PRODUCTION, RISK AND SURVEY DATA

Johanna Pluske* and Rob Fraser#

*Agricultural and Resource Economics, The University of Western Australia with support from an Australian Wool Research and Development Corporation postgraduate scholarship.

#Associate Professor, Agricultural and Resource Economics, The University of Western Australia.

Contributed Paper presented at the 39th Annual Conference of the Australian Agricultural Economics Society, 14-16 February 1995, Perth.

Abstract

Farmers in the high rainfall region of Western Australia are able to obtain agricultural information and incorporate this information into their production systems. As a result risk associated with this production may alter. To determine the benefits of this change, farmers were asked to directly value the information that they received by using questionnaires based on the contingent valuation method (CVM). These valuations combined with additional data collected from the questionnaires were incorporated into profit functions and farmers' attitudes towards risk were estimated. It was hypothesised that these estimations would be consistent with the Australian literature and would therefore be valid and reliable. Results showed that generally farmers' risk aversion coefficients, estimated using their valuations for the information that they used, were small and so comparable to other recorded findings. It may therefore be argued that farmers were able to nominate valid and reliable valuations for the information that they used.

Key Words: non-market goods; contingent valuation; validating survey data.

Introduction

Traditionally the contingent valuation method (CVM) has been used to value consumer goods (Mitchell and Carson, 1989; Wilks, 1990; Adamowicz, 1991). However, if the supply of non-market production inputs, for example those used in agriculture, is to be continued, suppliers of these inputs need to understand their value in order to make efficient allocation decisions. To ascertain the suitability of the CVM to valuing a production input agricultural information provided to farmers in the high rainfall region of Western Australia was selected as the focus of this study. Such information is provided to farmers by both private and public sources.

To ensure the credibility of the results, survey data should also be assessed for its reliability and validity. Several suggestions may be found in the CVM literature as to testing reliability and validity (Kealy, Dovidio and Rockel, 1988; Mitchell and Carson, 1989; Reiling, Boyle, Phillips and Anderson, 1990; Imber, Stevenson and Wilks, 1991). One such test which is appropriate for determining reliability associated with the value placed on a production input by way of surveying users involves conducting econometric analyses. This procedure has been explored by Pluske (1994) but will not be further discussed in this paper. Instead Asafu-Adjaye's (1989) initiative of testing for validity and reliability by determining if the values obtained from a CVM survey agreed with predictions from economic theory will be developed.

In particular, data including the maximum value (MV) each farmer placed on the non-market production inputs used were collected in a survey designed to reduce as many potential biases as possible. These responses were then incorporated into a model so that unknown production characteristics such as farmers' attitudes towards risk could be estimated. The reasoning behind this procedure was based on work completed by Fraser (1992) which showed that farmers' attitudes towards risk could be estimated from survey data concerning willingness-to-pay for crop insurance collected by Patrick (1988). In addition it was noted from Freebairn (1978) and Babcock (1990) that agricultural information is of value to farmers if its use increases farmers' levels of utility. This increase may be achieved by farmers using information that causes risk associated with output price to be reduced. Therefore by placing relevant data concerning this risk reduction into a production model, the estimated risk aversion coefficients could be compared to those estimated, for similar farmers, using other methods such as outlined by Bond and Wonder (1980) and Bardsley and Harris (1987). This comparison will provide the CVM researcher with some knowledge as to the reliability and validity of the survey data.

In the remainder of this paper the methodology developed to estimate the risk aversion coefficients of farmers, given their nominated MVs for information and expected level of farm revenue is explained. Then the methodology is applied using data collected from farmers by Pluske (1994). Results are presented and discussed and conclusions are drawn at the end of the paper

Methodology

In this study it is assumed that farmers know the prices for all their inputs, therefore the only uncertain price parameter is the output price (ie., wool price) and is referred to in what follows as price-risk. In addition, wool yield per hectare was assumed to be known with certainty. This assumption was based on empirical data regarding the variability of wool production. Harris, Crawford, Gruen and Honan (1974) estimated that output variability was responsible for less than six per cent of wool income variation, while Piggott (1987) estimated the coefficient of variation of fine combing wool (20-24 microns) to be only 3.7 per cent.

