Agricultural Systems 103 (2010) 345–350

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Probabilities for decision analysis in agriculture and rural resource economics: The need for a paradigm change

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ARTICLE INFO

Article history:
Received 9 March 2009
Received in revised form 11 January 2010
Accepted 19 January 2010
Available online 18 April 2010

Keywords:
Decision analysis
Risk and uncertainty
Subjective probabilities

ABSTRACT

The notion that we can rationalize risky choice in terms of expected utility appears to be widely if not universally accepted in the agricultural and resource economics profession. While there have been many attempts to assess the risk preferences of farmers, there are few studies of their beliefs about uncertain events encoded as probabilities. We may attribute this neglect to scepticism in the profession about the concept of subjective probability. The general unwillingness to embrace this theory and its associated methods has all too often caused researchers to focus on problems for which frequency data are available, rather than on problems that are more important where data are generally sparse or lacking. In response, we provide a brief reminder of the merits of the subjectivist approach and extract some priorities for future research should there be a change of heart among at least some of the profession.

1. Introduction

There is a strong case for the need to improve the quality of risky decisions made by farmers and other rural land managers. Similarly, there is a case that the handling of risk in policy-making in the agricultural and resource sectors leaves scope for improvement. There is also a need to gain a better understanding of how these decision-makers actually make risky choices. Perhaps these choices are most starkly illustrated by the risks to the rural sector (and the planet) from climate change. Why was there, and why is there still, so much disagreement about the need to limit greenhouse gas emissions? In addition, what do we know about how land and other natural resource managers will respond to climate change, with or without economic incentives such as carbon trading?

Most decisions entail a degree of uncertainty about the consequences, and if the possible differences in consequences are important, we define such decisions as risky. Decision analysis is widely used in the analysis of such risky decisions. There are two assessment tasks in decision analysis: namely, assessing beliefs about the chances of occurrence of the uncertain outcomes (probabilities); and assessing relative preferences for the outcomes (utilities). These components of the analysis are then integrated to reach a decision.

There has been much discussion in the agricultural and resource economics (ARE) literature about the methods and problems in assessing the preferences of farmers and others for risky outcomes, but relative neglect of discussion of the assessment of probabilities. Yet arguably, probability assessment is often the more important analytical component (Hardaker et al., 2004, pp. 113–118). This is the focus of this paper.

We argue that the general unwillingness of ARE professionals to embrace the theory of subjective probability has too often caused the researcher to focus on problems for which frequency data are available, rather than on more important problems for which data are generally sparse or lacking. Changing the way ARE professionals think about probability will require a significant paradigm shift. The main aim of this paper, therefore, is to argue the case for a shift in the way probabilities are regarded and used for decision analysis in ARE. We aim to do this by contrasting what has happened in the past, based on the prevailing view of probabilities as relative frequencies, with a possible future in which the subjectivist view would prevail.

We first summarize what we see as the 'state of play' in decision analysis in ARE. We then turn to the future to outline what we hope might be the way forward. In this context, we outline the two main competing schools of thought about the nature of probabilities. We point out some of the unfortunate consequences of the predilection for frequency-based probabilities among the ARE profession and summarize the case for the subjectivist view. We conclude by suggesting new priorities for future research and development based on better, more thoughtful ways of deriving

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0308-521X/$ - see front matter © 2010 Published by Elsevier Ltd.
doi:10.1016/j.agsy.2010.01.001

probabilities for decision analysis. Inevitably, our treatment is highly opinionated, but we trust that the paper will stimulate a deeper consideration and discussion of these important issues.

2. Where are we now?

To provide a comprehensive description of the status of decision analysis in ARE would require an extensive literature review too voluminous to report here. We have not attempted such a review. Instead, we briefly outline where we judge matters stand today, leaving it to others to accept or reject our views.

2.1. Theory

After much early debate and toying with a range of models of risky choice, it appears that expected utility theory has been widely if not universally adopted in ARE as the best basis for decision analysis. It is true, however, that there remains considerable and justifiable mistrust about attempts to elicit from most decision-makers utility functions that can be confidently regarded as properly representing their attitudes to risk. Partly for this reason, and to make the results applicable to decision-makers with differing risk attitudes, many research studies use stochastic efficiency criteria to partition choice options into risk-efficient and dominated sets for a plausible range of risk attitudes. Most efficiency criteria, though not all, are derived from or consistent with the expected utility hypothesis.

