# GENERALISED UTILITY THEORIES - IMPLICATIONS FOR STABILISATION POLICY

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## GENERALISED UTILITY THEORIES - IMPLICATIONS FOR STABILISATION POLICY

Risk aversion is central to the case for government intervention to stabilise returns to producers of agricultural commodities. Until recently, analysis of decisions under risk has been based on the Expected Utility model, despite the existence of a number of well-established violations of this model in observed behaviour. More recently a number of generalisations of the model have been presented in an attempt to account for these observations while maintaining the power of the Expected Utility model. The objective in this paper is to describe the implications of these more general models for the case for stabilisation and for the design of appropriate stabilisation policy.

Policies at least ostensibly aimed at stabilising the prices faced by farmers and the incomes they receive are widespread in Australia. Not surprisingly, they have been the subject of extensive analysis by economists. Issues of choice under risk and uncertainty have played a central role in the debate. The expected utility (EU) approach of Von Neumann and Morgenstern (1944) has been a vital tool in analysing such choices.

After a long period of pre-eminence, however, EU theory has been challenged. The breakdown of the dominance of EU theory reflects the increasing body of evidence that the choices made by many people systematically violate the predictions of the theory. The axiomatic foundations of the theory, and in particular the 'independence axiom', have also received severe questioning, beginning with the famous critique of Allais (1953).

Several theorists have presented models in which the independence axiom is either relaxed or abandoned altogether. These models permit the analysis of behaviour inconsistent with EU theory, such as that evident in the Allais paradox and the common ratio effect (see Machina 1983 for a discussion and MacCrimmon and Larsson 1979 for experimental evidence). In the present paper, attention will be confined to models such as those of Machina (1982), Quiggin (1982), and Chew (1983) which provide proper generalisations of EU theory, preserving the axioms of transitivity and first stochastic dominance[1].

In this paper an outline of these generalised utility theories (GUTs) and a review of the existing stabilisation literature is provided. Following that the implications of the generalised theories for stabilisation policy are outlined.

### An outline of GUTS

As is usual, the analysis of choice under uncertainty presented here is based on the concept of a set $\Omega$ of possible states of the world. For ease of exposition, the special case where $\Omega$

[1] Others including Handa (1977), Karmarkar (1978, 1979), Kahneman and Tversky (1979), and Loomes and Sugden (1982) have proposed models in which one or both of these axioms is violated.

is a finite set consisting of N equiprobable states will be used to illustrate the key issues.[2] In addition, it is necessary to define a space of outcomes, W, which will be characterised as a set ordered by a preference relationship denoted by P, and an associated indifference relationship denoted by I. It is frequently convenient to assume that W corresponds to wealth, and may be represented as a subset of $\Re$. A prospect is defined as a mapping from $\Omega$ to W and may be represented as a vector $w = (w_1, w_2 ....w_n)$. The space of all prospects will be denoted by $W^N$. It will also be useful to define $W^{N*} = \{w \in W^N : w_1 = w_2 = ... w_n\}$, which is an isomorphic image of W in $W^N$. If $w \in W$, then its image in $W^N$ will be denoted $w_c$.

It is also useful to employ the notion of comonotonicity, due to Schmeidler (1984). Two random variables $w^0$, $w^1$ are said to be comonotonic if $w_i^0 \geq w_j^0 \Leftrightarrow w_i^1 \geq w_j^1$. Since the models of concern rank variables in terms of their cumulative distribution functions (CDFs) it is possible, without loss of generality, to assume that all random variables under consideration are comonotonic and hence that the space $\Omega$ is ordered from worst to best with ordering $\gtrsim$.

It is now possible to define a number of GUTs in terms of the notation presented above. These models work by constructing a real-valued functional V on $W^N$, such that $V(w) \geq V(w')$ if, and only if, w P w'. The basic EU model is given by

$$(1) \qquad V(w) = \sum_{i=1}^{N} p_i \, U(w_i)$$

Machina (1982) presented a generalisation of EU theory based on the abandonment of the independence axiom. Because Machina's model is most naturally presented in terms of cumulative distribution functions rather than discrete probability distributions, his original notation will be followed here. The special case of N states of the world corresponds to cumulative distribution functions which are step functions having jumps at intervals of 1/N. Machina considers general Frechet differentiable preference functionals V(F), where $F \in D[0, M]$, the space of probability distributions over some interval [0, M]. This class includes the standard EU functional $V(F) = \int U(w) \, dF(w)$, which has the special property of being 'linear in the probabilities'.