If it is further assumed that wool price uncertainty is multiplicative, then revenue before the use of wool price-risk information may be given by:

$$\Psi = \phi w L Þ \qquad (1)$$

where: Ψ = revenue generated from on-farm operations
ϕ = random variable representing wool price uncertainty ($E(\phi) = 1$)
w = wool yield per hectare
L = hectares of land allocated to wool
Þ = expected price received per unit of wool

Since $E(\phi) = 1$, expected revenue can be given by:

$$E(\Psi) = w L Þ \qquad (2)$$

Profit can be expressed as:

$$\pi = \Psi - P_i x - F \qquad (3)$$

where: π = profit
P_i = vector of input prices
x = quantity of inputs
F = whole farm fixed costs

So that expected profit may be represented by:

$$E(\pi) = E(\Psi) - P_i x - F \qquad (4)$$

Given the assumption of certain input prices, variance of profit can be expressed as:

$$Var(\pi) = Var(\Psi) = (w L Þ)^2 \; Var(\phi) \qquad (5)$$

Information aimed at reducing price-risk can then be added into the model. The consequence of this addition is to create an opposite effect to that of mean preserving spread. As Sandmo (1971) explained[1], the effect of reducing variance in a model can be achieved by replacing price with $[1/(1+I_1)(p - Þ) + Þ]$ where for the purpose of this study I_1 is the quantity of information required to reduce price-risk. Therefore when information aimed at reducing price-risk is obtained, revenue can be written as:

$$(\Psi_{I1}) = 1/(1+I_1)\,[\Psi - E(\Psi)] + E(\Psi) \qquad (\text{where } 0 \leq I_1) \qquad (6)$$

and so $E(\Psi)$ is unchanged from Equation 2 above.

[1] Hey (1979) extends upon this theory.

Profit may be represented by:

$$(\pi_{I1}) = 1/(1+I_1)\,[\Psi - E(\Psi)] + E(\Psi) - P_i\,x - P_{I1}\,I_1 - F \qquad (7)$$

(where: P_{I1} = price of information)

so that $E(\pi)$ remains unchanged to that of Equation 4 except that payment for information has been added as an additional cost.

Variance of profit may be depicted by:

$$Var(\pi_{I1}) = [(w\,L\;\text{Þ})/(1+I_1)]^2\;\; Var(\phi) \qquad (8)$$

which is less than or equal to the $Var(\pi)$ shown in Equation 5 above as $0 \leq I_1$. That is, $Var(\pi)$ has decreased but so also has $E(\pi)$ by the MV that a farmer has nominated for the information.

The MV for information aimed at reducing variance of wool prices depends not only on farmers' expected revenue and profit, derived from wool production, but also on their expected increase in utility resulting from use of the information which, in turn, depends upon their attitude towards risk. Expected utility of profit may be written as:

$$E[U(\pi)] = U[E(\pi)] + ½\, U''[E(\pi)]\; Var(\pi) \qquad (9)$$

which indicates that expected utility can be approximately expressed as a function of mean and variance of profit (Newbery and Stiglitz, 1981). Although an approximation, mean-variance analysis has been widely used in theoretical and empirical studies of microeconomic decision making because of its analytical tractability. Moreover, recent simulation studies by Hanson and Ladd (1991) and Garcia, Adam and Hauser (1994) have provided support for the accuracy of this approximation in agricultural production studies.

Farmers' utility functions were estimated using the constant relative risk aversion function which is supported by Pope and Just (1991) for use in agricultural research. In finding the risk attitudes of Australian farmers, Bardsley and Harris (1987) estimated the partial risk aversion coefficient. However, for an expected utility model expressed in terms of profit (as in this study) instead of wealth, Pope and Just (1991) stated that relative and partial risk aversion are identical and therefore the results derived from this study can be compared to those estimated by Bardsley and Harris (1987).

The constant relative risk aversion function may be expressed as;

$$U(\pi) = \pi^{(1-R)}/(1-R) \qquad (10)$$

where; R is the risk aversion coefficient

and $U''[(\pi)] = -R\,(\pi)^{-R-1}$ *or* $-R\,(\pi)^{-(R+1)}$.