Reliance on the expected utility hypothesis to model risky choice is cast into some doubt by the considerable evidence that it often fails to explain how people act when faced with particular risky choices. Although given different terms in different contexts, there is substantial evidence of 'loss aversion', meaning that people often appear to place much more weight on avoiding losses than they assign to equivalent gains (e.g. Rabin and Thaler, 2001). Such evidence challenges not only the expected utility hypothesis but also contingent valuation methods, as well as the indifference curves that underpin the foundation of demand theory. Curiously, a number of econometric studies of the risky choices made by farmers have yielded estimates of risk aversion coefficients much lower than implied if loss aversion is widespread (e.g. Antle, 1987; Oude Lansink, 1999; Lence, 2000; Lien, 2002). To our knowledge, these apparent contradictions remain unresolved. We suspect that loss aversion is significant when decision-makers face small decisions, but that farmers do not generally exhibit the same extreme aversion to possible losses when making more strategic choices. Indeed, farming in much of the world is so risky that universally loss-averse people would surely not take it up. While human behavior is so diverse and inconsistent that no modelling approach is likely to predict all outcomes accurately, it would appear that expected utility theory has been widely though not universally thought to be a 'good enough' basis for the study of risk-taking behavior by farmers and other decision-makers (e.g. Just and Pope, 1979; Newbery and Stiglitz, 1981; Pope and Just, 1991; Mahul, 2001).

Judging from the literature, there is less widespread acceptance, at least among the ARE profession and allied sciences, of the essentially subjective nature of the probabilities used in decision analysis. Yet the foundation of decision analysis is the *subjective* expected utility hypothesis, so called because it embodies subjective or personal probabilities (Savage, 1954). The widespread discomfort with the notion of subjective probabilities means that we find published studies based on historical frequencies that are often of dubious relevance to the modelled risky phenomena. Those who can only entertain probabilities based on historical frequencies appear not to consider the possibility of the non-stationarity of risky phenomena, despite the fact that all kinds of change in the world imply that many (perhaps most) are non-stationary processes. For example, the study by McCarl et al. (2008) of the impact of climate change on crop yield distributions shows that stationarity does not hold. Likewise, the recent global financial crisis illustrates all too starkly that risk assessments based on frequencies from the recent past can be seriously flawed.

Contrasting with the strong interest over the years in the *preferences* (attitudes to risk) of farmers and other decision-makers, there have been few studies of the arguably more important aspect of their *beliefs* about risk, encoded as probabilities. Included among these few are the review by Norris and Kramer (1990) of subjective probability elicitation methods and a number of studies of farmers' adoption of innovations using Bayesian learning models (e.g. Lindner and Gibbs, 1990; Marra et al., 2003; Roberts et al., 2006). However, we are aware of very few studies that have sought to develop and test methods of eliciting 'good' probabilities from agricultural decision-makers or experts. Certainly, such studies in ARE are rare indeed, and most of the general work made along these lines was many years ago (e.g. Winkler, 1972). We are also unaware of many studies of how farmers and others actually form probability assessments about the risks they face.

However, several surveys have sought to elicit from farmers and others the perceived risks they face and the main strategies used to deal with these risks (e.g. Patrick and Musser, 1997; Meuwissen et al., 2001; Flaten et al., 2005; Lien et al., 2006; Patrick et al., 2007; Størdal et al., 2007; Greiner et al., 2009). Unfortunately, it would appear that there is often a poor connection between what are identified as important risks and the risk management strategies nominated by respondents as essential. We have found too little discussion of why this should be so.

2.2. Methods

There have been relatively few major innovations in the methods of decision analysis over recent decades, with most of those used today developed by the 1960s or 1970s. Since then there have been major advances in computerization. The advent of personal computers and specialized decision analysis software has dramatically expanded the scope for routine decision analyses for research or decision support. For example, computer-based decision tree analysis, stochastic simulation and mathematical programming applications are now many times more powerful and user-friendly.

In the analysis of farm production responses accounting for risk, the Just and Pope (1979) production function allows the statistical determination of the influence of inputs on both the mean and variance of output. This pioneering work has also been extended to account for skewness/downside risk aversion (e.g. De Falco and Chavas, 2006), the relationship between output variance and technical inefficiency (e.g. Kumbhakar, 2002), and analyses of optimal hedge ratios under price and output uncertainty (e.g. Alghalith, 2006). However, the parametric estimation of production models with risk is often driven by the choice of functional form. Accordingly, recent studies avoid the assumption of a parametric function through non-parametric estimation of econometric risk models (e.g. Kumbhakar and Tsionas, 2010).

Chambers and Quiggin's (2000) publication of a volume on the state contingent approach appeared to provide both a theoretical advance and the promise of a new and better set of methods for decision analysis. However, adoption of this approach appears to have been slower than expected, perhaps because of difficulties in implementation, notably data limitations for econometric applications. Nevertheless, it is still too early to judge whether its early promise will be fulfilled. Among the few empirical studies known, we particularly refer to O'Donnell and Griffiths (2006) and Chavas (2008).