Machina demonstrates the existence of a local utility function $U(\bullet;F)$ such that, for any $F^* \in D[0,M]$

$$(2) \qquad V(F^*) - V(F) = -\int (F^*(w)-F(w)) \, dU(w;F) + o(\| F^*-F \|)$$

[2]At this point, it is worth noting that the restriction to a finite number of states is a useful simplification rather than a crucial feature of the argument. In place of known objective probabilities for a finite set of states, it would be perfectly satisfactory to employ a probability measure over a, possibly infinite, state space. The finite case may be regarded as the 'counting measure' on the space {1..N}.

Machina shows that, if all the local utility functions share properties such as preservation of first and second stochastic dominance then so does the global functional V.

An alternative class of generalisations of EU theory is based on the notion of ordering the outcomes and weighting them accordingly. The basic model was first presented in Quiggin (1981, 1982) under the name Anticipated Utility (AU) theory, and independently rediscovered in the model by Allais (1986) and Yaari (1987), for the special case of a linear utility function. The model will be referred to here as Rank-Dependent Expected Utility (RDEU) theory.

In addition to the utility function, the RDEU model employs a probability weighting function q: $[0,1] \rightarrow [0,1]$. For the special case considered here in which there are exactly N states of the world, it is useful to define the rank r(j,w) of a state j (for a given prospect w) as the number of states yielding outcomes less than or equal to $w_j$. Then the RDEU model is given by

(3) $$V(w) = \sum_{i=1}^{N} U(w_i)\, h(r(i,w))$$

where $h:[1,N] \rightarrow [0,1]$. Thus

(4) $$h(r(j,w)) = q\left(\sum_{\{k:w_k \le w_j\}} p_k\right) - q\left(\sum_{\{k:w_k < w_j\}} p_k\right) = q(F(w_k) - q(F(w_{k-1}))$$

A more general class of rank-order models of the form

(5) $$V(w) = \int U(w, F(w))\, dF(w)$$

may be referred to under the name Rank-Linear Utility (RLU). These models have been examined by Segal (1986) and Green and Jullien (1988).

In the special case where $\Omega$ is a set of N states of the world (5) may be written as

(6) $$V(w) = \sum_{i=1}^{N} U_r(w_i)$$

where $r = r(i,w)$ is the rank of state i under the prospect w.

An alternative approach, known as weighted utility is put forward by Chew (1983).

Broadly speaking, all of the models presented here may be considered as special cases of the Machina (1982) model. However, the RDEU and RLU models do not yield a Fréchet differentiable preference functional. Apart from some technical difficulties in the derivation and interpretation of local utility functions, the most important implication of this is that these models do not display local risk-neutrality.

## The literature on stabilisation

The objective in this section is to summarise the central themes in the literature on stabilisation, with particular reference to the Australian literature, and to assess the role of the EU framework. In much of the Australian literature on stabilisation and stabilisation policy, the effects of risk on the behaviour of decision makers are not modelled in any explicit form. Even in the case of the broad empirical literature on supply response, there are only a limited number of attempts to include risk variables. However, as the analysis has become more formal and rigorous in the recent literature, issues of risk-reduction have come to the fore.

The theoretical literature on stabilisation can be broadly divided into three themes. The first is the debate over the benefits of buffer stock stabilisation, arising from the work of Waugh (1944), Oi (1961) and Massell (1969). In Australia, this debate took a distinctive form in the 'hidden gains and losses' literature on the question of wool price stabilisation. The early literature is represented by the papers by Powell and Campbell (1962), Gruen (1964), Tisdell (1972, 1973) and Chapman and Foley (1973). The framework employed is based on the notion that the most important effects of a buffer-stock stabilisation scheme revolve around the impact of intertemporal and interpersonal transfers of income. No explicit attempt was made to model the effects of risk. This 'hidden gains and losses' approach to the problem was dominant in the Australian literature up to the debate between Campbell, Gardiner and Haszler (1980), Richardson (1982) and Haszler and Curran (1982). After this, attention turned to the way in which stabilisation acted to transfer and spread risk. Quiggin (1983a), using a mixture of the EU and mean-variance approaches, argued that wool price stabilisation acted to transfer risk from wool producers to wool processors. Hinchy and Fisher (1988), using the Newbery and Stiglitz (1981) framework, concluded that both wool producers and processors could gain from price stabilisation if the elasticity of demand for wool lies within the range frequently estimated in econometric studies.

