RISK ATTITUDES AMONGST AUSTRALIAN FARMERS

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A procedure for the measurement of risk attitudes is developed and applied. The data for the analysis were obtained from a survey in which 201 farmers throughout Australia were asked to provide points of indifference between sure amounts of income and risky prospects. Although the conclusions from this pilot study are of a tentative nature, it is suggested that risk aversion is the most prevalent risk attitude in the agricultural sector. However, the average degree of risk aversion is relatively small and, in an expected utility context, farmers gave a wide variety of responses. The latter result highlights the need to consider the size distribution of risk attitudes in economic modelling. Influences of socioeconomic and other variables on risk attitudes are examined. The results, when considered jointly with other studies, emphasise the desirability of further research into the determination of risk attitudes.

Introduction

The presence of risk in agriculture has long been viewed as having a significant influence on farmers' production and investment decisions. Not only has much of the technological research in agriculture been aimed at providing farmers with a more certain environment in which to operate, but also many government policy initiatives have been specifically oriented towards risk reduction.

While there can be no question that risk is an obvious characteristic of the agricultural decision environment, there exists a very large gap in our knowledge and understanding of the attitudes which farmers have towards risk. The problem stems from the way in which risk attitudes are intimately associated with the complex behavioural characteristics of the individual farmer and the difficulties in separating risk-related responses from other forms of behaviour.

The cornerstone of economic research into risk attitudes is the set of behavioural axioms proposed by von Neumann and Morgenstern (1947) and subsequently developed by Arrow (1970) and Pratt (1964), among others. Use can be made of these axioms to demonstrate that an individual's preferences between two or more outcomes of a risky prospect can be determined, provided we know the distributional properties of the risky prospect and the curvature properties of the individual's utility function. It is the latter which lie at the heart of what are known as 'risk attitudes'.

Reversing the order of this argument, it is evident that an individual's risk attitude can be inferred if the preference ordering and distributional properties of the risky prospect are known. The task, therefore, is to obtain a systematic procedure for placing these two latter factors together and to apply this procedure to the estimation of farmers' risk attitudes.

In the first part of the paper, a procedure for measurement of risk at-

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titudes is developed. It is followed by the description of a questionnaire in which farmers were requested to provide points of indifference between sure amounts of income and risky prospects which have alternative outcomes. Attitudes of individual farmers towards income variability are then derived in terms of formulations based on utility function derivatives. An attempt is made to see whether the wide variety of basic risk attitudes in the sample are related to some socioeconomic variables. Finally, some of the more important conclusions and areas for future research are discussed.

A Framework for Assessing Risk Attitudes

In this section of the paper, a theoretical framework is established for the purpose of linking the characteristics of a risky prospect and the attitude which an individual has towards such a prospect. The risk premium as a measure of risk attitude is developed initially and the measures used for risk coefficients in programming models are then investigated.

The risk premium

It is assumed that the individual farmer is concerned with the variability of returns generated by current investment and production decisions. This means that the risky prospect under consideration is the net monetary return to the farm enterprise over some defined period. When x denotes the net monetary return to some individual in a given period, a utility-of-money function for that individual in that period may be written as $u(x)$.[1]

If x is a random variable distributed as x_j with associated probabilities α_j (where $\Sigma_j\alpha_j = 1.0$), the expected utility of the risky prospect to the individual is given by

(1) $$E[u(x)] = \Sigma_j\alpha_j u(x_j).$$

The expected value of x is given by $x^* = \Sigma_j\alpha_j x_j$ and the difference between $u(x^*)$ and $E[u(x)]$ can be used to define risk attitudes as

(2) $$\begin{aligned} &u(x^*) > E[u(x)] \text{ under risk aversion,} \\ &u(x^*) < E[u(x)] \text{ under risk preference,} \\ &u(x^*) = E[u(x)] \text{ under risk neutrality.} \end{aligned}$$

From this, the certainty equivalent can be defined as the sure sum of money x_o which gives the same level of utility as the random prospect x. Thus, the certainty equivalent is the amount x_o such that

(3) $$u(x_o) = E[u(x)].$$

From (2) it can be seen that x_o will be smaller (greater) than x^* under risk aversion (preference).

The risk premium is then defined as the difference between x^* and x_o:

(4) $$\pi = x^* - x_o$$

where $\pi > 0$ under risk aversion, $\pi < 0$ under risk preference and $\pi = 0$ under risk neutrality.

Writing (3) and (4) together gives

(5) $$u(x^* - \pi) = E[u(x)].$$

[1] See Dillon (1971).

Solving (5) directly for π gives

(6) $$\pi = x^* + u^{-1}(E[u(x)]).$$

The measure of the risk premium given by (6) does not lend itself easily to empirical manipulation. Following the methods of Pratt (1964) and Malinvaud (1972), however, a useful approximation is provided by

(7) $$\pi \simeq -\tfrac{1}{2} V[x] u''(x^*)/u'(x^*)$$

where $V[x]$ is the variance of the risky prospect x and $u'(x^*)$ and $u''(x^*)$ are the first and second derivatives, respectively, of the utility function evaluated at the point x^*.

In equation (7) the risk premium which an individual attaches to a given risk, x_j, is dependent on the variance of x and the ratio of utility function derivatives $u''(x^*)/u'(x^*)$. The negative of this ratio has been termed the 'absolute risk aversion function' and plays a key role in the theoretical developments of Arrow and Pratt.[2] The approximation sign is used to indicate that it may represent an incomplete specification of the true value of the risk premium as determined by the von Neumann-Morgenstern axioms. It is difficult to judge, *a priori*, the empirical consequences of using such an approximation. In the results which follow, the expression for π in (7) will be used as if it were an equality.[3]

It can be seen from (7) that different individuals will attach different risk premiums to the same risky prospect whenever their subjective assessments of $V[x]$ differ and/or if the natures of their utility functions differ. In particular, much of the theory dealing with risk attitudes assumes away the processes by which individuals form probability assessments (including the formation of expectations). Due to a lack of information, it can be expected that many of the factors which influence income variability cannot be assessed in 'objective' probability terms and that 'subjective' probability formation is a key factor in revealed risk attitudes. In the questioning procedure described later in this paper, this problem of subjectivity is overcome to some extent by presenting farmers with the probabilities attached to the different income possibilities.

