3.5 REPORT ON MODELLING RISK MANAGEMENT AND INTERFACES TO THE MIND STEP MODEL TOOLBOX

Background and target

Farms face numerous uncertainties and risks. In particular, extreme weather events and yield losses present major challenges. Climate change will exacerbate these risks. Against this background, the aim of task D3.5 is to improve the capacity to model agricultural risk management policies by developing an individual decision making (IDM) module that captures the acceptance and risk-reducing impacts of farm risk management instruments. In this study, we analyse the potential of different behavioural approaches, such as prospect theory and heuristics, to enhance modelling. We take into account the heterogeneity of individual risk behaviour. In our module application, we analyse the effects of various types of crop insurance at a whole-farm level in Germany, considering the effects of different deductibles and levels of yield variation. Finally, we highlight the potentials and challenges of implementing a risk management module in the MIND STEP toolbox and discuss the opportunities and challenges for an extension of the developed module to other countries and to other risk management instruments.

Module framework

The theoretical framework of the risk management module is based on the cumulative prospect theory. Within this framework, risk behaviour can be modelled with a set of functions and parameters that incorporate the subjective assessment of risky monetary values and their probabilities into the decision-making process. By doing so, it accounts for the following four behavioural economic observations. People often overweight low probabilities and underweight high probabilities. They classify risky prospects into gains and losses relative to their personal reference point. People value losses more than a corresponding gain. People try to insure gains but avoid to insure losses.
Multiple studies confirm that in many situations prospect theory describes risk behaviour more accurately observed than the frequently-applied expected utility theory. Moreover, it is flexible enough to account for situation-specific, simplifying decision rules when making decisions under risk, so-called heuristics.
The developed module consists of several building blocks. These include the elicitation of survey data, the processing of survey data and FADN data, the simulation of crop yields, and the modelling of whole farms with FarmDyn. The module elements are programmed in R and GAMS. Easily accessible interfaces that facilitate a case-study specific approach include FarmDyn parameters and farm sample specifications, the yield variance covariance matrix and the FarmDyn result file.

Eliciting risk preference parameters

To provide an empirical basis for the behavioural modelling, a framed field experiment with 237 farmers in Germany was conducted. Using incentivized lottery-based multiple price lists, the effects of heuristics is explored within the prospect theory framework. The results indicate that when low-probability weather shocks require decisions involving monetary losses, average farmers exhibit risk-loving behaviour, leading to a low willingness-to-pay for risk mitigation. Our results also highlight the influence of heuristics on risk management

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 817566.

decisions against low-probability shocks. Farmers use the imitation heuristic to imitate other successful farmers, when such farmers exhibit risk-loving behaviour and not risk-neutral behaviour. Farmers use shock experience heuristics; in particular, the non-occurrence of low-probability shocks leads farmers to assign less weight to low probabilities. Furthermore, farmers apply the threshold of concern heuristic and generally neglect low probabilities, decreasing their willingness-to-pay for risk management. The estimated behavioural parameters depend on farmers' characteristics as well as on the use of heuristics, providing a basis for modelling the heterogeneity of individual risk behaviour. This approach is complemented by an artefactual field experiment with farmers to estimate the parameters defining risk behaviour under the cumulative prospect theory. A comparison to the literature shows that mean values lie in the range of empirical findings of other studies.
Another field experiment with Italian farmers sheds light on the insurance adoption behaviour of tomato producers. The experiment shows that the WTP for traditional insurance and WII are positive among the tomato producers, and it is expected that an increasing risk aversion would increase the WTP for both insurance types. It is also expected that lower deductibles and a higher subsidy level would induce a higher rate of adoption. Results based on the experiment can be translated into a farm-level model for policy simulation. These results can also be useful for drawing policy implications related to the public funding of risk management tools, both at the EU and at the Member state level.

Modelling farm risk and insurance take-up

The application and outcomes of the MIND STEP risk management module are illustrated for a case study. We apply FarmDyn to a sample of arable farms from North Rhine-Westphalia, a region in the west of Germany that represents the yield risk levels of typical cropping systems at European locations with temperate climate. The model specification is based on information from the national Farm Accountancy Data Network (FADN), accounting for farm individual characteristics like farm size, crop shares, average crop yields, and available family labour, supplemented by standard values from the literature, usually from the KTBL, the German reference work for technological agricultural management data. The results from the empirical analyses of prospect theory parameters and their determinants are used to specify individual risk behaviour. Yield volatility is accounted for by an empirically based estimate of the variance-covariance matrix of yields for FADN farms in the study region. The module applies informed rotations of Gaussian quadratures to generate a computationally manageable set of yield scenarios.
FarmDyn, extended with the risk module, is used to analyse and compare different scenarios covering the different specifications of risk behaviour (individual parameter specifications and prospect theory heuristics), the availability of revenue insurance, and different levels of insurance costs, deductibles, and yield risk exposure.

Results on farm risk and insurance take-up

The results show that the availability of yield insurance reduces farms' revenue risk in our sample only to a small extent. This is because the farms have a diversified crop rotation, resulting in small risk-reducing effects of insurance payments and low insurance take-up. Psychologic reasons for risk behaviour, that align with the prospect theory, contribute to explaining the low insurance demand. Even in the scenarios with insurance subsidies, farmers do not insure the total area. Increasing the risk level, based on the empirical yield

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 817566.

volatility of Brandenburg, raises insurance premiums by about 50% but does not significantly increase the share of the insured area for the modelled farms.

Potentials and challenges of implementing a risk management module

To apply the developed risk management module to other countries, FarmDyn needs to be populated with national or EU FADN data. Supplementary farm management data is required for the specification of the production technology in FarmDyn, which may be challenging in some countries. The yield risk should be specified using corresponding data from secondary sources or estimated based on time series from FADN. The risk module can be applied using default data on behavioural parameters and heuristics and their determinants based on the survey of German farmers. Additionally, sample-specific risk preference parameters can be derived following the experimental protocols described in this report, but this requires considerable resources.

The FarmDyn objective function fully integrates the behavioural specifications of the cumulative prospect theory. This integration is advantageous for investigating the production effects of insurance decisions. However, we found no significant impact of the analysed insurance options on cropping patterns under the North Rhine-Westphalian conditions. This indicates that it might be sufficient to model the insurance decision separately (as an independent decision). This would significantly reduce complexity and computational effort and allow more yield realizations to be modelled that take into account more complex joint distribution functions, allowing for a more detailed study of extreme events. In addition, it would allow for flexible risk management specifications in the design of the risk management module.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 817566.