor – dairy), South Africa (Gensec Bank – apple cooperative freeze cover) and India (ICICI Lombard – groundnut, cotton, coriander and orange). Given weather is one of the biggest risks faced by farmers, weather-indexed risk management products have been suggested as a potential alternative to the traditional crop insurance programs for smallholder farmers in the emerging markets. Traditional multi-peril crop insurance programs have several problems when they are translated from the developed world to emerging markets. Most notably the high unit administration costs, high entry barriers for farmers and difficulties of control make traditional crop insurance schemes neither practical nor cost effective in small-farmer economies. These new weather risk management insurance instruments provide a viable alternative to traditional insurance instruments, potentially offering real advantages to households, businesses and governments in developing countries.³

³ Weather Risk Management for Agriculture by Joanna Syroka

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