Therefore substituting this functional form into equation (9) gives;

$$E[U(\pi)] = E(\pi)^{(1-R)}/(1-R) + ½(-R\,E(\pi)^{-(1+R)})\; Var(\pi) \qquad (11)$$

By using this equation, an approximation of the expected utility, with and without information to reduce price-risk, may be derived. The difference between these two values may be converted into a certainty equivalent of profit which should approximate MV. Alternatively, given MV, the R required to equate the expected utility before the use of information, with expected utility after information is used (ie., with MV paid for a reduction in price risk) can be estimated.

In so doing a number of steps had to be taken. First initial revenue and profit were estimated from information provided by farmers who completed the questionnaire. Second to calculate profit after the use of risk reducing information, the MV farmers placed on price-risk information was assumed to be also the cost of this information and so was deducted from the initial profit amount.

Third the initial price-risk and the decrease in this risk resulting from the use of information had to be calculated by assumption. This step was required because it was considered too difficult a task for farmers to provide this data. However, as assumptions had to be made in this context a sensitivity analyses was conducted using various values for the original coefficient of variation of wool price (CV_P). In addition assumptions as to the extent of reduction in this CV_P resulting from the use of information were also varied.

Given the data available from the farmer surveys and that derived from the assumptions made, an estimate for the value of the risk aversion coefficient (R) could thus be determined. As stated above this can be achieved by varying R until the value of expected utility before and after use of risk reducing information is equated.

To elaborate upon these important steps in the model the following numerical example has been devised from fabricated data. Mr Farmer achieves an expected wool revenue of $100 000 and an expected profit of $50 000. The CV_P is assumed to be 20 per cent. Mr Farmer may acquire information that will reduce this CV_P by 25 per cent to 15 per cent. He decides that his MV for this risk reduction is $500. Incorporating this data into the model discussed above, Mr Farmer's risk aversion coefficient may be found by altering R until his expected utility before and after use of the risk reducing information is the same. This step is accomplished with a value for Mr Farmer's risk aversion coefficient (R) of 0.259.

Application

The two Australian studies most relevant to compare with the results from this project are those completed by Bardsley and Harris (1987) (this research showed that farmers in the high rainfall region of Australia had a mean partial risk aversion coefficient of 0.1 while those in the sheep/wheat zone had a coefficient of 0.7) and Bond and Wonder (1980). It was concluded from both studies that farmers operating in a high rainfall zone were slightly risk averse. Therefore it was hypothesised that this project would show that farmers operating in the high rainfall region of Western Australia would be risk averse and that their average risk aversion coefficient would be small.

Murrell (1992) estimated the underlying coefficient of variation of price for 21 micron wool to be 23.34 per cent and for 23 micron wool to be 12.38 per cent. Farmers in the high rainfall region specified in this study produced wool at around 21 micron (I.H. Williams, pers. comm.).[2] Therefore for this study the coefficient of variation of wool price (CV_P) was assumed to be 20 per cent. However, sensitivity analyses with the CV_P at 17, 18, 22 and 23 per cent were also undertaken.

Murrell (1992) found that the impact of the RPS for wool was a general reduction in the CV_P. She estimated that for 21 micron wool the CV_P was reduced from 23.34 per cent to 10.28 per cent, which is a 56 per cent reduction in CV_P. As the farmer survey used to collect MVs for information to reduce price-risks was conducted after the removal of the RPS, a difficulty in this study was estimating the decrease in CV_P derived from farmers using this information because they were not asked to estimate the decrease in CV_P from the information that they utilised. Since Newbery

[2] I.H. Williams is a Senior Lecturer, Department of Animal Science, The University of Western Australia.

and Stiglitz (1981) found that most individuals are not proficient at estimating probabilities, it was decided that farmers could have problems estimating the decrease in the CV_P achieved from using information and this could have jeopardised other survey results. Instead it was assumed that the decrease in CV_P for all farmers obtaining risk-reducing information was one half of that estimated by Murrell (1992) as achieved by the RPS. That is, a reduction of 28 per cent. This scenario will be referred to as the *base-case* scenario. The CV_P was also decreased by one quarter (14 per cent), three eighths, or 21 per cent, five eighths, or 35 per cent and three quarters (42 per cent) in sensitivity analyses.

The survey used to collect farmers' MVs for information to reduce price-risk also contained questions to find out demographic information about farmers. These included wool production figures which were placed in an optimal farm plan, so that expected revenue and profit could be estimated for each farmer.[3] It was assumed that the cost of acquiring this information for the farmer was negligible and so it was not included in the calculations.