In the riskless presentation of the Massell model, welfare gains from stabilisation arise from the introduction of storage. These are represented, in the simple hidden gains model, by the speculative profit accruing to the stabilisation authority. When private storage is introduced these gains are eliminated, unless government can offer storage more cheaply than the private market. This argument is formally similar to that regarding risk. However, it seems more plausible to suppose that governments have particular advantages in handling risk than to suppose they are better in providing storage services. For this reason, more recent literature on buffer stock schemes and most notably the work of Newbery and Stiglitz (1981) is concerned primarily with the effects of risk transfers.

The analysis of the wool minimum reserve price scheme by Hinchy and Fisher (1988) represents a natural extension of the hidden gains and losses literature in which an estimate is made of the risk benefit of the scheme. The literature on underwriting, particularly that employing the Newbery and Stiglitz framework (see Hinchy 1988; Fraser 1988) is closely related to the latest work on the wool buffer stock.

The most striking feature of this literature is the ambiguity of its conclusions. In the early literature, the direction of transfers turned on factors such as whether disturbances were additive or multiplicative and whether demand and supply functions were linear or logarithmic. In the literature on risk effects arising from the work of Newbery and Stiglitz, the results are similarly ambiguous. For example, Fraser's (1988) analysis of underwriting suggests that, for high levels of risk aversion, supply response to underwriting will be negative.

The second theme, which is particularly well represented in the Australian literature, is the attention given to the decomposition of gross income variance into its component parts and the analysis of the effectiveness of various policy instruments following from that. The technique used in the early work represented by Houck (1973), Harris et al. (1974) and Motha, Sheales and Saad (1975) was that developed by Burt and Finley (1968). The decomposition of gross income into its price and quantity components represents a useful approach only under restrictive assumptions about the nature of supply and demand. The decomposition advanced by Piggott (1978) into supply, demand and interaction components is more general. However, all such decompositions are at best descriptive. A major problem with the published work has been the concentration on the use of industry aggregate data. As pointed out by Johnson and Baum (1986, p.9) in an analysis of US farm data, policy analyses using aggregate data are likely to be misleading because of the large differences in characteristics between individual farm firms. Perhaps more importantly, in none of this work has an attempt been made to address the fundamental question of how risk affects the individual decision maker and how the introduction of a stabilisation scheme will change both the level and the variability of net income, the major determinants of farmers' welfare.

More recent theoretical and empirical work has addressed these issues. The IAC (1978) and Quiggin and Anderson (1979) considered the possibility of regionally-based stabilisation and insurance schemes which would deal with both price and yield uncertainty. Bardsley, Abey and Davenport (1984) examined the potential for insurance against yield variation using rainfall as a proxy variable. Their conclusions, which were generally negative, were criticised in several respects by Quiggin (1986a) and defended by Bardsley (1986). In this area a lot of empirical work remains to be done. It is not at all clear for example that stabilisation schemes designed to affect industry aggregate variables have a positive effect on farmers' net incomes. Two approaches to this research could be adopted. One is to analyse movements in net farm incomes and attempt to relate these to policy changes. The other is to attempt to trace the effects of policy changes at the aggregate industry level to the farm level using simulation techniques. Research on both these fronts is under way at the University of New England and the Australian Bureau of Agricultural and Resource Economics.

The third strand of the literature, and the one most explicitly based on the EU framework, derives from the theory of the neoclassical firm under uncertainty (Sandmo 1971, Leland 1972, Coes 1977). The results derived in this literature yield a strong presumption that reductions in risk will lead to an increase in output. The central claim made by advocates of stabilisation such as Blandford and Currie (1975) and Quiggin and Anderson (1979) is that risk-averse producers will reduce output levels below those which would prevail in the absence of risk and that if governments can spread risk cheaply an increase in both output and social welfare will result. The idea of risk-aversion is central to this argument. If producers are risk-averse and capital markets are imperfect, then there is a potential gain from stabilisation arising from the transfer of risk from producers to the government, which has a large and diversified portfolio.

