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"Towards a holistic approach to Sustainable Risk management in agriculture" Sus-Risk

Report on the conducted systematic literature review

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1. Behavioural factors influencing farmers' adoption of risk management tools

From a behavioural perspective, the economic framework that is generally used to understand and predict farmers' decisions to cope with agricultural risks is rooted in expected utility theory (EUT) (von Neumann and Morgenstern, 1947). However, some fairly recent empirical applications have demonstrated that farmers' decisions to insure their production often depart from standard EUT. Non-standard economic theories, such as prospect theory, explain farmers' choice behaviour more parsimoniously (e.g., Babcock, 2015; Dalhaus et al., 2020; Feng et al., 2021). These empirical findings determined the development of a small but growing research that investigates the extent to which behavioural factors such as farmers' probabilistic beliefs, probability weighting, risk and uncertainty preferences, and loss aversion influence farmers' decisions to purchase an insurance product (e.g., Fezzi et al., 2021) and participate to mutual funds (Rippo and Cerroni, 2023; Čop et al., 2023). These behavioural factors are generally elicited using experimental methods, while their ability to explain and predict farmers' choice behaviour is tested by combining data from economic experiments with primary data obtained using stated preference surveys or available secondary data on actuarial farmers' purchasing decisions (Iyer et al., 2019). In this section, we mainly focus on the literature related to subjective probabilities, risk and uncertainty preferences.

Subjective probabilities are considered to be important predictors of farmers' behaviour because farmers, like any other economic agent, base their decisions on their beliefs or expectations when the decision context is highly uncertain. If expressed in a probabilistic fashion, these beliefs or expectations are defined as subjective probabilities (e.g., Hardaker and Lien, 2010). The literature looking at the role of subjective probabilities in explaining farmers' behaviour is scant, and only a very small number of studies examined how subjective probabilities influence farmers' decision to purchase an insurance product (see Cerroni, 2020; Čop et al., 2023; Cerroni and Rippo, forthcoming for recent reviews). There are a couple of

noticeable exceptions. Čop et al. (2023) found that subjective probabilities are important predictors of farmers' decisions to enrol to a sector-specific IST related to grapevine. Fezzi et al. (2021) found that farmers' subjective probabilities regarding production losses due to extreme climatic events are not in line with objective measures of risk. Hence, policy interventions geared to reduce this gap could have important policy implications regarding insurance subsidization. One potential drawback of these studies is the elicitation of subjective probabilities using hypothetical methods that are not incentive-compatible and therefore do not induce farmers to elicit truthful beliefs. However, the literature on decision analysis provides several incentive-compatible methods that are able (in theory) to elicit truthful beliefs under a proper incentive scheme. These methods could be used to elicit more accurate subjective probabilities related to uncertain agricultural outcomes (see Cerroni and Rippo, forthcoming for a review). More accurate probability assessments should have in theory a higher degree of external validity and explain farmers' choice behaviour more parsimoniously.

Risk preferences have been shown to be an important driver of farmers' decision-making processes, especially those related to the adoption of new technology and crops (e.g., Liu, 2013; Barham et al., 2016). However, only a few studies have investigated whether these preferences can play a role in explaining farmers' decision to purchase insurance products. Recent research indicates that risk preferences are poorly correlated with the decision to purchase traditional insurance products (Menapace et al., 2016; Coletta et al., 2018; Rommel et al., 2019; Čop et al., 2023). These results may be driven by some confounding factors that have been recently identified in the related literature. First, risk preferences appear to be highly context-dependent (Finger et al., 2022) and therefore their ability to explain farmers' choice behaviour may be context-dependent too. Second, a wide range of approaches exists to elicit risk preferences (see Cerroni, 2020, and Cerroni et al., forthcoming for recent reviews), and, unfortunately, empirical evidence suggests that different elicitation techniques provide

inconsistent measures (e.g., Reynaud and Couture, 2012). Once again, the elicitation technique used may have an impact on the ability of elicited preferences to explain choice behaviour. Some practitioners advocate that adding an agricultural context to standard monetary lotteries can improve the external validity of elicited preferences, thus boosting the predictive power of elicited risk preferences. On the other hand, contextualization may lead farmers to use heuristics that undermine the internal validity of experimental data (see Cerroni, 2020 for an application of contextualized field experiments and a discussion on strengths and limitations).

If farmers' risk preferences are extensively researched in the related literature, uncertainty and ambiguity preferences are not. There are only very few studies eliciting farmers' uncertainty and ambiguity preferences (e.g., Baharam et al., 2014, Bougherara, 2017; Cerroni, 2020). None of these studies attempt to use such preferences to explain farmers' behaviour when purchasing insurance products. In this section, we use the terms uncertainty and ambiguity interchangeably, however, we have to acknowledge that the distinction between risk, uncertainty and ambiguity is far from being clear in the decision analysis literature (see Cerroni and Rippo, forthcoming for a discussion).

The most popular approach to disentangling these concepts is the frequentist. According to this school of thought, risk refers to situations where definite numerical probabilities are known and can be objectively measured, while uncertainty refers to situations where definite numerical probabilities are unobservable (Knight, 1921). However, other paradigms exist, such as the subjectivist, under which subjective probabilities play a key role under both conditions of risk and uncertainty (Ramsey, 1931; de Finetti, 1931, Savage, 1954). Furthermore, there are other stream of thought that try to differentiate uncertainty from ambiguity. For example, according to Harrison (2011), uncertainty refers to situations when the agent can form a unique and well-defined subjective probability distribution, while ambiguity refers to situations when the agent is not capable of doing so.

This brief discussion on the role that subjective probabilities, risk and uncertainty preferences can have on farmers' decisions to use risk management tools allows to highlight a few key points relevant in the case of the use of insurances. First, the literature exploring the extent to which these behavioural factors affect these decisions is almost non-existent. The literature focusing on standard agricultural insurances and mutualistic solutions is limited. While common sense suggests that subjective probabilities, risk, and uncertainty preferences can affect the uptake of risk management tools, the extent of these impacts and the underlying behavioural mechanisms are unclear and under researched. Second, there is still an open discussion in the decision analysis literature regarding the most appropriate way to elicit these behavioural factors. Many methods are available to elicit subjective probabilities, risk and uncertainty preferences in the literature and empirical evidence suggests different methods lead to different results. This may have an influential impact on the role these behavioural factors play in explaining farmers' insurance decisions. The horse race to truthful probabilistic beliefs, risk and uncertainty preferences is not over yet. Exploring the internal and external validity of results obtained via different elicitation methods appears to be the only strategy to shed light on these issues. Third, behavioural factors can be useful also to predict farmers' choice behaviour. A new stream of research is emerging that seeks to incorporate these behavioural factors into simulation models to enhance their ability to explain and predict choice behaviour (e.g., Huber et al., 2022). This line of research definitively contributes to build a more holistic view about sustainable risk management in agriculture.

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