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Weather index insurance: a useful tool to reduce performance risk in crop farms?

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Context

Weather conditions and extreme meteorological events such as heat, drought or storms may cause considerable fluctuations of farm income (performance risk). Nevertheless, farmers' demand for novel risk management tools such as weather index insurance (WII) remains low so far. Two different explanations have been put forward to explain the low adoption of WII: bounded rationality of farmers and a low risk reducing capacity (hedging efficiency) of WII (cf., e.g., Gsottbauer & van den Bergh, 2011, Mußhoff et al., 2014, Schulte-Geers, 2014). Due to increasing high temperature and water scarcity periods such as in summer 2015 (Agrarzeitung, 2015), yield-related performance risk is assumed to be on the rise in German crop farming. Hence, decisions regarding the use of costly (hedging) instruments such as WII are becoming an increasingly prominent concern for crop farmers who struggle most with water problems (cf., Gömann et al., 2015). Against this background, the decisive question for farmers is how WII reduces the volatility of farm income. A suitable measure of farm income can be a relevant performance figure such as the farm's total gross margin, which is the most important yardstick for production program decisions (Schweitzer and Küpper, 2011). In the past, only few studies have analyzed the hedging efficiency of WII regarding the volatility of a farm's total gross margin. These studies have found a risk reducing effect of WII (Kellner & Mußhoff, 2010, Schulte-Geers, 2014). Their informational value regarding the risk-reduction capacity of WII in practical farming, however, is limited due to severe data restrictions. They either resort to short time series (ca. 10 years) and/or to averaged, instead of farm-specific data. To our knowledge, there are no studies that are based on (more convincing) longer time series of farm-specific gross margins.

In view of these research gaps, this study aims to analyze the risk reduction capacity of WII in crop farms in various regions of Germany. In particular, the following questions for the farms under investigation will be answered:

1) How would WII have changed the volatility of the farm's total gross margin compared to historic volatility without the use of WII?
2) What does the farm's forecasted risk profile (volatility of total gross margin) with and without the use of WII look like?

Methodology

Using historical simulation, the hedging efficiency of WII is analyzed ex-post. No parametric estimates of distributions are needed since the analysis is based on the sampling distributions of the farm's single gross margins and its historic production programs. In a first step, the variability of the farm's past total gross margins is quantified. We then specify hedging strategies based on weather index insurance

contracts[1] and analyze how they would have changed volatility.[2] In an alternative approach, time series analysis will be used to obtain parametric estimates for the distributions of the farm's single gross margins, the distribution of the cash flows produced by the respective hedging instrument under consideration, and the correlations. Based on this information, we treat the farm's production program as a portfolio of activities fraught with risk (cf., Markowitz, 1952) and use the variance-covariance method (cf., Mußhoff & Hirschauer, 2007) to compute the variance of the farm's total gross margin (portfolio variance) ex-ante. As a start, the risk reducing capacity is measured from a static point of view. That is, holding all else constant, we compare the portfolio variance without hedging instrument to the portfolio variance with the instrument (cf., Mußhoff & Hirschauer, 2008).

The object of study are crop farms in North Rhine-Westphalia and Lower Saxony. These regions cover a range of soil and climate conditions in Germany that can be considered as "average" compared to sites such as Brandenburg, which suffers from poor soils and comparatively low rainfall, or Bavaria with its high rainfalls (see Table 1). Furthermore, a certain degree of comparability is assumed because the conditions in both regions are quite similar.

Table 1: Geographic and climate conditions of selected regions in Germany

	Quality of the soil (ground points)	**Average annual precipitation** (mm)	**Average annual temperature** (°C)
North Rhine-Westphalia	54	1072	8,9
Lower Saxony	57	1070	8,6
Brandenburg*	41	586	8,7
Bayern**	54	1656	7,5

*Federal state with lowest average annual precipitation; **Federal state with highest average annual precipitation.
Sources: Bundesanstalt für Geowissenschaften und Rohstoffe (2015) and Deutscher Wetterdienst (2015a, 2015b).

Contrary to most previous studies, we do not resort to farm models based on averaged data. Instead, data from real farms over a period of at least 15 to 20 years are used. Data include the farm's production program, its total gross margin, as well as the yields, prices, and variable costs for each of the farm's activities. To model the gross margins (cash flows) of weather index insurance we use long time series of location-specific weather data.

(Expected) Results

As the above-mentioned research questions are subject to current research, no results can be presented yet. But, due to the findings of past studies, a risk reducing effect of WII is expected regarding the volatility of a relevant economic performance figure such as a farm's total gross margin.

Conclusion

Due to changing climate conditions and therefore increasing income volatility, insurance against volumetric risks such as WII may become increasingly important for crop farms in Germany. Hence,

[1] Strategies will be specified based on market offers from professional providers such as "Wetter Protect" or "CelsiusPro". Specified strategies do not necessarily coincide with the optimal-hedge-ratio strategy.
[2] A similar methodical approach has been used by HEIMFARTH and MUßHOFF (2010). Their analysis is based on the volatility of sales revenues and therefore does not go far enough to measure the reduction of volatility of farm income.

analyzing the capacity of WII for risk reduction in crop farms is more relevant than ever. For a preliminary assessment of the relevance of WII for farmers, it is important to analyze their risk reducing capacity in real crop farms in regions with average conditions as those selected.

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