Agricultural Insurance Schemes

Executive Summary

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1. Introduction

This study focuses on the assessment of index tools for agricultural insurances. Index insurances basically differ from traditional agricultural insurances in that they do not refer to the actual farm losses, but to the losses evaluated from an index. This index can be, for example, some area yield or revenue, some meteorological or agro-meteorological parameter or a satellite imagery parameter. The analysis considers the coherence with the WTO agreements and the effectiveness to deal with the risk of substantial income reduction of farmers. The study is structured in three main parts. The first part analyses the loss risk from FADN data. The second part evaluates index insurances. The third part makes a cross-validation of index insurances based on FADN data. The analysis covers all 27 Member States of the EU. However, most aspects of the study are restricted to EU-15 because of data availability, in particular for the FADN loss risk assessment, for which long time series are not available for the new MS. Income indicators based on FADN data are taken into account since 1994, yield indicators from Eurostat data since 1975, meteorological and agro-meteorological indicators since 1975 and indicators based on coarse resolution satellite images since 1998.

2. Review of index insurances

This chapter starts with a thorough review of index-based risk management tools. Index contracts are more properly financial derivatives or options than insurances. However, under certain conditions, they can be considered as insurance: “the weather derivative can be brokered as an insurance contract or as an over-the-counter traded option”, according to Turvey (2001). Weather derivatives or weather options are managed by the private sector, and limited information available about them. The financial weather contracts market has been originally in the hands of the energy sector, but from 2005 to 2007, the Over-The-Counter end users related to the agricultural sector has doubled. In Swiss Re’s client database, the majority of the business covering weather risks outside developed countries (North America, Europe, Japan and Australia) is with counter parties in the agricultural sector. Anyway, as a whole, this market is in the early stages. The pricing of index insurance is a complex issue: traditional methods for pricing financial derivatives have been used, but insurance or actuarial methods can be more adequate. On the other hand the possible impact of climate change is difficult to assess.

The main advantages over classical insurance is that they avoid moral hazard and adverse selection problems, which allows higher levels of coverage; it is easy to sell through banks and any financial organisations; it is transparent and affordable with very low administrative costs. However, an insured event may not always reflect the production losses experienced by the individual farmers, so it is better adapted for very homogeneous areas and for reinsurance.

There is a wide variety of types of index insurance. We can distinguish two main groups:

- area yield and revenue insurance (the index is directly an area average yield or income);;
- indirect index insurance: exogenous and yield tailored. At the same time, they can be based on one or several indicators, which can be either:
    - meteorological, (the indices are variables such as rainfall or temperature);
        - agrometeorological (the indices are indicators which include agronomic parameters relative to the crop, such as soil moisture or leaf area index);
        - satellite imagery indicators (vegetation indices computed from satellite images).

The literature review includes both studies that analyse area yield insurance and studies that refer to indirect insurances based on meteorological indicators. Among these, there are seven examples of exogenous index insurance, and five of yield tailored insurances. A particular example which combines an exogenous standardised contract and yield-tailoring is the work by Torriani et al. (2007) in which the weather derivative which triggers the payment is exogenous but he proposes a yield-tailored combination of weather derivatives for the farmer.

The exogenous indexes can either have a fixed payment per unitary index decrease (for example a payment of 1€ per 1mm rainfall shortfall), or be proportional (a decrease of the rainfall of 50% would trigger a compensation of the 50% of the insured capital). The yield-tailored examples with multiple indicators adjust yield with the estimation of a model combining different indicators. Other yield-tailored indexes have only one indicator. They optimize the index-yield correlation by the application of weights for the different agronomic growth stages. The three examples available of them are calculated for drought and use the cumulated precipitation. Their results show that a better correlation is achieved when the exogenous single indicator is weighted on the agronomic growth stages. Globally, most of the studies agree on the fact that the better or worse results from index products depend fundamentally on the correlation existing between the real loss of the farmers and the index analysed.

There are several area yield insurance experiences in the world; we have classified the main ones in four categories, according to the nature of the indicators used:

- Area-index insurance has been tested for several years in USA (area yield), Canada, Brazil, India (area revenue); Morocco (area yield insurance for drought).
- The weather or meteorological index insurances are rather new in the market. There is one based on rainfall in Ontario (Canada); still in Canada, in Alberta an insurance is available based on lack-of-moisture and another one on temperature index for silage maize. Other experiences of indirect index insurance based on weather data exist as pilot programs in many developing countries: Mongolia, Mexico, India (rainfall for several crops-very developed scheme), Romania

(rainfall), Nicaragua, Ethiopia (drought and food insecurity), Malawi (crop protection based on weather indices against drought).

- In Malawi there is an agro-meto index insurance for maize production based on plant water availability.
- Satellite index insurance for fodder exists as pilot programs in Canada (2001).