The theory of the firm provides a theoretical basis for the analysis of supply response to stabilisation. In particular, Coes (1977) shows that, given decreasing absolute risk-aversion, a multiplicative increase in risk will always lead to a reduction in output. Quiggin and Anderson (1981) and Quiggin (1983b) take this further for the cases of price-band stabilisation and underwriting, showing that these will lead to increases in output for all risk-averse producers. Critics of stabilisation, such as Colman (1978), did not generally contest this point but focused on whether governments could in fact bear risk more efficiently than markets.

At first sight, the results mentioned above are inconsistent with results arising from the model of stabilisation presented by Newbery and Stiglitz (1981). Newbery and Stiglitz do not refer to the literature on stabilisation and risk-reduction and their results differ in important respects from those which were taken as common ground by participants in that debate. In particular they yield the result that a beneficial reduction in risk will lead to a negative supply response for plausible values of parameters on risk aversion. Fraser (1988) specifically examines the case of underwriting and concludes that for values of the relative risk-aversion coefficient greater than unity, underwriting will lead to a reduction in output. This result directly contradicts that of Quiggin (1983b) mentioned above.

This conflict may be explained by reference to assumptions about the process of production. Labour supply plays a key role in the Newbery-Stiglitz model. The crucial assumption is that labour is the sole factor of production and has a zero opportunity cost (apart from the disutility of effort). By contrast, in the neoclassical model of the firm under uncertainty, all inputs are purchased in competitive factor markets and the objective is to maximise the expected utility of net profits (revenues minus factor costs). Quiggin (1988a) examines this difference and shows that, in the Newbery-Stiglitz model, the coefficient of relative risk-aversion will be greater than unity if and only if the producer displays backward-bending labour supply. Thus it is not surprising that these producers should display 'perverse' supply response in relation to risk.

The Newbery-Stiglitz model seems reasonable as a description of the situation facing peasant producers of cash crops, the group with whom their analysis is principally concerned. However, in the Australian context, operator and family labour is by no means the sole production input to and generally has a positive opportunity cost. Thus, it seems likely that the neoclassical model would be more appropriate in this case.

Two aspects of the empirical literature on stabilisation are of central interest. First, there have been attempts to measure the risk-aversion of farmers, notably by questionnaire methods.

These have generally found farmers to be risk-averse, and there has been fairly good support for the plausible hypothesis of decreasing absolute risk-aversion (Hamal and Anderson 1982). However, some attempts at measuring risk aversion among farmers (for example see Bond and Wonder 1980) found that average levels of risk aversion were very low and that many farmers were risk seekers. Other observations such as the popularity of gambling and other activities involving voluntary assumption of risk raise questions concerning the assumed prevalence of risk-aversion.

The empirical literature on supply response is almost devoid of any consideration of the effects of risk. In the limited number of studies in which risk is considered explicitly it has been treated in one of two ways. The first approach has involved the use of actual variability in prices over a recent short period as a measure of risk. Measures such as a moving standard deviation or a moving range of prices have been employed. Examples of this approach can be found in Behrman (1968), Freebairn (1973), Wilson, Arthur and Whittaker (1980) and Brennan (1982). The second approach to the inclusion of risk in supply response models has been to assume that uncertainty results from the difference between actual and expected outcomes. Models of this form have been used by Just (1974), Traill (1978), Hurt and Garcia (1982) and Harrison (1982). This approach was considered in a rational expectations framework by Fisher and Hanslow (1984) who show that, unless special conditions hold, the effect of the risk variable cannot be separately identified in econometric models of this type. Given the extent of the empirical supply response literature the overall effort devoted to estimating the effects of risk in econometric supply response models seems to have fallen far short of what is required to provide good information for policy formulation.

Finally it is useful to examine some general implications of EU theory for stabilisation policy, and in particular, the choice between full stabilisation and partial stabilisation. One of the most noteworthy results from the EU theory of risk-reduction through stabilisation is that complete stabilisation is optimal if and only if stabilisation is costless. A similar and better-known result arises in the EU theory of insurance. It may be shown that full insurance is always sub-optimal (unless insurance is actuarially fair). This result is somewhat problematic in view of the empirical observation that people are often willing to purchase full insurance even at actuarially unfair prices.