Results

In the base-case scenario, the risk aversion coefficient (R) for each farmer nominating a MV for agricultural information to reduce price-risk was calculated when the coefficient of variation for wool price (CV_P) was decreased by 28 per cent from an original value of 0.2. This base-case reduction resulted in a mean R value (R') of 0.28 (Table 1). In a series of sensitivity analyses the CV_P was reduced by 14 per cent to give a R' of 0.47 and by 21 per cent resulting in a R' of 0.35 (Table 1). When the CV_P was reduced by 35 per cent, R' was found to be 0.23 and with a decrease of 42 per cent, the R' fell to 0.20 (Table 1). To test whether the R' found in each of the sensitivity analysis was significantly different from the R' determined for the base-case reduction, independent samples T-tests were conducted. For reductions in the CV_P of 14, 21, 35 and 42 per cent the hypothesis that the R' values would not be significantly different to that found for a reduction of 28 per cent was accepted only for the scenarios with a decrease in the CV_P of 21 and 35 per cent ($p>0.05$) (Table 1).

Table 1 The mean risk aversion coefficients (R') for farmers when the base-case CV_P of 0.2 was decreased by 28 per cent and 14, 21, 35 and 42 per cent in sensitivity analyses with the statistical T-test values shown in brackets.

Decrease in CV_P (%)	R'
28 (Base-case)	0.28
14	0.47* (-3.16)
21	0.35 (-1.44)
35	0.23 (1.20)
42	0.20* (2.03)

* denotes values that are significantly different to the base-case of R'=0.28 ($p<0.05$)

[3] The optimal farm plan (using MIDAS) was developed by John Young, Department of Agriculture, Western Australia.

To gain a better understanding of the range of R values for the individual farmers, four groups were identified: R>1; 1>R>0.7; 0.7>R>0.3; 0.3>R>0 (Table 2). For a reduction of 28 per cent in the CV_P, none of the farmers had a R value greater than one, two per cent had a R value of between 1 and 0.7, 38 per cent of farmers had a R of between 0.7 and 0.3 and the remaining 60 per cent had a R less than 0.3 (Table 2). When the CV_P was reduced by 21 per cent, two per cent of the farmers had a R value greater than one, with 13 per cent having a R value between 1 and 0.7, 36 per cent of the farmers possessing a R value between 0.7 and 0.3, and the remaining 49 per cent having a R value less than 0.3 (Table 2). Reducing the CV_P by 35 per cent showed that none of the farmers surveyed had a R value above 0.7, 29 percent experienced a R value between 0.7 and 0.3, and the remaining 71 per cent had a R value less than 0.3 (Table 2).

Table 2 The mean risk aversion coefficients (R') and the percentage of farmers falling into each of the four groups when the CV_P was reduced by 28 per cent and 21 and 35 per cent in sensitivity analyses.

Group	R'(ΔCV_P=28%[a])	{%}[b]	R'(ΔCV_P=21%[a])	{%}[b]	R'(ΔCV_P=35%[a])	{%}[b]
R>1.0	N/A	{0}	1.04	{2}	N/A	{0}
1.0>R>0.7	0.83	{2}	0.81	{13}	N/A	{0}
0.7>R>0.3	0.48	{38}	0.44	{36}	0.46	{29}
0.3>R>0.0	0.14	{60}	0.14	{49}	0.14	{71}

[a]Signifies a reduction by that value in the CV_P, ie., a 28%, 21% and 35% reduction in the CV_P
[b]The percentage of individual risk aversion coefficients falling into each group

Sensitivity analyses concerning a change in the base-case CV_P were also conducted. In these analyses the initial CV_P was increased from 0.2 to 0.22 and 0.23 while it was also decreased to 0.18 and 0.17 (Table 3). Reducing each of these new CV_P by 28 per cent as was done for the base-case analysis, resulted in the R' for the former analysis being 0.23 and 0.20 respectively while for the latter analysis the R' was 0.35 and 0.38 respectively (Table 3). These results may be compared to the base-case CV_P of 0.2 being reduced by the same 28 per cent giving a R' of 0.28 (Tables 1 and 3). However, only the analysis whereby the CV_P was reduced by 0.23 could the hypothesis that there was not a significant difference between the R' for each of the sensitivity analyses and the base-case analysis be rejected (p>0.05) (Table 3).