Differences in the nature of individuals' utility functions present a much more difficult problem in interpreting risk attitudes. In the analysis so far it has been assumed that the individual's utility function contains only money, but a more realistic specification would see the inclusion of many other factors. These may include initial wealth and characteristics not necessarily of a pecuniary nature, such as length of life, health, education and life style.

The difficulty that these other factors can create in the analysis of an individual's risk attitudes can be more clearly understood when the utility function is written as

(8) $$u = u(x, y_s) \quad s = 1, 2, \ldots, t$$

where y_s denotes factors other than money for an individual.

Partially differentiating (8) with respect to x will give first and second derivatives which may or may not involve y_s terms. Consequently, the

[2] Malinvaud (1972, pp. 291-2) developed his result by defining $E[u(x)] = u[(1-p)x^*)$, where $(1-p)x^*$ is the certainty equivalent of the random variable x. From (4) above, it can be seen that $p = \pi/x^*$ and, when this value of p is substituted into Malinvaud's equation 27, the result $\pi \simeq -\tfrac{1}{2} V[x]\, u''(x^*)/u'(x^*)$ is obtained.

[3] See Pratt (1964, p. 125).

ratio of derivatives $u''(x^*)/u'(x^*)$ in (7) will often depend on the presence of nonmonetary utility characteristics. Indeed, the only situation in which the partial derivatives will not be affected by the nonmonetary characteristics is when the utility function is separably additive in x and y_s. Any other functional form will result in the value of the risk premium being dependent on the nonmonetary characteristics.

In the section of this paper entitled 'Influences of socioecomomic, regional and property-type variables', various tests are made to examine the hypothesis that some association exists between certain nonmonetary attributes and revealed risk premiums. These tests are conducted to obtain results which may be compared with those of other researchers in this field. As indicated by the previous discussion, however, the adequacy of these tests is severely constrained by lack of knowledge concerning the form of the utility function.

Risk coefficients in programming models

Measures of risk attitudes are frequently employed in mathematical programming studies of the farm firm. These models usually embody an objective function in which the expected payoff (or income) from farming activities receives a positive weighting and the variability in payoff receives a negative weighting. The latter weighting is used to denote risk aversion.

More generally, the objective function is specified so as to determine the strategy x' such that $E[u(x)]$ is greater for x' than any other x. Maximisation of expected utility of x is identical to maximisation of the certainty equivalent of x (from equation (3)). From (4) and (7), the certainty equivalent can be written as

(9) $$x_o = x^* + \tfrac{1}{2} V[x] u''(x^*)/u'(x^*)$$

and, hence, the objective function specification is written

(10) $$max\, x_o = max\, [x^* + \tfrac{1}{2} V[x] u''(x^*)/u'(x^*)].$$

A number of approaches to this specification have been used. One approach is to employ the variance (or standard deviation) of returns directly[4]:

(11) $$x_o = x^* + \phi(V[x])^{1/2}$$

(12) $$x_0 = x^* + A\, V[x].$$

The parameters ϕ and A in (11) and (12) are referred to as risk coefficients. Solving for ϕ and A using (9) gives[5]

[4] See Scandizzo and Dillon (1979), Hazell and Scandizzo (1974) and Freund (1956).

[5] A point worth noting at this stage with respect to the work by Scandizzo and Dillon (1979) is that their approach gives the same estimates of ϕ as the Malinvaud-Pratt approach used in this study. From Scandizzo and Dillon, $u(x) = E[x] + \phi(V[x])^{1/2} = x_o$, where x represents the random payoff of the risky prospect and x_o is the certainty equivalent. Thus,

(A) $$\phi = (x_o - E(x))/V[x]^{1/2} = -\pi/(V[x])^{1/2}.$$

Following the Malinvaud-Pratt route, (B) is obtained.

(B) $$\phi = \tfrac{1}{2}(V[x])^{1/2}\, u''(x^*)/u'(x^*)$$

Equating (A) and (B) gives

(C) $$-u''(x^*)/u'(x^*) = 2\pi/V[x],$$

which is equivalent to our (18).

(13) $$\phi = \tfrac{1}{2}(V[x])^{1/2} u''(x^*)/u'(x^*).$$

(14) $$A = \tfrac{1}{2} u''(x^*)/u'(x^*).$$

An alternative approach to the specification of objective functions is the Minimisation of Total Absolute Deviations (MOTAD) method.[6] In this approach the mean absolute deviation of profit (or income) is used as a measure of risk rather than the variance of profit. If the mean absolute deviation is written as M, then the objective function specification is

(15) $$x_o = x^* + \gamma M.$$

The value of γ in (15) can be solved in the same way as ϕ and A above only if M can be expressed as a function of $V[x]$. As shown by Herry (1965), a relationship between M and $V[x]$ can be obtained as

(16) $$V[x] = 1.57\, M^2$$

when x is normally distributed.[7]

Using this relationship, an expression for γ can be obtained from (9), (15) and (16) as

$$\gamma = 0.625(V[x])^{1/2} u''(x^*)/u'(x^*)$$

or

(17) $$\gamma = 1.254\phi.$$

Estimation of ϕ, A and γ requires knowledge not only of the distributional properties of x, but of the ratio $u''(x^*)/u'(x^*)$ as well. From (4) and (7), this ratio is given by

(18) $$u''(x^*)/u'(x^*) = -2(x^* - x_o)/V[x].$$

It is possible to measure the right-hand side of (18) directly and hence obtain information on the ratio of the utility function derivatives. From this information, the risk coefficients ϕ, A and γ can then be estimated.

Questioning Procedure

The survey questionnaire used in this study (a copy of which is presented as an appendix) to estimate risk attitudes is based on the premise that, if an individual's attitudes to risky alternatives *vis-à-vis* sure outcomes are known, and if the statistical properties of the alternatives can be specified, the risk attitude(s) of that individual can be inferred. Hence, the questionnaire was designed to elicit certainty equivalents of various risky prospects.

The approach adopted is based upon the standard reference contract or von Neumann-Morgenstern method (von Neumann and Morgenstern 1947; Raiffa 1968; Schlaifer 1969; Halter and Dean 1971). This method utilises the continuity axiom, which states that, if there is an outcome x_1 which is preferred to x_2, and x_2 is preferred to x_3, there is a probability ($p > 0$) such that the individual is indifferent between $px_1 + (1-p)x_3$ and x_2 (see Dillon 1971, pp. 23-4).