In relation to stabilisation, the issues have been somewhat obscured by the existence of two forms of partial stabilisation. Underwriting and price-band stabilisation schemes involve payouts only when the market price falls below a particular level. These schemes may be contrasted with schemes which involve partial stabilisation in every time-period. In comparisons using simulation models of stabilisation programs based on buffer stocks, the second class of solutions have yielded superior results (Gardner 1979). By contrast, Quiggin and Anderson (1981), analysing a buffer fund model, show the price-band approach will generally yield a given reduction in risk at a lower cost, in terms of the degree of intervention and the loss of useful price information.

In a buffer stock scheme, the principal costs are associated with storage. Hence, for any given state of demand and supply, the optimal level of intervention will vary smoothly with the size of the existing stock. A price-band policy cannot meet this criterion. In a buffer fund scheme, the principal costs relate to payments into and out of the fund. If intervention is beneficial then a price-band policy will be optimal. This is a generalisation of the results of Quiggin and Anderson (1981), which rely on the assumptions of quadratic target costs and linear instrument costs. Quiggin (1983b) proves a corresponding result for the optimality of underwriting within the class of pure subsidy schemes. Examination of the proofs presented in these papers will show that the quadratic-linear assumptions are unnecessary.

**The impact of generalised theories**

There are three main ways in which the task of applying the generalised models to problems such as those of price stabilisation theory may be approached. First, conditions may be established under which results derived using EU theory may be carried over to a more general framework. This has the benefit of showing that these results are not dependent on the special assumptions of EU theory.

In Machina's framework, this task is undertaken using the notion of local utility functions. Many properties which are shared by all of the local utility functions carry over to global functions. An example is risk-aversion in the sense of aversion to mean preserving spreads. Machina shows that, if all the local utility functions are concave, then the preference functional V will exhibit the corresponding global property, namely that $V(F^*) < V(F)$ whenever $F^*$ differs from F by a mean preserving increase in risk in the sense of Rothschild and Stiglitz (1970, 1971).

A similar analysis can be carried out in the RDEU context. An analogue to the local utility function can be derived from equation (5), and is concave for all F and w if and only if U" and q" are negative. Chew, Karni and Safra (1987) prove that, if these conditions apply, RDEU functions will be averse to mean preserving spreads.

However, given the probability weighting approach inherent in RDEU theory, it is more natural to work in terms of the transformed distribution $q^\circ F$. If, whenever a given relationship holds between F and $F^*$, the same relationship holds between $q^\circ F$ and $q^\circ F^*$, then results from EU theory will carry over to the RDEU framework. For example, for concave q, $q^\circ F$ second stochastically dominates $q^\circ F^*$ if and only if F second stochastically dominates $F^*$.

For many purposes, the requirement that q be concave is too strong. In particular, the standard definition of risk aversion, namely that the certainty equivalent of any risky distribution is less than the mean, holds whenever U is concave and $q(p) \geq p \ \forall \ p$. A simple way of verifying this result uses the partitioning of the RDEU risk premium proposed by Hilton (1988). This divides the risk premium into two parts. The first is the difference between $E[q^\circ F]$ and $E[F]$ and the second is the EU risk premium applicable to $q^\circ F$. The suggested risk aversion condition ensures that both of these premiums are positive.

It is straightforward to prove that this risk-aversion condition is weaker than Machina's. In fact, it is easy to exhibit distributions $F_1$ and $F_2$, and an RDEU functional V, satisfying $q(p) \geq p \ \forall \ p$, such that $F_1$ SSD $F_2$ but $V(y_1) < V(y_2)$. Thus, the class of RDEU functionals preserving second stochastic dominance is strictly smaller than those which are risk-averse in the classical sense of preferring certainty to risk. Those in the larger class will be referred to as RDEU risk-averse.

Most of the standard results of EU theory can be generalised using these risk aversion conditions. In particular, Quiggin (1986b, 1988b) demonstrates that the standard results of the neoclassical theory of the firm under uncertainty, with their applications to stabilisation theory, can be generalised using either definition of risk aversion. Risk-averse producers will produce less under uncertainty than under certainty and will reduce their output in response to a multiplicative increase in risk.

The second way of applying generalised utility theories is to flag cases where results from EU theory may not carry across. One such case, relating to the derivation of risk attitudes from questionnaires, played a significant role in the development of alternative theories. EU theory suggests that the utility function can easily be estimated using choices between certain sums and two-outcome lotteries with fixed prizes and varying probabilities. In practice, this approach has generally produced inconsistent answers, as would be expected if phenomena such as probability weighting were present. Quizon, Machina and Binswanger (1984) and Quiggin (1981) have re-analysed the data from experiments of this kind in the light of more general theories and have succeeded in explaining some of these inconsistencies.

