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Farmers and Risk

INTRODUCTION – RISKS FACED BY FARMERS

Farmers everywhere face risks emanating from their natural, economic and socio-political environments. Most overtly, the natural environment features risks associated with climate, particularly in terms of precipitation and temperature. Other risks from the natural environment – notably pests and diseases – may be influenced by climate. The economic environment features many uncertainties with variable product prices reflecting variations in factors underlying demand, such as incomes, and factors influencing supply, such as climate. Some of these uncertainties can be modified by forms of intervention such as stabilisation schemes or other more heavy-handed government measures. The final broad source of risk is the socio-political environment. Agriculture is increasingly subject to unforeseen interventions by government and in many countries there is a high degree of uncertainty built into the socio-political environment which has its origins in changing power structures or other influences on policy.

In summary, the conjunction of uncertainties from natural, economic and socio-political sources leads to a plethora of risks for farmers. Seldom are these uncertainties amenable to precise prediction and so, while the farmer's environment is unstable, it is inherently risky and, overall, might well be described as turbulent.

THEORETICAL ADVANCES AND RETREATS

The decision analysis paradigm

Agricultural economists have been striving for adequate modelling of the risky environment and decision-making processes of farmers for several decades. Many ideas have come and gone; universal agreement on the framework that is most appropriate is yet to be realised. Our preferences in this matter are clear with our stated choice and exploitation of the modern paradigm of decision analysis in which the decision-maker is seen as choosing so as to maximise subjective expected utility (Anderson, Dillon and Hardaker 1977). While one can be critical of the elements of this paradigm, as we are in what follows and as others such as Allais

(1984) have been, we have yet to encounter a more satisfactory framework for considering farmers and risk.

A sketch of the paradigm. Decisions under uncertainty, i.e., practically all decisions in real life, involve the choice by an individual (or group) of one option from a set of alternative actions. The consequences of the selected action depend on the outcome of relevant uncertain events. Decision-makers are assumed to hold beliefs about the chances of occurrence of the uncertain events bearing on their choices as well as preferences for the possible consequences. The beliefs are encoded as subjective probabilities (thereby implying a probability distribution for the consequences associated with each possible choice) while the preferences can be captured via a suitably elicited function as utilities. A rational decision is one that is consistent with the decision-maker's beliefs and preferences and thus corresponds to choice of the action whose probability distribution of consequences maximises the decision-maker's subjective expected utility. Though developed mainly as a normative model, decision analysis (as discussed below) has also been seen as having positive or behavioural relevance.

Normative relevance of the paradigm. Normative use of decision analysis is based on the presumption that the decomposition of at least some important decision problems into their components, followed by analysis that integrates the components into a choice consistent with the elicited beliefs and preferences of the decision-maker, is better than wholly intuitive choice. The procedure does not guarantee correct choice. Where chance is involved, some decisions will turn out well and others badly. Decision analysis can only lead to decisions that are 'good' in the *ex ante* sense of being consistent with expressed beliefs and preferences, not decisions that are 'right' in the *ex post* sense of being regret free.

A considerable portfolio of methods has been developed to put the deceptively simple ideas of decision analysis to work in the normative analysis of a wide range of choice problems. Little use has been made, however, of these in the context of everyday farm decision-making. From a farmer perspective, the reasons for non-adoption would seem to be difficulty with the concepts involved, the apparent complexity of the approach, the cost of data gathering and the possibly limited benefit for all except significant decisions. From an extension perspective, these difficulties are compounded by the personal nature of the approach which implies, in principle, separate analysis for each farmer. Like mathematical programming, farm-level use of decision analysis would seem likely to be confined to larger scale, if not corporate, farms.

Probability

Probability is the language of uncertainty. We find it impossible to conceptualise any analysis of the risks that farmers face without using this language. Unfortunately, the language has problems when it comes to elicitation of the decision-maker's subjective probabilities. Despite some decades of practice, procedures are still anything but standardised.