Two main shortcomings of the standard reference contract procedure have been cited in the literature.[8] First, the subject may possess a liking

[6] See Hazell (1971).

[7] If a sample of size n is used to estimate M, then (16) becomes $V[x] = M^2(1.57n/n-1)$. See Herry (1965, p. 259) and Anderson, Dillon and Hardaker (1977, p. 209).

[8] See Dillon (1971, p. 24).

or disliking for gambling *per se*, so that his certainty equivalents are possibly influenced by the fact that the questions asked involve risky versus sure prospects. Second, bias may be introduced by the likelihood that some people exhibit preference for particular probabilities. Anderson, Dillon and Hardaker (1977, p. 69) have argued that this latter bias may distort the utility assessment if probabilities rather than outcomes of a gamble are varied in order to obtain a utility function over a range of money gains and/or losses.

To overcome the problem of probability preference, Dillon (1971) and Makeham, Halter and Dillon (1968) suggest the use of questions which vary outcomes of events and use fixed neutral probabilities (i.e. $p=0.5=1-p$). Dillon refers to this method as the modified von Neumann-Morgenstern approach and notes that investigators at the University of New England have found that the procedure is generally quite satisfactory.[9] It is clear that the use of neutral probabilities does overcome the bias associated with probability preference in the sense that the choice between the risky prospects and the certain event is not unduly influenced by the fact that the outcomes of a gamble are weighted with differently preferred probabilities. However, the approach may have some inherent difficulties. In particular, the use of neutral probabilities appears to induce subjects to exhibit undue preference for fifty-fifty gambles. Such a display of preferences is reported by Coombs and Pruitt (1960).

The modified von Neumann-Morgenstern method is often employed for the purpose of plotting a utility function over a range of money gains and/or losses.[10] Such information was not required for this study. Instead, the questionnaire was designed to obtain certainty equivalents of four different gambles which represent local risks that farmers might confront. Each subject was asked what his personal experience had been with respect to income fluctuations and he then selected the series of gambles which was thought to be relevant to his situation. Subjects were given the mutually-exclusive choice of three situations, namely: (a) income in most years steady, occasionally high, (b) income in most years steady, occasionally low and (c) both (a) and (b), in which case the subject was asked to respond to two series of gambles. The lowest cash incomes that an individual would trade for the risky prospects shown in the

[9] Anderson et al. (1977, p. 70) called this procedure the Equally Likely Certainty Equivalent approach (ELCE). We are aware of only one study which has empirically tested the comparative performance of the ELCE method and alternate preference elicitation procedures. Officer and Halter (1968) have conducted comparative tests of the standard reference contract, ELCE and Ramsey approaches. The Ramsey or Equally Likely Risky Outcome (ELRO) procedure attempts to overcome both of the above-mentioned criticisms of the standard reference contract method by presenting questions which involve equally likely gambles. The subject is asked to choose sequentially between linked pairs of risky prospects. Officer and Halter concluded that the ELCE and ELRO procedures were superior to the standard reference contract approach. Although the most consistent results were obtained by the ELRO method, this was at the cost of a more complicated questioning procedure.

[10] Anderson et al. (1977, p. 72) present a format of the modified von Neumann-Morgenstern approach that may be used for the purpose of plotting a utility function. However, one problem which they do not discuss and which may be encountered in empirical studies is that certainty equivalents of the lower branches of their tree structure may be difficult to obtain, owing to a small range of the alternatives presented in the risky prospect. Under such conditions, individuals may be unable to perceive a significant difference between the alternatives of a risky prospect.

Appendix (i.e. the certainty equivalents) were determined by an iterative process between interviewer and respondent. For example, if the respondent supplied an answer of $20 000 to the first risky prospect of situation (a), the interviewer then asked the respondent whether or not he was prepared to accept a lower sure sum (e.g. $19 000). Once the respondent and interviewer were both satisfied that the 'true' certainty equivalent had been determined, they went on to the following risky prospect.

The range of income levels chosen for the questionnaire (from $2000 to $40 000 a year) was based on an examination of returns from previous grazing industry surveys. Although it is recognised that many grazing properties experienced negative incomes during this period, such outcomes were excluded from the questionnaire design because of the interpretational difficulties that might have been encountered. The use of risky prospects that include only positive outcomes may limit the applicability of the results for studies concerned with examination of policy options for the alleviation of negative farm incomes.

Denoting the above-mentioned situations (a) and (b) as response codes 1 and 2 (RC1 and RC2), respectively, a plot of the risks with which farmers were presented is given in Figure 1. Inspection of the figure indicates that the four risky prospects of RC1 and RC2 have successively smaller expected values.

Whilst the four risks of RC1 have successively increasing variance, those of RC2 have successively decreasing variance. This difference in variance succession between the two response codes is a direct consequence of the chosen questionnaire design and was not intended as part of any behavioural test. It is possible, however, that the order in which participants are presented with risky alternatives can influence their response and this is an aspect that might be considered in future questionnaire design.

Following Scandizzo and Dillon (1979), the probabilities of the two alternatives of each risky prospect were held fixed at 75 per cent ('three out of four years') for one outcome and 25 per cent ('one out of four years') for the other outcome. A period of four years was used to represent the minimum amount of time required to make the prospect realistic to the subject.

Perhaps the greatest difficulty with this approach to estimating risk attitudes is that individuals may give responses to the questionnaire which are not always consistent (for example, subjects may change from an attitude of aversion to preference and back to aversion again when responding to three successive risky prospects). As noted above, it has been observed by previous researchers that systematic inconsistencies can be overcome in part through careful questionnaire design. There are, however, greater difficulties in handling problems of random inconsistencies since these are likely to be generated by a multitude of factors of a highly individual nature.

Whereas it may be theoretically possible to explore the many psychological aspects of this problem in such a way that the inconsistencies may be all but eliminated, it is unlikely that applied studies will achieve this desirable state in the near future. Nevertheless, the problem of subjects being inconsistent in their responses might be minimised by undertaking one of several courses.