The second example arises in relation to the Newbery-Stiglitz model of buffer stock stabilisation. A number of the key results of this model depend very strictly on the EU interpretation of risk attitudes in terms of concavity of the utility function, or, in other words, decreasing marginal utility of wealth. A corollary, which is implicit in many of the results of Newbery and Stiglitz is that, for utility functions with constant relative risk aversion coefficient $c$, $c > 1$ if and only if the labour supply curve is backward-bending. This implication does not hold in the generalised theories which permit, for example, high levels of risk-aversion to be consistent with constant marginal utility of wealth.

A final example arises in relation to the optimality of partial stabilisation. This result is dependent on the local risk neutrality property of EU theory. Because individuals are approximately risk-neutral in a neighbourhood of certainty, the marginal benefit of stabilisation approaches zero as complete stabilisation is approached. Hence, if stabilisation is costly, complete stabilisation is always sub-optimal. The property of local risk neutrality carries over to a number of the generalised utility theories including that of Machina.

However, the RDEU model and its generalisations are not, in general consistent with local risk-neutrality, except in the EU special case. As Segal and Spivak (1988) have shown, this means that full stabilisation may be optimal in these models.

The first two approaches to the application of GUTs take the existing EU analysis and checks its validity in a more general context. The third and most interesting role of GUTs is their potential contribution to the development of new theoretical analysis. This arises from the treatment of problems which are not amenable to analysis using EU theory and from the application of new theoretical tools, such as alternative concepts of stochastic dominance.

Perhaps the most important aspect of behaviour where EU theory is inadequate is that of risk-taking. Risk preference is modelled in EU theory in terms of convexity of the utility function, but this does not provide an adequate account of risk-taking behaviour. Quiggin (1986b, 1987) shows that an EU maximiser with globally convex utility function would gamble continuously, ending up either bankrupt or a billionnaire. Similarly bizarre, though less extreme, behaviour would be expected from someone with concave and convex segments in their utility function (the case proposed by Friedman and Savage 1948).

The generalised models permit a much more sensible account of the behaviour of individuals who are generally risk-averse but sometimes risk-seeking. Typically, such people will display risk-seeking behaviour in relation to bets offering a small probability of a large gain, such as lottery tickets. Less firmly established is the claim, put forward by Kahneman and Tversky (1979) among others, that people display risk-preference in the domain of losses.

Given these preferences, estimates of risk-aversion obtained on the basis of EU theory will tend to overstate the degree of risk-aversion in relation to risks where the distribution is skewed to the right and understate it in relation to risks where the distribution is skewed to the left. Since many forms of stabilisation, notably underwriting, operate to reduce the degree to which distributions are skewed to the left, this bias will tend to lead to an under-estimation of the benefits from stabilisation.

A more formal analysis may be undertaken by attempting to define the most preferred distribution having a given mean. For risk-averters, this is obviously the distribution yielding that outcome with probability 1. For EU risk-preferrers, the distribution is undefined, since an increase in risk is always desirable. Quiggin (1987) analyses this question in an RDEU context on the assumption that preferences are such as to favour bets with small probabilities of a large payout. It is shown that the most preferred distribution having a given mean is skewed to the right and has the lower tail truncated at some fixed value, normally not far below the mean. This is the type of price distribution which arises from underwriting. Hence for some plausible preferences, an underwriting scheme may be preferable to complete stabilisation combined with a subsidy yielding the same expected price. Note the contrast with EU theory where, if stabilisation is complete, perfect stabilisation is always preferred.

This analysis implies the need to examine the shape of the distribution of outcomes rather than a couple of parameters such as mean and variance. This point, has, of course, already been made by EU theorists criticising the earlier mean-variance approach (see for example Borch 1969) but it is reinforced in the generalised context. This is particularly true in relation to low-probability high-loss events such as severe droughts, and suggests a need for re-examination of the rainfall insurance debate in the light of generalised theories.