In the European Union there are, to our knowledge, only two examples of indirect index insurance: the pilot projects in Austria of a weather index insurance based on meteorological data to cover yield from the risk of drought, and the satellite index insurance for fodder in Spain

3. Feasibility of index insurance in the EU

Some characteristics of index products have to be taken into account in the analysis of feasibility:

- Index products are useful for systemic risk, at the aggregate level, so they are more adapted to reinsurance and catastrophic risks.

- Index-based products are best suited for homogeneous areas, where all farms have correlated yields. Given the heterogeneity of climates and geography in many European countries, the efficiency of index products will be probably lower than in the large homogeneous areas of the USA (for example, the corn belt).

- Insurance can be properly designed when there are yield time-series available (or losses time series). In Europe time series are only available for relatively large regions. Some of these regions are quite heterogeneous in cropping conditions, climate, topography and soils. This creates difficulties for the efficiency of index insurance for all farmers in the region.

Besides, insurances have to comply with European and international regulations. If insurance was to be considered within the CAP framework, the subsidies should comply with WTO green box criteria. Subsidies to index insurance could be considered as payments (made either directly or by way of government financial participation in crop insurance schemes) for relief from natural disasters (Paragraph 8 of Annex 2 of WTO Agreement on Agriculture), because indexes are intended to reproduce yield or production risks. However, it is not clear whether an index insurance by its nature can be considered under the Green Box, given that its nature is not to compensate the actual loss of an individual, but the loss indicated by a parameter (a farmer that did not suffer from a loss could potentially benefit from compensations). Practical difficulties would also arise from the requirement of a formal recognition by the Governmental authorities of natural disaster, as it would have to be linked to a certain threshold for the indexes used. Other technical characteristics of the insurance and its compliance with the Green Box criteria are also analysed.

4. Regional (FADN region) yield index

We have analysed the potential of a hypothetical Regional Yield Insurance (RYI) from Eurostat-REGIO data applied at the level of FADN region. We have estimated the premiums rates and the maximum total premium amounts. The calculation of the risk that is covered by the insurance company results in a risk rate which is known in technical terms as “actuarially fair premium” rate (also risk premium or fair premium). We have expressed it as a percentage of the total insured amount. From this fair premium, the commercial premium is then estimated by adding the management and administrative costs and the profit of the insurance company, reinsurance, etc. The fair premium rates for wheat with a trigger of 30% and no deductible ranges from 0 to 14%, with average of 1.1%. The average seems quite affordable, but the maximums are very high. This highlights the large variation of yield risks between different regions. The premium with a 30% deductible was also calculated. In this case, the maximum would reach 6.48% and the average 0.25%. We should underline here that the risk of fall by 30% of a regional average is much lower than the risk of fall by 30% for an individual farm. This explains why the average fair premium of 0.25% is low. With a 15% trigger wheat premiums reaches the 15.7% in Spain. On the whole, these results show that premium rates are very sensitive to the deductibles and trigger levels. The total premium amount can be multiplied by 2 or even up to 6 when reducing the trigger from 30% to 15%.

The commercial premiums of Regional Yield Insurance (RYI) with a 30% trigger and a 50% market penetration (and assuming there is no adverse selection) and assuming a load on the fair premium of 42%, could be around EUR 77.6 million for potato, EUR 79.5 million for barley and EUR 69.8 million for wheat, of which EUR 54.67 million, EUR 56 million and EUR 49.1 million respectively are the pure premiums. The country average fair premiums per hectare oscillate between EUR 4.17 and EUR 9.17 for most arable crops, but reach EUR 30.70/ha for potato.

5. Meteorological parameters or weather indexes

Some meteorological indicators were analysed following the model of the area yield-tailored insurance from several indicators. An insurance product could be thus designed for each region on the most relevant parameter or combination of parameters according to the results. However, these combinations of indicators do not explain yields optimally, as the Multiple R-Square is only 30%. Perhaps other indicators should be explored. Besides, it is also possible that there is too much heterogeneity within each NUTS2 region and a meteorological yield-tailored index could only have a good explanation capacity at a more disaggregate level. The meteorological indices analysis is useful to underline that the index risk can differ very much from one European region to another. The example shown in Chapter **Error! Reference source not found.** aims to explain the level of vulnerability of the same crop, at the same development stage can vary in function of climatic conditions. The results of the late frost study expresses the need of analyse the climatic risk under many points of view, accounting with many physiological aspects related to the crop and more expertise is needed to aggregate data in order to reach robust outputs.

6. Parameters computed from an agro-meteorological model

Agrometoerological parameters are built by modelling the crop growth, based on the Crop Yield Forecasting System (MARS). Three parameters were selected to study their potential to explain yield variability: Relative Soil Moisture (RSM), Total Water Consumption (TWC) and the Water Limited Storage Organ Weight (WLSOW).