First, questions that check for inconsistency in response may be in-

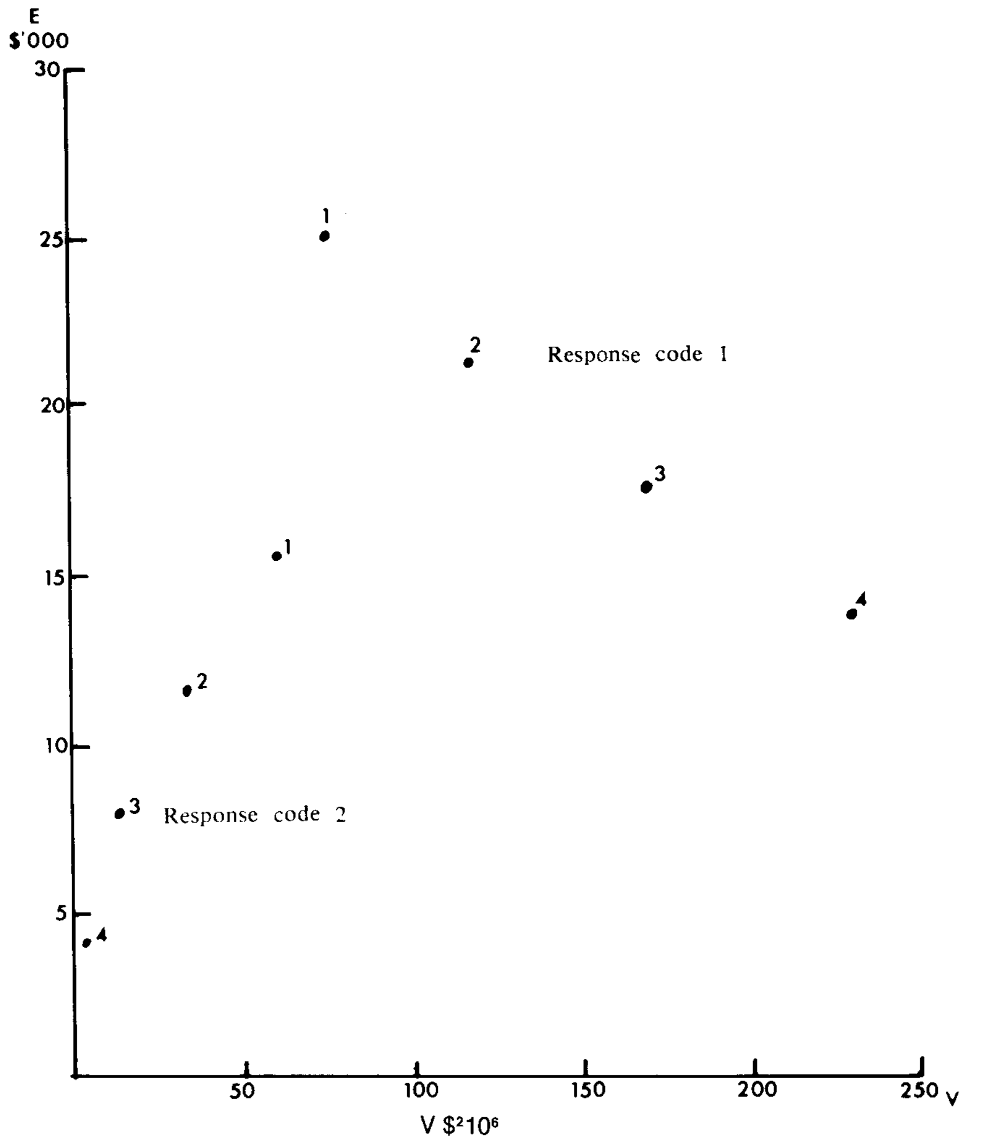

FIGURE 1—Risky alternatives presented to individuals in the mean-variance (E-V) space.

cluded in the questionnaire design.[11] This procedure is particularly suitable when certainty equivalents are elicited for the purpose of plotting utility functions. However, when the interviewee is presented with a series of risky prospects that are not designed for the purpose of plotting a utility function, the inclusion of 'check' questions may not be so practicable. Under such conditions, the individual would be required to answer many questions, thus necessitating that a considerable amount of time be spent with the subject. The questions presented to farmers involved in this current study were a supplement to a significantly larger BAE Australian Agricultural and Grazing Industry Survey (AAGIS) (BAE 1977). If the problem of inconsistent responses is to be minimised

[11] See Anderson et al. (1977, p. 72).

by the inclusion of 'check' questions that may be very time consuming, it is likely that risk attitude interviews (other than the variety which seek information for plotting a utility function) would have to be conducted independently of other data collection.

The second option is concerned with circumstances whereby each individual gives biased responses but the distribution of biases throughout the population possesses some degree of symmetry and (hopefully) centres around zero. The objective in this case would be to interview as many individuals in the defined population as possible in order to evaluate the 'true' average risk attitude.

A third option has been reported by Binswanger (1978, p. 53) in a study of risk attitudes in semi-arid, tropical India. Binswanger abandoned the von Neumann-Morgenstern methodology and used a technique whereby subjects were asked to make real choices over a six-week period. The reasons underlying this decision were twofold. First, Binswanger detected systematic inconsistencies in the certainty equivalents obtained from use of the von Neumann-Morgenstern methodology in neighbouring villages of the study area. Second, Binswanger has noted that the von Neumann-Morgenstern method suffers from the problem that subjects are asked to make an instantaneous decision on their risk attitude without time to reflect on the answers given. Consequently, Binswanger's methodology might be viewed as an attempt to overcome both systematic and random inconsistencies in subjects' responses.

It is difficult to judge the relevance of the difficulties that Binswanger encountered with the modified von Neumann-Morgenstern approach for the current study. Unlike the farmers who participated in the current study, many of the respondents in Binswanger's sample were illiterate and may have experienced learning difficulties with the game they were asked to play. Moreover, Binswanger suggests that the inconsistent answers obtained can be partially explained by the method's proneness to investigator bias, but such claims are difficult to evaluate. Nevertheless, Binswanger's use of an approach that comes closer to the decision process in agriculture may be an important step forward in elicitation methodology. What is uncertain is how far it is possible to abstract from real decision choices and still obtain meaningful responses. For example, although the questionnaire used in the current study did not permit the interviewee to reflect on his certainty equivalents for an extended period of time, respondents were encouraged to check that they were satisfied with their responses. Furthermore, as mentioned previously, some realism was imparted to the risky events of the questionnaire by using returns from past surveys as a guide to the appropriate magnitudes of alternative outcomes.