The nature of subjective probabilities as statements of belief makes them essentially personal judgements. Their personal nature emphasises the sovereignty of decision-makers in choices that affect their welfare. There are no right or wrong probabilities, but they should reflect the decision-maker's true feelings of uncertainty, taking account of all the information to hand about the uncertain events of concern. A rational person will thus strive to make subjective probability judgements that are as 'objective' as possible.

Considerable evidence exists that these worthy ideals in probability elicitation are not easily achieved (see, e.g., Hogarth 1975 and Kahneman, Slovic and Tversky 1981). It is disappointing that there has seemingly been little development on this front, especially in agriculture. We believe that the reference lottery technique (Spetzler and Stael von Holstein 1975) is under-utilised in applications as a means of keeping respondents 'honest'. We also look for studies with peasant farmers, analogous to those of Binswanger (1981) in eliciting preferences, where money prizes are used rather than hypothetical rewards. We recognise, however, that bias in subjective probability judgements is likely to be difficult to eliminate, suggesting a need to provide more extension information for farmers in a sensible probabilistic framework.

Utility

As noted by Anderson, Dillon and Hardaker (1977, p. 108), though only developed in recent decades, the major ideas involved in utility or the encoding of decision-makers' preferences have been around for centuries. The Dillon (1971) article might be regarded as a convenient watershed marking the start of the active exploitation of the concepts in agricultural economics. This year of the mid 1980s is not, then, the time to be elaborating on the methodology of utility assessment which is widely exposited in convenient sources such as Anderson, Dillon and Hardaker (1977, ch. 4) and Farquhar (1984). Rather, the emphasis here is first on some pragmatic procedures which economise on resources used in applying the utility concept and then on a brief review of the continuing difficulties in the theory.

Risk aversion and pragmatism. The essence of using utility concepts to capture non-neutral attitudes to risk is that, if choices can be made in relatively simple situations, the inferences from these choices can be formalised and used to appraise complex situations that it would be too difficult to resolve consistently otherwise. Procedures for capturing risk preferences are now well known and more or less tried. However, it is also established that psychological difficulties intrude into expression of risk preferences, even in simple situations (Machina 1981).

If a farmer's risky decision problem involves very significant changes in wealth, a full-blown formal risk analysis may be unavoidable, requiring complete encoding of preferences over all relevant ranges of potential consequences. However, many risky decisions do not involve such sweeping changes. In these situations, more pragmatic procedures deserve careful consideration. One such procedure is based on the notion that, over restricted ranges of risk, measures of risk aversion may be approximately constant. The two main measures of risk aversion, absolute and relative, are defined as

$$r_A = -U_2(W)/U_1(W) \quad \text{and} \quad r_R = Wr_A,$$

respectively, where the numerical subscripts denote the derivatives of U(W), the univariate utility function with respect to wealth.

Speculations as to likely values of r_R (which is measured in dimensionless units) have ranged from about unity to two. Sample data from Nepal suggest that, in extremely resource poor farming situations, it may even reach values as extreme as four and greater (Hamal and Anderson 1982). A value for r_R can be adopted for use in an analysis, the value used depending on how the analyst perceives the decision-maker. The value presumed might, for instance, be unity if the individual is regarded as being 'normal', two or three if considered fairly risk averse, and four if extremely risk averse. On the other side, values as small as 0.5 might be presumed if an individual were regarded as hardly concerned with risk.

The coefficient of absolute risk aversion is also commonly used in both theoretical and empirical work. Unfortunately, this measure is not unit free and its magnitude depends critically on the units in which wealth is measured. However, if a value for r_R can be presumed, then – given an estimate of wealth (including the present value of future net earnings) – r_A can be estimated as r_R/W. Once estimated, r_A can readily be incorporated in various sorts of analysis. It is most simply applied to those decision problems that are linear in uncertain quantities that are normal in distribution (Freund 1956). Thus, for instance, if risky farm income can be regarded as approximately normal, the certainty equivalent C (which serves as a surrogate for expected utility) for a particular option can be calculated as $C = E - 0.5r_A/V$ where E and V are respectively the mean and variance of farm income under the option being assessed. This result is fairly robust with respect to departures from normality since it can also be regarded as a second-order approximation to the certainty equivalent.