Assuming that the Eurostat-REGIO yield is a good indicator of the yields to be insured (or reinsured, since we are working at regional level), the parameters which have been analysed reach sometimes high correlations. Some examples regards the relative soil moisture, which reaches in Baden-Wurttemberg (Germany) a 0.96 correlation on 10 years, or TWC which reaches 0.74 on 29 years in Bretagne (France), both for grain maize. Unfortunately this high level of correlation is far from being achieved in general.

The analysis of the agro-meteorological indices is made on a large scale (EU 27); this factor certainly limits the quality of the results, because the domain of observations is very wide. We have to take into account is the climatic differences in Europe: Certain areas suffer lack of water, while others face problems due to excessive rain; this means that it is sometimes problematic to analyse the same index on areas with different meteorological problematic. The idea to divide Europe into climatic zones could represent an improvement for the analysis; this could help to refine the outputs and to determine which index can better represent the yield variability for each zone and for each crop.

At present, the results raise major doubts on the opportunity to apply index insurances based on agro-meteorological indicators in the EU. The study suggests several directions that could be taken to comprehend how far an index can serve to assess losses due to climatic event or to prevent income losses through an insurance scheme based on agro-meteorological indices.

7. Parameters from satellite images

Analyses for NDVI (Normalised Difference Vegetation Index) computed on SPOT4-VEGETATION images show that the maximum NDVI appears as a poor indicator of crop yield risk in the European conditions. While a good spatial correlation can be observed between maxNDVI and yield, the time correlations in each FADN region are low. A factor influencing negatively these correlations is the small number of years available (only 7). However, correlation results improved when taking into account only those maximum NDVI which fall in the period when the crop is more sensitive to nutrients and water stresses. This means that the capacity of NDVI for explaining yields could be improved by exploring other NDVI-based indicators, such as the maxNDVI of this sensitivity period. On the other hand, ongoing activities within the Agriculture Unit of the JRC have proved that the correlation between the indicators derived from NDVI and yield is dependent on the regions. A study in Spain showed that the max NDVI but also cumulated NDVI values for different periods of the growing season are significant. Further analysis could include indicators such as the start NDVI or the end NDVI of the growing season; the cumulated NDVI during the length of growing season; and cumulated NDVI between start and max NDVI, or between max NDVI and end NDVI of the season.

8. Quantitative assessment of the loss risk on the basis of FADN data

The individual farm income and yield risk have been analysed in order to compare them with the risk from the index insurance analysis. We use the data from the Farm Accountancy Data Network (FADN). FADN is the best available source of data at single farm level. The use of FADN data allows setting up the link between the index-based triggers and the risk of loss of yield or income at farm level.

The concept of risk is the expectation of the loss compared to the "normal" yield or income. It can be calculated as the loss averaged on time, after applying a trigger or deductible, if necessary. This is often labelled in the academic literature as "fair premium", although in practice the premium is higher because of the management costs (including loss expertise) and the profit of the insurance company. The WTO agreements define the normal income or yield as the average of the "*preceding three-year period or a three-year average based on the preceding five-year period, excluding the highest and the lowest entry*". An alternative option is to consider as "normal" the value of the long term trend for the yield or the income at the farm level. Limiting the sample to the farms for which data are recorded for more that 4 consecutive years reduces the sample size to less than 30% of the total sample. Moreover, if we only consider farms with data on 6 consecutive years, the sample will then be too scarce in many regions for any calculation. On the other hand the application of this rule requires an individual record of yearly production for each farm, but such system does not exist in most European countries. Therefore we need to find an alternative criterion that can be seen as equivalent. A common definition of normal yield is the long-term trend for the farm, but again we seem to be in a cul-de-sac: unfortunately no data are available to estimate long term trends for each farm of the FADN sample. We have developed a procedure to indirectly estimate the variation compared to the trend without estimating the trend for the farm: it is what we call the "2-year constant sample" method. The procedure is model-based and consequently its validity depends on the acceptation of the model, but we consider it is reasonable enough and it allows to exploit the data of a farm whenever data are available for that farm on two consecutive years. The results obtained with this method are compared with those from the 3-year moving averages as defined in the WTO agreements.

The analysis of yield reduction risk is carried out for EU-15 countries and for wheat, barley, grain maize, sunflower and soybean. The analyses are restricted to EU-15 because long time series are not available for the new MS. Both approaches give results that are consistent with each other, but the two-year constant sample method gives in general slightly lower values for the risk than the 3-year moving average method for winter cereals. A possible explanation for this fact is that the WTO criteria do not take into account the long term trend, which is often increasing. We point out that the practical application of the WTO rule would require a farm-level register of yields going at least 3-5 years backwards; this does not seem to be available in most EU countries.