In the current study, the questionnaire was presented to 201 farmers who participated in the 1975/76 AAGIS (BAE 1977). The survey was carried out from mid-to-late 1977 in each of the three major climatic zones of the Australian rural sector, i.e. the High Rainfall, Wheat-Sheep and Pastoral Zones. Details of the 1975/76 risk study subsample, the AAGIS sample and the estimated population numbers are given in Table 1. The diversity of property types in AAGIS is due to the multi-enterprise nature of many Australian farms and the eligibility criteria of the survey. Despite the wide geographical coverage of the survey, respondents to the

TABLE 1

Distributions[a] of 1975-76 Grazing Industry Population, AAGIS Sample and Risk Study Subsample: By Zone and Property Type[b]

Zone	BS	SS	CS	M	Total	Total
	%	%	%	%	%	no.
Population						
High Rainfall Zone	63.94	23.67	1.96	10.42	100.00	59 507
Wheat-Sheep Zone	14.76	20.92	50.87	13.45	100.00	50 175
Pastoral Zone	39.65	39.24	16.34	4.77	100.00	10 178
	no.	no.	no.	no.	Total sample	
AAGIS sample						
High Rainfall Zone	284	192	8	50	534	
Wheat-Sheep Zone	49	105	139	72	365	
Pastoral Zone	174	127	23	12	336	
	no.	no.	no.	no.	Total subsample	
Risk study subsample						
High Rainfall Zone	54	24	2	6	86	
Wheat-Sheep Zone	7	23	28	7	65	
Pastoral Zone	37	12	1	0	50	

[a] Estimated from Australian Agricultural and Grazing Industry Survey.

[b] BS, Beef Specialist: those properties where opening beef cattle herd, measured in stock equivalents, represented more than 50 per cent of total stock equivalents supported by that property; SS, Sheep Specialists: those properties where opening sheep flock, measured in stock equivalents, represented more than 50 per cent of total stock equivalents supported by that property; CS, Crop Specialists: those properties where area of cash crops harvested during the survey year represented more than 50 per cent of total stock equivalents supported by that property; M, Mixed: those properties where distribution of stock equivalents between enterprises did not accord with any of the previous definitions.

risk attitude questionnaire were selected for the purposes of a pilot study only and the results are not to be regarded as being necessarily representative of the farming population.

Ten interviewers were trained to elicit responses prior to the collection of field data. Interviewers carried out pretesting of the questionnaire by conducting preliminary tests with local farmers and colleagues. Once in the field, the interviewers qualitatively established that respondents understood the questionnaire before obtaining certainty equivalents for the nominated set(s) of risks.

Discussion of Results

Responses to the questionnaire

In Table 2, a classification of risk attitudes (in terms of the risk premium) is given. Depending on whether the risk premium is positive, zero or negative, each subject may be described as risk averse, risk neutral or risk preferring. The aversion-to-preference category refers to individuals who displayed risk aversion initially but who switched over to risk preference for later risks. For instance, the response to risk 1 may

TABLE 2

Responses to Risk Attitude Questionnaire

Risk attitude	Frequency
Aversion	77
Preference	25
Neutrality	33
Aversion-to-preference	11
Preference-to-aversion	18
Other	53
Total	217

have been aversion, but for risks 2, 3 and 4 it may have been preference. The opposite pattern holds for the preference-to-aversion category.

The 'other' category includes those persons who went from, say, preference to aversion and back to preference again. It is clear that such responses imply a rather peculiar indifference mapping in mean-variance space and it is very likely that these individuals experienced some interpretational difficulties for at least part of the interview. The fact that this category accounted for almost 25 per cent of the total responses emphasises the need for careful questionnaire design and signals the need for caution in drawing anything but tentative conclusions from this study. In particular, two problems were highlighted by the size of the 'other' category. First, interviewers reported that some farmers may have lost concentration after finishing the main AAGIS survey schedule (2 to 3 hours completion time) or during completion of the risk attitude questionnaire (30 to 40 minutes completion time). Second, the number of responses in the 'other' category may have been reduced if there had been sufficient interview time to include 'check' questions in the questionnaire.

Examination of the responses in the 'other' category did not reveal any interviewer bias. These responses appeared to be randomly distributed between interviewers and were not confined to the first few interviews conducted by particular field staff. These results contrast to those obtained by Binswanger (1978, p. 53) who reported stable patterns of investigator bias in responses obtained from use of the von Neumann-Morgenstern methodology.

Distributions of the estimates

In Table 3, Australian estimates[12] of the risk premium π and risk coefficients ϕ, A and γ are presented. The results suggest that, on average, there is only a 'moderate' degree of risk aversion in the rural sector, but that attitudes towards risk vary markedly between individuals. For example, consider the estimated coefficients of the mean of ϕ in Table 3 (for which there are attached estimates of significance).

For those subjects who nominated RC1, the estimated mean ϕ co-

[12] The estimates of γ in Table 3 cannot be regarded as unbiased as they have been derived on the assumption that the net monetary return (x) of each of the risky prospects is normally distributed. It is clear that this is not the case and that it would be necessary to derive the appropriate relationship between the mean absolute deviation (M) and $V[x]$ if unbiased estimates of γ are to be obtained.