The notion of monotone spreads provides an example of a useful analytical tool developed in response to the needs of the generalised theory. As was noted above, risk-aversion in the general context is not equivalent to preservation of second stochastic dominance. It is of interest to derive a partial ordering on the class of distributions which is equivalent to risk-aversion. Quiggin (1988c) derives the required property and terms it a 'monotone spread'. Suppose that $\lambda$ is a spread parameter such that as $\lambda$ increases all of the outcomes move 'further away' from some central point, so that the distance between the outcomes for any two states increases. Then an increase in $\lambda$ may be referred to as a monotone spread. More formally, recalling that the states $\omega \in \Omega$ are ordered from worst to best, $y_2$ is said to be derived from $y_1$ by a mean-preserving monotone spread if there is a path $\varphi: [0,1] \rightarrow Y^*$ such that:

(i) $\varphi(0) = y_1, \varphi(1) = y_2$;

(ii) $\partial/\partial\lambda \ E[\varphi(\lambda)] = 0 \ \forall \lambda \in [0,1]$; and

(iii) $\omega_1 \geq \omega_2 \Leftrightarrow \partial/\partial\lambda \ \varphi(\lambda(\omega_1)) \geq \partial/\partial\lambda \ \varphi(\lambda(\omega_2)) \ \forall \omega_1, \omega_2 \in \Omega, \lambda \in [0,1]$.

This class includes multiplicative spreads about the mean, such as increases in the variance of the normal distribution. Also, the monotone spread relationship is transitive; that is, the result of any combination of monotone spreads is also a monotone spread.

Because the monotone spread concept represents a more restrictive notion of increasing risk, it yields an expansion of the class of preference functionals for which stochastic dominance applies. In particular, all RDEU risk-averse individuals, and not merely those with concave weighting functions, are averse to mean-preserving monotone spreads. In fact, as Quiggin shows, two random variables with equal means are related by a monotone spread if and only if the first is preferred by all RDEU risk-averse individuals.

A particularly interesting result in the present context arises for monotone spreads about the mean, that is, those for which only outcomes below the mean are made worse and only outcomes above the mean are made better. Quiggin (1988b) shows that all RDEU risk-averse producers will reduce their output in response to a monotone spread about the mean. This is a generalisation of a result originally proved by Quiggin and Anderson (1981) and, in a different context, by Meyer and Ormiston (1983). Quiggin and Anderson showed that a price band stabilisation scheme will always yield an increase in output. It is clear that, under price band stabilisation, the original price distribution and the stabilised distribution are related by a monotone spread about the mean.

More generally, if the utility function satisfies decreasing absolute risk-aversion, then any monotone spread in prices will lead to a reduction in output and hence any stabilisation scheme which yields a monotone contraction in prices will lead to an increase in output. Most optimal buffer stock rules satisfy this condition since they have the property that the lower the market price, the higher *ceteris paribus* are the purchases by the stabilising authority. Given a well-behaved market excess demand function, this will guarantee a monotone contraction.

## Concluding Comments

In much of the early Australian literature on stabilisation policy little explicit attention was paid to how risk affects individual decision makers. This tendency has been reversed with the more recent work on stabilisation policy using the Newbery-Stiglitz framework. Further progress can be made in this area by careful consideration of the results available from the generalised utility theories.

The results from the generalised theories reinforce the need to examine the shape of the distribution of outcomes rather than a limited number of parameters such as the mean and variance when considering stabilisation policy. This is particularly true in the case of high-loss low-probability events such as severe droughts and fires and suggests a need for a re-opening of the debate on rainfall insurance.

The generalised models account more sensibly for the behaviour of individuals who are generally risk averse but sometimes seek risk. Even so, many of the standard results of EU theory remain applicable. For example, risk averse producers will produce less under uncertainty than under certainty and will reduce output in response to a multiplicative increase in risk. However, given the typical preference of risk-seeking behaviour in relation to bets offering a small probability of a large gain, such as is the case with lottery tickets, estimates of the degree of risk aversion based on EU theory will tend to overstate it in the case of risks where the distribution is skewed to the right and understate it in relation to risks where the distribution is skewed to the left. Some forms of stabilisation, such as underwriting, reduce the degree to which distributions are skewed to the left. In this case, the bias in estimates of the degree of risk aversion based on EU theory will lead to an under-estimate of the benefits from stabilisation. More formally, given the preferences described above, it has been illustrated that underwriting may be preferred to complete stabilisation combined with a subsidy yielding the same expected price. This may help to explain the revealed preference of producers for stabilisation in spite of the results of many studies apparently illustrating that the gains are small.

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