It is the experience of many analysts that accounting for risk aversion in a full-blown manner leads in many cases to very modest adjustments in the optimal quantities (i.e., utility maximising rates are often similar to expected profit maximising rates). This is bound to be the case at modest levels of risk aversion as would often be associated with relatively high levels of wealth. It also implies that if adjustments are rather small, the consequences of using more pragmatic methods to assess them are robust.

Criticisms of the subjective expected utility model. The axiomatic basis of subjective expected utility (SEU) has been the subject of much criticism as documented in, e.g., Allais (1984) and Bouyssou (1984). There is mounting evidence that decision-makers often violate some of the axioms that underlie the SEU model. Schoemaker (1982) points out that, from a positive perspective, the interpretation of the evidence counter to the model is complicated. From what he calls a 'postdictive' perspective, it is possible to argue that apparent violations of the SEU model in studies designed to test its predictive power occur because improper account is taken of the costs and benefits influencing the decision-maker's choice. The trouble with this argument, however, is that it makes the SEU model impossible to falsify. Schoemaker argues that it would be appropriate to examine the kinds of behavioural anomalies being documented with a view to developing a model of choice more in tune with observed cognitive processes. While we accept this view as reasonable, we note that no such alternative model, attracting widespread acceptance, has yet been developed.

For normative applications, the observed violations of the axioms are somewhat less worrying. The fact that people do not always make the most rational choices under uncertainty is a necessary condition for the SEU model to have prescriptive power. Nevertheless, there are some worrying aspects. Most obviously, decision-makers are unlikely to accept prescriptions from analyses based on assumptions that depart appreciably from their actual view of the world. Furthermore, persistent violations of some axioms may make the model inoperational, for instance, through the impossibility of eliciting utility functions that adequately capture the decision-maker's real preferences. Thus, following a reappraisal of his well-regarded work in deriving utility functions for Indian peasants, Binswanger was forced to conclude that his results were inconsistent with the SEU model (Quizon, Binswanger and Machina 1984).

The accumulating evidence against the SEU model, whether for positive or normative application, is certainly not to be dismissed lightly. Nevertheless, as Schoemaker (1982, p. 556) concludes:

> ... until richer models of rationality emerge, expected utility maximization may well remain a worthwhile benchmark against which to compare, and towards which to direct, behavior. On the other hand, it is likely that today's paradoxes and persistent expected utility violations hold the seed of future normative as well as descriptive theories of choice.

We take a somewhat stronger position than this in arguing that, despite its imperfections, the SEU model is likely to remain for some time as the best operational framework for considering risk in agriculture. It has proved its worth not only in numerous overt applications, but in more subtle ways, for example by sensitising farmers, their advisers, scientists and the makers of agricultural policy to the importance of risk in farm decision-making and to the need to recognise the effects on farmers' behaviour of the widespread existence of risk aversion.

Stochastic efficiency

The idea of stochastic efficiency appraisal is to proceed as far as possible in decision analysis without having to elicit decision-makers' preferences. The implementation of the maker's procedure involves comparison and some manipulation of probability distributions of uncertain consequences expressed as cumulative distribution functions. The procedures, which are elaborated for the cases of first, second and third degree stochastic dominance in Anderson, Dillon and Hardaker (1977, ch. 9), are reasonably straightforward. The main difficulty is that the resultant efficient sets of options may not be definitive as guides to decision-making in the sense that too many actions may remain for decision-makers to choose amongst according to their individual preferences. However, as exemplified by Quiggin (1983), there have been useful applications to the appraisal of policy options for risk mitigation.