TABLE 3

Risk Premiums and Coefficients—Australian Sample

Premium or coefficient	Risk 1 Mean	Risk 1 SD	Risk 1 CV	Risk 2 Mean	Risk 2 SD	Risk 2 CV	Risk 3 Mean	Risk 3 SD	Risk 3 CV	Risk 4 Mean	Risk 4 SD	Risk 4 CV
Response Code 1 ($n=98$)												
π	199	3064	15.40	631	3410	5.40	730**	3246	4.45	962**	3582	3.73
ϕ	−0.02	0.35	−15.39	−0.06	0.32	−5.43	−0.06**	0.25	−4.46	−0.06**	0.24	−3.75
A	-3.0×10^{-6}	4.1×10^{-5}	−13.67	-5.0×10^{-6}	2.9×10^{-5}	−5.80	-4.0×10^{-6}**	1.9×10^{-5}	−4.75	-4.0×10^{-6}**	1.6×10^{-5}	−4.00
γ	−0.03	0.44	15.24	−0.07	0.39	−5.40	−0.07**	0.31	−4.46	−0.08	0.30	−3.73
Response Code 2 ($n=119$)												
π	694**	2408	3.47	426**	1588	3.73	349**	1040	2.98	165**	893	5.42
ϕ	−0.09**	0.31	−3.47	−0.08**	0.28	−3.65	−0.09**	0.27	−2.96	−0.08**	0.43	−5.28
A	-1.1×10^{-5}	4.0×10^{-5}	−3.64	-1.4×10^{-5}**	5.0×10^{-5}	−3.57	-2.6×10^{-5}**	7.7×10^{-5}	−2.96	-5.9×10^{-5}**	3.3×10^{-4}	−5.59
γ	−0.11**	0.39	−3.48	−0.10**	0.35	−3.66	−0.11**	0.34	−2.95	−0.10**	0.54	−5.30

SD Standard deviation.
CV Coefficient of variation = SD/Mean.
** Significantly different from zero at the five per cent level of significance.

efficient ranged from -0.02 to -0.06 over the four gambles but the estimated standard deviation of ϕ for the same risky prospects varied from 0.24 to 0.35. The degree of risk aversion was found to be marginally higher for those subjects who categorised themselves in RC2. For this latter group of respondents, the estimated mean ϕ coefficient ranged from -0.08 to -0.09 and, unlike the results for RC1, all the estimated mean ϕ values for RC2 were significantly less than zero at the five per cent level of significance.[13]

The more pronounced display of risk aversion for RC2 (relative to RC1) might be explained by the possibility that individuals regard the gambles of RC2 as risky prospects that threaten a minimum standard of living (see Figure 1). In their study of risk attitudes in North-East Brazil, Dillon and Scandizzo (1978, p. 429) present some evidence to suggest that individuals may perceive a qualitative difference between one set of gambles which assures subsistence and another set which puts subsistence at risk. Some support for this type of behaviour in the Australian context is provided by this study in that there was a tendency amongst the 16 individuals who nominated response code 3 on the questionnaire to exhibit greater risk aversion for the gambles of RC2 than for those of RC1.

A more detailed understanding of the empirical results may be obtained from the cumulative frequency distribution of the estimated risk coefficient ϕ presented in Figure 2. It can be seen that the median values of ϕ are concentrated over a relatively narrow interval and this same degree of concentration was evident for most of the other risk coefficients as well. The only exception was for risk coefficient A in response code 2 and the distributions of responses for this coefficient are shown in Figure 3.

Comparisons of results with other studies

In regard to the results obtained in this study *vis-à-vis* those of other researchers, the findings presented in Table 3 and Figures 2 and 3 extend a fundamental argument of Dillon and Scandizzo (1978, p. 431) beyond a subsistence economy to an advanced agricultural sector. In particular, Dillon and Scandizzo 'highlight the need to take account of the size distribution of risk attitudes and not merely of the categorisation into risk averters and risk preferrers'. This conclusion represents one of the basic findings of the current study. However, there are notable differences between our results and those of Dillon and Scandizzo. First, the mean levels of risk aversion are much less in this study than for the sample analysed by Dillon and Scandizzo (in terms of comparable estimates of the risk coefficients). Second, while the mean-standard deviation model (equation (11)) provided the greatest degree of discrimination between the risks presented to Brazilian subsistence farmers, the same model did not give significantly different distributions of ϕ for the four risks presented to the Australian sample (see Figure 2). Furthermore, except for the risk coefficients estimated for the mean-

[13] In the discussion of the questioning procedure, it was mentioned that subjects were also given the opportunity to choose a third response code which characterised the farmer's income fluctuations as moving up and down from steady levels. Only 16 individuals selected this third option and each half of their certainty equivalents were allocated to RC1 and RC2, respectively.