Table 3 The mean risk aversion coefficients (R') for farmers when the original CV_P of 0.20, 0.22, 0.23, 0.18 and 0.17 were decreased by 28 per cent in sensitivity analyses with the statistical T-test values shown in brackets.

CV_P	R'
0.20 (Base-case)	0.28
0.23	0.20* (1.99)
0.22	0.23 (1.37)
0.18	0.35 (-1.31)
0.17	0.38 (-1.80)

* denotes values that are significantly different to the base-case of R'=0.28 (p<0.05)

The R values were, as previously, divided into four groups: R>1; 1>R>0.7; 0.7>R>0.3; 0.3>R>0 (Table 2 and Table 4) when the CV_P was reduced by 28 per cent. Reducing a CV_P of 0.22 by 28 per cent resulted in none of the farmers having a R value greater than 0.7, with 29 per cent experiencing a R value between 0.3 and 0.7 and the remaining 71 per cent having a R value below 0.3 (Table 4). Changing the initial CV_P to 0.18 and then reducing it by 28 per cent resulted in two per cent of farmers having an R value greater than one, with 13 per cent having an R value between one and 0.7, 36 per cent having a R between 0.3 and 0.7 and the remaining 49 per cent having a R value below 0.3 (Table 4). A reduction in a CV_P of 0.17 by the same percentage did not change the percentage of farmers falling into each group from the previous analysis.

Table 4 The mean risk aversion coefficients (R') and the percentage of farmers falling into each of the four groups when the CV_P was reduced by 14 and 28 per cent from the original CV_P of 0.22, 0.18 and 0.17 in sensitivity analyses.

Original CV_P	Group	R'(ΔCV_P=28%[a])	{%}[b]
0.22	R>1.0	N/A	{0}
	1.0>R>0.7	N/A	{0}
	0.7>R>0.3	0.45	{29}
	0.3>R>0.0	0.14	{71}
0.18	R>1.0	1.02	{2}
	1.0>R>0.7	0.79	{13}
	0.7>R>0.3	0.43	{36}
	0.3>R>0.0	0.14	{49}
0.17	R>1.0	1.08	{2}
	1.0>R>0.7	0.85	{13}
	0.7>R>0.3	0.46	{36}
	0.3>R>0.0	0.15	{49}

[a]Signifies a reduction by that value in the CV_P, ie., a 28% reduction in the CV_P
[b]The percentage of individual risk aversion coefficients falling into each group

Discussion and Conclusion

In this paper traditional producer methodology has been adapted to include the value farmers place on information to reduce risk associated with wool prices. The results showed that the risk attitude of farmers can be estimated on the basis of their MV for information to reduce risk associated with wool prices, the decrease in variance of wool price and their expected wool revenue.

Given the assumptions for the base-case scenario including the coefficient of variation for wool price (CV_P) of 0.2 being reduced by 28 per cent, the analysis estimated that farmers were risk averse, with a mean risk aversion coefficient (R') of just under 0.3. Due to the difficulty of calculating the reduction in the CV_P achieved from the use of wool price-risk information various sensitivity analyses were conducted. Of the assumptions made in this paper reducing the CV_P over a range from 14 to 42 percent in sensitivity analyses showed that the mean risk aversion coefficients of farmers changed little over a range from 0.2 to a value just below 0.5. Moreover, only the extreme values of this range were statistically significantly different from the base-case R' of 0.28. Sensitivity analyses of the assumed initial level of the CV_P of 0.2 were also conducted. Varying the CV_P from 0.17 to 0.23 resulted in the R' varying slightly from around 0.4 to 0.2. Once again from a statistical perspective, only increasing the CV_P to 0.23 gave R values which were statistically significantly different to those when the CV_P was 0.2.

In the analyses errors may have arisen in the calculation of the farmers' risk aversion coefficients due to experimental error in collecting the data for the model, from the mispecification of the production function, wrongly assuming the source of risk to be multiplicative or from incorrectly specifying not only the extent of risk reduction from the use of information, but also the uniformity of this reduction among farmers. Nevertheless the results found in this study strongly support the argument that farmers generally express some degree of risk aversion with over half of the farmers having a risk aversion coefficient under 0.3 with a mean value of 0.14. This finding compares to those of Bardsley and Harris (1987) and Bond and Wonder (1980). Furthermore the level of risk aversion of most of the surveyed farmers is between that estimated by Bardsley and Harris (1987) for farmers in the sheep/wheat zone (ie., 0.7) and that estimated for those in the high rainfall zone (ie., 0.1). Therefore it may be concluded that the results support the argument that the valuations given by farmers participating in this CVM survey were valid and reliable estimates of their actual valuations of agricultural information.