More recently, there have been applications based on the development by Meyer (1977*a, b*), of the concept of stochastic dominance with respect to a function. This concept has many potential interpretations. One that is of relevance to the analysis of farm decision-making involves bounding more closely the efficient sets according to any designated degree of stochastic efficiency. Of most practical importance is the second degree since this allows for risk aversion and it is widely agreed that farmers generally are risk averse. The additional complexity of third degree stochastic efficiency, which is implied by the existence of decreasing absolute risk aversion, seems hardly worthwhile.

Meyer's concept amounts to putting limits on the degree of absolute risk aversion over which the set of decision-makers is defined. Unqualified second degree stochastic efficiency implies a range of r_A from zero to infinity. On the lower side, this borders on risk indifference, which is probably true only for extremely wealthy individuals, and on the upper would amount to pathological levels of risk aversion. Intuitively, any designated group of farmers will fall into some limited range of attitudes towards risk. All that needs to be done to implement the approach is to pin down these ranges approximately, perhaps by a purposive survey of the group directed to the individuals expected to be extreme in their risk attitudes. Once the empirical range of r_A is established, limits can be invoked in applying stochastic dominance with respect to a function. These ideas were used insightfully by King and Robison (1981) and have since been exploited widely in US farm-level applications of the procedures. Kramer and Pope (1981) have used the ideas in an analysis of alternative policy options in US commodity programs, as have Anderson and Griffiths (1982) in analysis of risky input use in a multi-factor production function context.

Amongst other potential applications of these notions are enhanced comparative statics of the risk-averse firm. For example, some policy-oriented applications have been explored by Quiggin and Anderson (1979). A promising line is the recent work of Meyer and Ormiston (1983) dealing with the particular changes that can be made to distribution functions which cause risk-averse decision-makers to adjust choice variables in the same direction. Such ideas will add both relevance and complexity to the traditional models of firm behaviour that agricultural economists so heavily rely on.

Another growth point in application of such ideas may be in the valuation of information. This can be thought of as a rather special aspect of comparative statics but it need not necessarily be just statics. Indications of the ways to go are indicated by Byerlee and Anderson (1982). The concepts are applicable in any attempts to value information on any source of uncertainty.

Multi-attribute considerations

The definition of utility over more than one attribute is making slow but steady progress in the practice of decision analysis. The procedures have been elaborated for some time, notably by Keeney and Raiffa (1976). A farm application is provided by Herath, Hardaker and Anderson (1982). Application is easier if some simplifying assumptions can be made about the nature of trade-offs amongst attributes, as described in part in Anderson, Dillon and Hardaker (1977, ch. 4).

An obvious further development would be to generalise the concept of stochastic efficiency across multiple attributes. There have been a few such attempts – see, e.g., Levhari, Paroush and Peleg (1975) – but these deal only with the straightforward concepts of one-way stochastic efficiency of pure form. The problem is difficult but progress may well be made if simplifying procedures analogous to those above are invoked as well as the simplifying trade-off assumptions that are built in to most multi-attribute applications.

ONGOING DEVELOPMENTS

In this short review there is very limited scope for exploring such a rapidly growing field of application. Our selections are thus idiosyncratic and surely biased but befitting the personal orientation of the decision analysis paradigm.

Risk and farmers' behaviour

Modern decision analysis has provided a framework for gaining a better understanding of how risk considerations affect the choices that farmers make. The SEU model may be given a direct behavioural interpretation with scope for applications to the analysis of farmers' behaviour under risk. Some relevant issues are considered in the first subsection below. In the second subsection, more econometrically-oriented attempts to assess farmers' risk behaviour are noted.

Behavioural decision theory. Although the SEU model was developed as a normative model of choice, a number of positive applications to agriculture are to be found in the literature. For example, there have been several studies using the paradigm to explore the important question of farmers' adoption of new but presumably subjectively very risky technology (e.g., Feder and O'Mara 1981). Likewise, applications have been made in agricultural sector modelling (e.g., Hazell 1982).