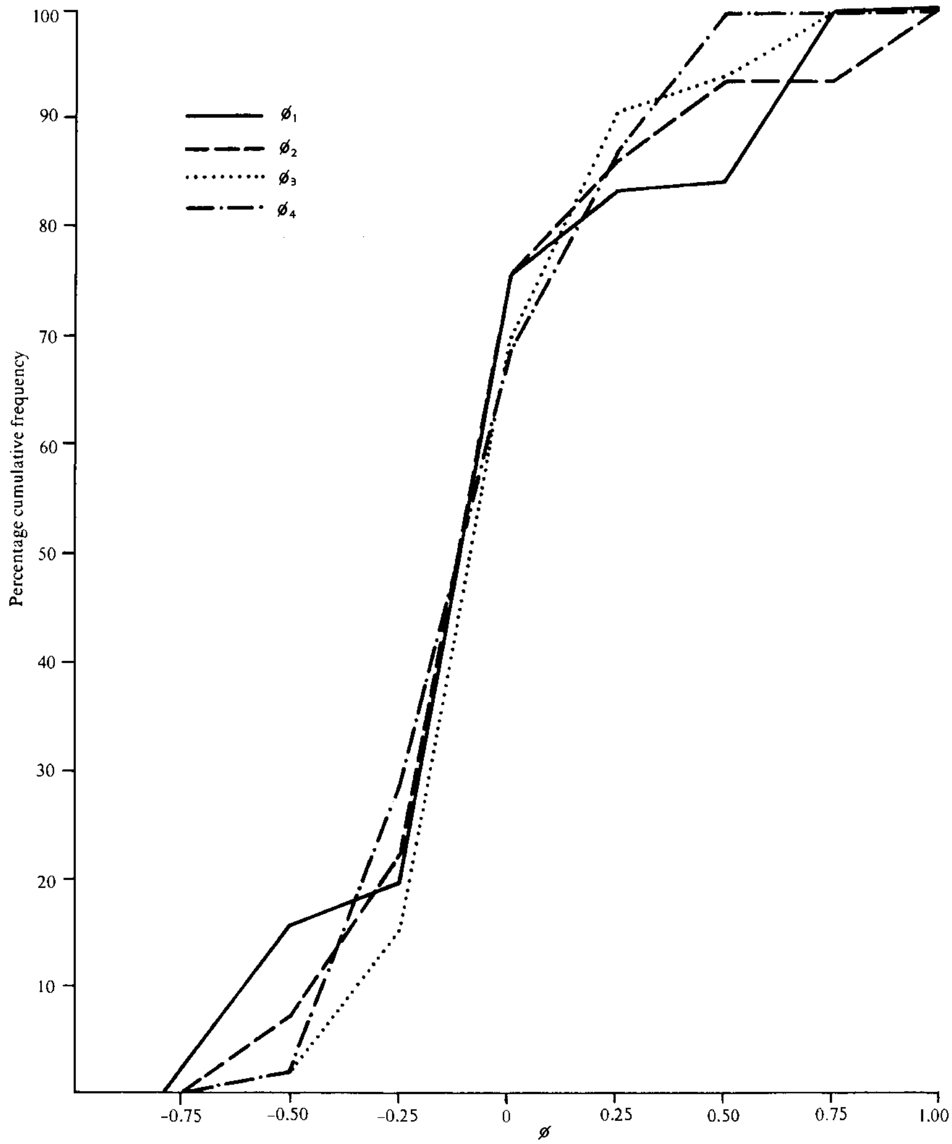

FIGURE 2—Cumulative frequency distribution of ϕ for four risks—Response Code 1.

variance model of RC2 (Figure 3), the distributions obtained for the adopted utility formulations are very similar. This latter result contrasts with the different skewness characteristics of the cumulative probability distributions of the models applied by Dillon and Scandizzo.

The most recent Australian research to add significantly to the body of empirical information on risk attitudes is that of Francisco and Anderson (1972). Because this study was restricted to the West Darling region of New South Wales, the results are of limited applicability. Nevertheless, as in the current study, Francisco and Anderson (1972, p. 91) detected evidence of both risk preference and risk aversion. Francisco and Anderson argued that the observed extent of risk preference in this arid region may be due to the riskiness of pastoral production.

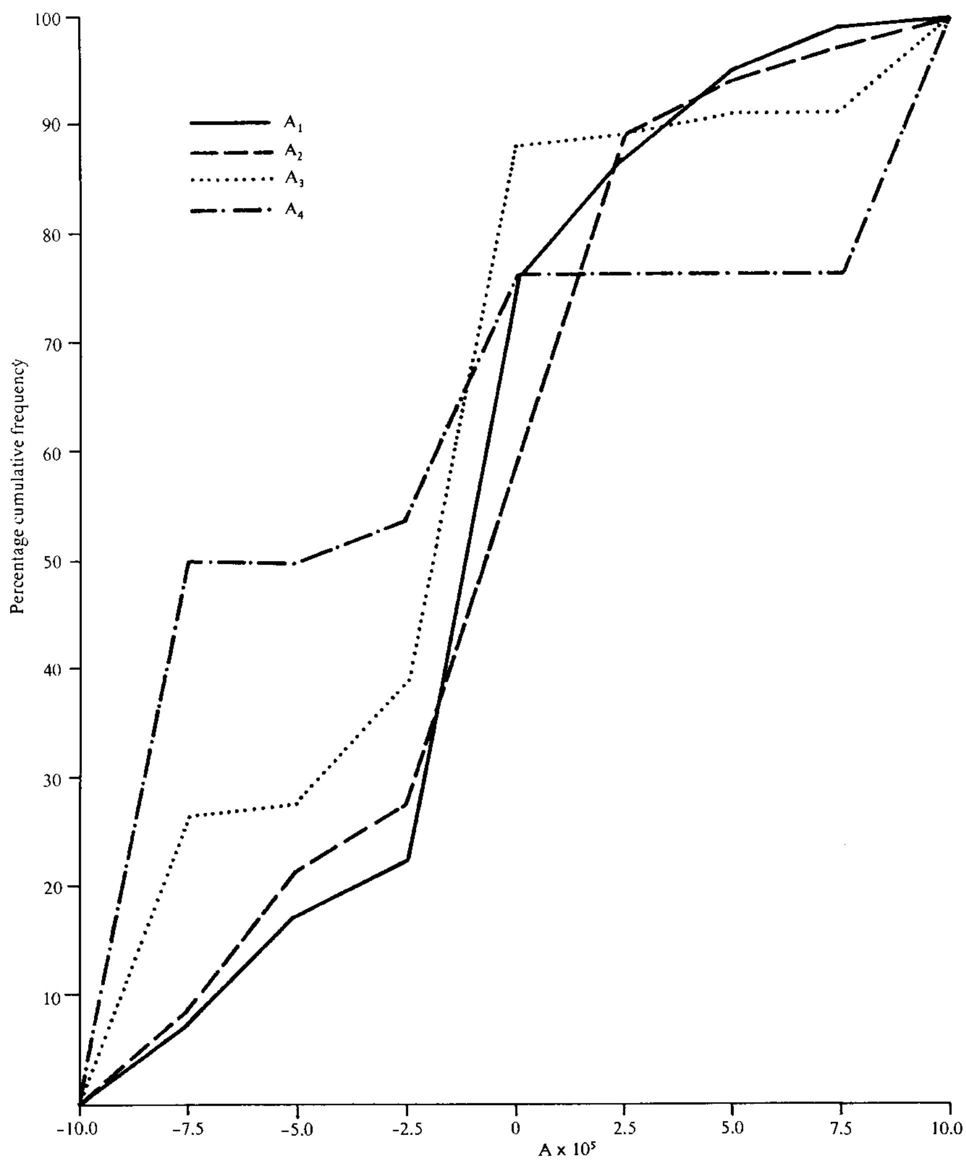

FIGURE 3—Cumulative frequency distribution of A for four risks—Response Code 2.

It would be incorrect to conclude that all risk studies have found a wide variety of attitudes toward risk. For example, Binswanger (1978) examined the risk attitudes of farmer and landless labour households in the semi-arid tropics of India and found a large concentration of households in the intermediate and moderate risk aversion classes. Unlike the results of Dillon and Scandizzo and those reported here, those of Binswanger (1978, p. 55) showed relatively few responses in any of the risk preferring, neutral or extreme risk aversion categories.