A spin-off of the study is the characterization of the regional yield trends with different functional shapes (linear, quadratic and logarithmic). This is a product that has a value as a tool to improve the current procedures of yield forecasting. However some additional work is necessary to collect time series of yields longer and more complete than the data available in the REGIO database.

The analysis of the income reduction risk is made by farm type instead of by crop. The application of the same methods to the income level measured through FNVA (Farm Net Value Added) is more problematic. We find a conceptual challenge in the application of the “30% deductible” when the average income in the previous year(s) is very low or even negative: What does it mean “a loss of more than 30% of the average income of the previous three years” when this average is negative? This inconvenient has been skipped by eliminating “awkward” ratios, but we have to warn that this may have a strong impact on the results, probably reducing the computed levels of risk. Even with this data cleaning implying a reduction of apparent risk, the risk levels computed for the income reduction are much higher than the risk of yield reduction. The reason for that is easy to understand: assuming relatively stable prices, a yield reduction of 30% correspond to an income reduction of much more than 30%, because the cost of production does not decrease with the yield. An additional analysis has been carried out on the value of production, or revenue, for which the estimated risk is much closer to the risk of yield reduction.

9. Cross validation of indirect index insurance with FADN data

We have made a cross-validation of the RYI (FADN region and yields from Eurostat-REGIO data) with the farm revenue from the crop. In order to attain this objective we have proceeded in the following way. We have applied to each FADN farm revenue (assuming a unitary price) the indemnities and the premiums from the RYI. By thus simulating the effects of RYI on the farms, we have obtained new values for the farm revenues with insurance. The risk was calculated with the “moving averages” method both for the original sample with no insurance and for the new sample with insurance. The comparison of both results allows to quantify the potential effects of the insurance on the average risk of the farms.

As could be expected, given that area yield indexes are more adequate for homogeneous regions, the risk reduction capacity of RYI is not very high for the example analysed. We can expect that the results do not depend from the crop type, but on the scale of the analysis. Besides, we have to take into account that it was underestimated due to the data constraints (the percentage indemnities were multiplied by actual farm yields and not by average or expected farm yields). However, there are some regions where the risk can be reduced up to a 68%. These results have to be considered cautiously, given that the quality of the data is not optimal. The correlations between Eurostat yields and FADN yield averages are often weak.

10. General conclusions

As collected from the literature review, index-based products are best suited for homogeneous areas, where all farms have correlated yields. Given the heterogeneity of climates and geography in many European countries, and that analysis had to be performed at NUTS2 or FADN region level, which is at large scale, index products efficiency results to be relatively low. It could be expected to be more useful for reinsurance, at the aggregate level, than at the farm level.

Premiums have been evaluated for a Regional Yield Insurance (RYI) for FADN regions and a number of arable crops. Results show that fair premium rates are very sensitive to the deductibles and trigger levels. Some meteorological indicators were analysed following the model of the area yield-tailored insurance from several indicators. The combinations of indicators analysed do not explain yields optimally. Perhaps other indicators could be explored, but there seems to be too much heterogeneity within each NUTS2 region and a meteorological yield-tailored index could only have a good explanation capacity at a more disaggregate level. Similar conclusions were derived from the agrometeorological indicators tests. The meteo- and agromoteorological indices analysis is useful to underline that the index risk can differ very much from one European region to another. The results suggest many directions that could be taken to comprehend how far an index can serve to assess losses due to climatic events. Analyses for NDVI show that the maximum NDVI appears as a poor indicator of crop yield risk. However, the capacity of NDVI for explaining yields could be improved by using the cumulated NDVI between the more sensitive crop development stages.

FADN data are used to compute and map the level of risk of yield reduction for major field crops at the level of the farm. Preliminary results confirm that the risk level at the scale of the individual farm is much higher than the risk level using regional yields. The analysis of the income reduction risk is made by farm type instead of by crop. The income risk reduction computed is much higher than the risk of yield reduction. The reason is that assuming relatively stable prices, a yield reduction of 30% corresponds to an income reduction of much more than 30%, because the cost of production does not decrease with the yield. An alternative concept has been analysed: the value of production, or revenue, for which the estimated risk is much closer to the risk of yield reduction.

The cross validation of area yield insurance with FADN data shows, as could be expected, that the risk reduction capacity of yield area index is not very high for the case analysed, even though it was underestimated. However, there are some regions where the risk can be reduced up to a 68%. The test for risk reduction capacity of other indexes could be done, however, it would be expected to be lower than the one from yield area index, given that theoretically regional yield area should describe the behaviour of farm yield better that other indexes at a regional scale.