Direct tests of the predictive power of the SEU model for farmers' behaviour have given mixed results (e.g., Officer and Halter 1968; Lin, Dean and Moore 1974). Certainly, the evidence is clear that farmers, on the whole, are risk averse and do respond as theory predicts to changes in riskiness. All else equal, therefore, any model that accounts for risk and risk aversion is likely to predict behaviour better than one that ignores these phenomena.

There are, however, at least two difficulties with the use of expected utility analysis as a model of behaviour. The first is the accumulating evidence already referred to of violations of the axioms of the theory. The psychological literature – see, e.g., Bouyssou (1984) – suggests that, at best, the model will predict behaviour very imperfectly, and the empirical evidence from agriculture confirms that a gap often exists between prediction and farmers' actual behaviour. Second, as evidenced by the theoretical criticisms and/or alternative models presented by Allais (1984), Kahneman and Tversky (1979), Machina (1982) and Quiggin (1982), there is much dissatisfaction with the SEU model *per se*. As Dillon (1979, p. 36) notes, it will require far more robust tests than have been used to date to select the more plausible of the models of behaviour under uncertainty. Meantime, use of the SEU model in behavioural applications must rest largely on its operational appeal *qua* model and on the richness of the insights it can give into so many important questions involving risky choice.

Risk responsiveness. There has been a long tradition of including variables that capture changes in the riskiness of environments in aggregate models of producer behaviour. In the ealier versions this was done mainly on an *ad hoc* basis (e.g., Freebairn and Rausser 1975). The pioneering work of Just (1977) added a more formal dimension to such work by introducing a Bayesian rationalisation that allowed riskiness, as measured by a time series concept of variance, to be estimated econometrically. Such models are demanding of data for reliable estimates and are computationally challenging since they are inherently non-linear. Applications have proliferated but there seems to be a swing away from the formality of Just's models back to more *ad hoc* specifications since the results seem robust across forms of specification.

One thing is clear from such work: farmers are indeed responsive to changing riskiness. If their economic environment becomes less risky through, say, the operation of a stabilisation scheme, they will respond by increasing production. The significance of this finding in policy analyses can be considerable, as MacLaren (1983) demonstrates. It is particularly important to account for risk responses in analyses of stabilisation schemes since ignoring such effects will seriously undermine the accuracy with which gains and losses can be measured.

Policy-induced uncertainties

Often, the policy environment is another source of uncertainty for farmers. Governments can intervene in many ways, from shielding or exaggerating the impact of international price fluctuations and trade distortions back to producers, through market operations under the banner of stabilisation, to more directly intruding into input markets to modify prices faced by producers. The need of politicians to trade for votes can lead, especially at election time or at times of rural crisis as may be induced by drought, to interventions which, with hindsight, can be seen as less than fortunate. However, such seems to be the nature of life in democracies, and implies the need for agricultural economists to develop frameworks for analysing the political market. The pioneering work of MacLaren (1980, 1983) in this regard is most insightful. The surface has, however, hardly been scratched and there remains much to be done by careful analysts to incorporate formal concern for policy uncertainty. Unless such unpredictability is accounted for, any policy analysis will be potentially flawed in its assessment of producers' response to designated incentives.

CONCLUSION

Although the analytical challenges of understanding the nexus between the farm and its risky environment are considerable, the rewards are likely to be great. It seems inevitable that the environment of farmers will be forever more or less turbulent and thus urgent progress must be made on both matching and applying analytical frameworks to this reality. Useful starts have been made in several directions. Much, however, remains to be done. This is particularly true in terms of policy analysis, the provision of guides to agricultural scientists in their search for appropriate new technology and the institution of mechanisms to enhance farmers' information about the risks they face. We hope that some of this unfinished business will be done before the next International Conference.

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