From the available evidence, it appears that risk aversion is the most common attitude towards risk. However, when the results obtained in the current study are combined with those of Dillon and Scandizzo, it can be concluded that risk preference and neutrality may also be considered as significant minority attitudes in both subsistence and advanced agricultural sectors.

Influences of socioeconomic, regional and property-type variables

In an attempt to explain the wide variety of risk responses, some data for socioeconomic, regional and property-type variables were obtained from the 1975/76 AAGIS to test for differences in the distributions of risk attitudes. Data were available for the farmer's age, net worth, off-farm income, climatic zone and type of property.[14]

Tests were carried out by constructing contingency tables of n rows by k columns, where n is the number of intervals of each of the socioeconomic, regional and property-type variables and k is the number of intervals of the four risk premiums. The calculated chi-square value of each of the contingency tables is given in Table 4.

An overall inspection of these results suggests that the questionnaire risk responses cannot be explained by the selected variables. In particular, the only variables to exhibit significantly different distributions of risk premiums were off-farm income and property type. However, the statistical significance of these differences was restricted to risks 1 and 2 of RC1 for off-farm income and risk 1 of RC2 for property type.

Although recent analyses of the relationships between risk attitudes and other variables have been confined to subsistence, rather than other agricultural, case studies, it may still be useful to compare the result

TABLE 4

Chi-Square Values Obtained when Testing for Significant Differences between Age, Net Worth, Off-farm Income, Zone, Property Type and π_1, π_2, π_3, π_4—Response Codes 1 and 2

Response code 1 ($n=98$)	π_1	π_2	π_3	π_4
Age	15.35	20.75	14.30	10.64
Net worth	8.17	14.71	17.90	12.24
Off-farm income	20.91**	21.30**	15.57	10.70
Zone	4.99	14.00	11.28	10.99
Property type	3.56	7.20	3.16	6.02
Response code 2 ($n=119$)	π_1	π_2	π_3	π_4
Age	10.64	10.69	7.27	14.65
Net worth	34.55	26.57	17.65	15.66
Off-farm income	13.46	13.72	7.69	13.49
Zone	20.34	3.83	12.50	15.76
Property type	13.91**	7.41	7.76	10.95

** Significantly different from zero at the five per cent level of significance.

Note: Critical values of χ^2 will be different for certain individual cells in the above table, due to differences in the number of degrees of freedom.

[14] The climatic zone variable includes the Pastoral, Wheat-Sheep and High Rainfall Zones. The property-type variable includes Beef-Dominant, Beef-Oriented, Sheep-Dominant, Sheep-Oriented, Crop-Dominant and Crop-Oriented farms. The terms 'Dominant' and 'Oriented' refer, respectively, to the facts that at least 75 per cent and between 50 and 75 per cent of total stock equivalents are employed in the denoted production category.

obtained here with those of Binswanger (1978) and Dillon and Scandizzo (1978). Binswanger employed a testing procedure similar to that adopted here and included a wealth measure and regional location, amongst other variables in his analysis. As in the current study, Binswanger did not find strong evidence of relationships between wealth and risk attitudes or region and risk attitudes. Dillon and Scandizzo used an econometric approach for examining the influences of socioeconomic variables upon risk attitudes. The common explanatory variables of their study and ours are income and age. The specification of income in the Dillon and Scandizzo analysis provided an opportunity to undertake a cross-sectional test of the Arrow-Pratt hypothesis of decreasing absolute risk aversion. The significant estimated coefficient of the income variable (in some equations) led Dillon and Scandizzo to conclude that the level of income influences peasants' attitudes to risk. However, the income coefficient changed signs between different risk situations, thus making it difficult to accept the Arrow-Pratt hypothesis. In regard to the estimated coefficient of the age variable, Dillon and Scandizzo did not find convincing evidence for either the direction or significance of the relationship with peasants' attitudes to risk.

When the results of this study and other research are considered together, it is clear that much more work is required in order to understand the determination of risk attitudes. Moreover, in addition to the problem of developing relevant theory to assist empirical analysis, there is also the difficulty discussed earlier of understanding how factors other than monetary payoffs enter an individual's utility function.

Conclusions

The main finding of this study is that, while risk aversion appears to be the most prevalent risk attitude amongst Australian farmers, the average degree of risk aversion is relatively small. Although of a highly tentative nature, these results suggest that farmers may, in aggregate, pursue production and investment strategies which are not very different from risk-neutral behaviour.

The methodology employed in this study has been oriented towards the estimation of risk coefficients suitable for incorporation into programming models of farm-firm behaviour. The variability of coefficient estimates obtained from a sample of 201 farmers suggests that farm-level models may need to be run over a wide range of coefficients to obtain a distribution of responses.

The role of socioeconomic and other variables as determinants of individual risk attitudes was investigated but no firm relationships could be identified. This finding, as well as those obtained by other researchers in this field, highlights the complexity of formation of risk attitudes and the possible need to investigate risk attitudes in an explicit multi-attribute utility context.

A major concern in this type of research is the process by which risk attitudes are elicited from individual farmers. There is considerable scope for seeking improvements in questionnaire design to reduce interpretational errors and to achieve a greater degree of accord between elicited responses and those prevailing in actual day-to-day decision making. In the short term, there is the opportunity to validate questionnaire-based risk responses. Results of programming studies based on the risk coefficients obtained here can be compared with real-world behaviour and hopefully, through time, a better understanding of risk attitudes will be obtained.

APPENDIX

The Questionnaire Design Used in this Study

Farm No................

We would like you to participate in a research project and would like to test your reaction to a question on income variation.

Imagine you operate a business which, apart from exceptional years, returns a steady cash income. In the exceptional years, possibly because of climate or prices, income will be HIGH (or LOW). You don't know in advance which years will be exceptional, but you do know that on average they will crop up 1 year in 4.

Now, you have a choice—on which type of situation do you wish to concentrate? Perhaps the situation closer to your experience is:

	Code
Income in most years steady, occasionally high	1
Income in most years steady, occasionally low	2
Both situations	3

What is the lowest constant year-in-year-out cash income which you would trade for the situations below?

Income in most years				
	$20 000	$15 000	$10 000	$5 000
But	rises to $40 000 (high)* / falls to $2 000 (low)*		one year in four	

* Delete as appropriate.

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