References

Adamowicz, W.L. (1991). Valuation of environmental amenities. Paper presented at the Interdisciplinary Symposium on Agriculture and Water Quality. University of Guelph, Guelph, Ontario. April.

Asafu-Adjaye, J. (1989). Issues in the valuation of nonmarket natural resource commodities: the case of wildlife resources in Alberta. PhD. Thesis. The University of Alberta, Edmonton, Canada.

Babcock, B.A. (1990). The value of weather information in market equilibrium. *American Journal of Agricultural Economics* 72(1):63-72.

Bardsley, P. and Harris, M. (1987). An approach to the econometric estimation of attitudes to risk in agriculture. *Australian Journal of Agricultural Economics* 31(2):112-126.

Bond, G. and Wonder, B. (1980). Risk attitudes amongst Australian farmers. *Australian Journal of Agricultural Economics* 24(1):16-34.

Fraser, R.W. (1992). An analysis of willingness-to-pay for crop insurance. *Australian Journal of Agricultural Economics* 36(1):83-95.

Freebairn, J.W. (1978). An evaluation of outlook information for Australian agricultural commodities. *Review of Marketing and Agricultural Economics* 46(3):294-314.

Garcia, P., Adam, B.D. and Hauser, R.J. (1994). The use of mean-variance for commodity futures and options hedging decisions. *Journal of Agriculture and Resource Economics* 19(1):32-45.

Hanson, S.D. and Ladd, G.W. (1991). Robustness of the mean-variance model with truncated probability distributions. *American Journal of Agricultural Economics*. 73(2):436-445.

Harris, S., Crawford, J.G., Gruen, F.H. and Honan, N.D. (1974). Rural policy in Australia. A report to the Prime Minister by a working group, AGPS, Canberra.

Hey, J.D. (1979). *Uncertainty in microeconomics*. Martin Robertson, Oxford.

Imber, D., Stevenson, G. and Wilks, L. (1991). A contingent valuation survey of the Kakadu conservation zone. Resource Assessment Commission, Research Paper No. 3.

Kealy, M.J., Dovidio, J.F. and Rockel, M.L. (1988). Accuracy in valuation is a matter of degree. *Land Economics* 64(2):158-171.

Mitchell, R.C. and Carson, R.T. (1989). *Using surveys to value public goods: the contingent valuation method.* Resources for the Future. Washington.

Murrell, A.J. (1992). Does the producer benefit from price stabilisation? An empirical analysis of the Australian Wool Corporation's Reserve Price Scheme. Master of Science in Agriculture thesis, The University of Western Australia, Perth.

Newbery, D.M.G. and Stiglitz, J.E. (1981). *The theory of commodity price stabilization. A study of the economics of risk.* Oxford University Press, New York, pp 69-109.

Patrick, G.F. (1988). Mallee wheat farmers' demand for crop and rainfall insurance. *Australian Journal of Agricultural Economics* 31(1):37-49.

Piggott, R.R. (1987). Sources of pre-intervention market instability for six grades of Australian wool. Paper presented to the Australian Agricultural Economics Society Conference, Adelaide, February.

Pluske, J.M. (1994).The value of information: an application to agriculture in Western Australia. PhD. Thesis, The University of Western Australia, Perth.

Pope, R.D. and Just, R.E. (1991). On testing the structure of risk preferences in agricultural supply analysis. *American Journal of Agricultural Economics* 73(3):743-748.

Reiling, S.D., Boyle, K.J., Phillips, M.L. and Anderson, M.W. (1990). Temporal reliability of contingent values. *Land Economics* 66(2):128-134.

Sandmo, A. (1971). On the theory of the competitive firm under price uncertainty. *American Economic Review* 61(1):65-73.

Wilks, L.C. (1990). A survey of the contingent valuation method. Resource Assessment Commission, RAC Research Paper No. 2. Canberra.