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Design and Valuation of Weather Derivatives in Agriculture: A Methodical Approach

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Abstract

The article discusses weather derivatives as a potentially effective risk management tool for agribusinesses looking to mitigate the risk of their revenue against changes in weather conditions. The design and evaluation of weather derivatives is an interdisciplinary approach that includes agro-meteorology, statistics, mathematical modeling, and financial and risk management. This document provides an overview of data sources first, and then methods for designing and evaluating meteorological derivatives at the regional level. The accompanying case study focuses on cereal cultivation in the Czech Republic. However, its generalization is simple. The analysis of major cereal growth stages was based on regression analysis using weather indices as the independent variable and crop yield as the dependent variable. Along with the bootstrap tool, burnout analysis is considered a useful tool for estimating the uncertainty of payouts, option prices, and income probability distribution statistics. The outcomes show that the space base and production risks reduce the effectiveness of weather derivatives. Finally, the potential for expansion of weather derivatives remains in low-income countries in Africa and Asia with systemic weather risk.

Keywords: Agri; Weather; Crops

Introduction

Weather determines decision making around the world. Lazo quantifies an overall year-over-year dollar volatility of 3.4% in US economic activity due to climate change. However, the sensitivity to weather conditions in high-income countries is relatively low because agriculture accounts for a small share of GDP. In contrast, the underdeveloped world and many emerging countries with a significant share of agriculture in GDP and employment face climate risks that do not have the financial and infrastructural resources to manage. They a financial weather contract is a conditional weather contract whose payout is determined by future weather events. The contract ties payments to a weather index which is a set of weather variables measured at a given location over a specified period of time. The basic "properties" of weather derivation are usually air temperature, precipitation, wind speed, etc. Many related studies examine the potential use of weather derivatives in agriculture [1,2]. The main advantage of index financial instruments is their ability to reduce information asymmetry. The gain is estimated by an objective, measurable and transparent weather variable that cannot be intentionally altered by the farmer or any other entity. Also, the biggest downside of the weather derivatives and index insurance they most often favor is the underlying risk. The cause of facility risk is that individual productivity fluctuations in general do not correlate perfectly with the relevant weather variable. Spatial basis risk arises from differences in weather conditions at the derivative reference point and the agricultural production site [3-5]. There is also an important prerequisite for the efficient use of weather derivatives in agriculture. Weather derivatives are more effective at hedging earnings risk on products with a higher probability of a low correlation between output and price. These arguments also raise the need to assess competition in terms of price performance. This article aims to evaluate the potential of weather derivatives to reduce income risk in agriculture taking into account the growing conditions in the Czech Republic. The problem with the risk management system in Czech agriculture is that systematic risk is not insured against drought, heat wave and persistent rain at harvest. This article is organized as follows. The first section focuses on describing a methodical approach to the design and evaluation of climate derivatives at the regional level [6-8]. The second section presents the outcomes and discusses the main outcomes, opportunities and limitations of agro-weather derivatives.

Issues in Agrometeorology

The selection of regions for the design of weather derivatives is based on the fact that the agricultural production of that region is large enough to warrant the liquidity of the contract. Structural and economic data show that four Czech regions produce more than 50% of the national agricultural output. In addition, the Olomoucký and Královéhradecký regions have a relatively higher risk of drought due to their large plains. These areas are also characterized by grain production on fertile soils. Meteorological data were purchased from the Czech Hydro meteorological Institute. The analysis uses average daily/ monthly air temperature and daily/monthly cumulative precipitation [9,10]. Monthly weather data is spatially averaged data provided by professional weather stations located in six selected regions. We apply the following meteorological indices: air temperature (°C), precipitation and dry index combined air temperature and precipitation, and CDD/ HDD, i.e. the number of degrees where the temperature is the average of a day higher/lower than a certain temperature degree. The CDD base air temperature was set using linear optimization to obtain the highest Pearson correlation coefficient between the basal air temperature and crop yield.

Discussion

A moderately statistically significant relationship occurred between wheat/barley yield and air temperature and drought index in May, June and July. Both grains have similar sensitivity to air temperature. Localized precipitation, the risk of lack or conversely, excess rainfall

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that is not systematic. An inverse relationship is shown between yield and rainfall during tillage before sowing. However, the correlation between wheat/barley yield and rainfall at the regional level is rather weak. The outcomes confirm the susceptibility of wheat/barley to a lack of rainfall and higher spring temperatures. Conversely, drier periods in some regions are beneficial when preparing the soil before sowing. The Jihomoravský region is the most drought-prone area, in which the correlation coefficient between yield and drought index exceeds 0.5 and is statistically significant at. The higher the risk, the higher the return - the Jihomoravský region is indeed a favorable region for growing high-quality wheat and barley.

Conclusion

In Czech agriculture, the climate index explains up to 48% of the variation in average grain yields. More than 50% of systemic risk of return cannot be hedged by weather derivatives or weather insurance. Given the potential of weather derivatives as a reinsurance tool, it is important to clarify the legal and institutional aspects of agricultural earnings risk management using weather derivatives, especially regulation and possible areas of cooperation between the public and private sectors. The analysis shows that a high fundamental risk can significantly distort contract performance. In the Czech Republic, weather index contracts can only reduce the change in grain earnings by 5-6%. If the underlying risk does not exist, the contract could reduce the variation in grain sales by more than 10%.

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