RISK PREFERENCES OF KWAZULU-NATAL COMMERCIAL SUGAR CANE FARMERS

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A direct elicitation of utility approach is used to measure risk preferences of commercial sugar cane farmers in the Mzimkulu, Sezela and Eston sugarmill areas of KwaZulu-Natal. Arrow-Pratt absolute risk aversion coefficients are elicited, adjusted for both range and scale of the data, to allow both inter and intra study comparisons of risk preferences. Of 53 farmers surveyed, two refused to participate in lottery games for religious or moral reasons. Of the remainder 57.2 percent were risk averse, 29.6 percent risk neutral and 13.2 percent risk preferring. On average they were risk averse although risk preferences vary significantly amongst individuals. Regression analysis indicates that on average sugar cane farmers are averse to a possible loss in wealth relative to initial wealth and they exhibit increasing absolute risk aversion although at a decreasing rate with increasing gamble range.

RISIKOVOORKEURE KOMMERSIËLE SUIKERBOERE IN VAN KWAZULU-NATAL

'n Direkte nutbepalingsbenadering is gebruik om risikovoorkeure van kommersiële suikerboere in die Mzimkulu, Sezela en Eston suikermeulgebiede van KwaZulu-Natal te bepaal. Arrow-Pratt absolute risikovermydingskoëffisiënte is bepaal, aangepas beide vir die strekkingswydte en skaal van die data om beide inter- en intrastudie vergelykings van risikovoorkeure moontlik te maak.

Van die 53 boere in die opname het twee weens godsdienstige of morele oorwegings geweier om deel te neem aan loteryspele. Van die res was 57.2 persent risikovermydend, 29.6 persent risikoneutraal en 13.2 persent het risiko verkies. Oor die gemiddeld was hul risikovermydend hoewel risikovoorkeure betekenisvol tussen persone wissel. Regressie-analise toon dat in die gemiddeld suikerboere 'n moontlike verlies in rykdom relatief tot beginrykdom wil vermy en dat hul toenemende absolute risikovermyding, hoewel teen 'n afnemende koers, openbaar met 'n toenemende wydte van dobbelspel.

1. INTRODUCTION

This study uses a direct elicitation of utility (DEU) approach to elicit individual risk preferences over a series of dichotomous lotteries, systematically varying the level of monetary payoffs in order to assess this effect on the pattern of revealed risk preferences. The literature is replete with similar experiments. What differentiates this study is the approach towards standardising the Arrow-Pratt absolute risk aversion coefficient (AP) for the scale and range of the data,

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allowing for both inter-study comparison of elicited coefficients and utilisation of estimated coefficients in secondary studies without prior adjustment. Secondly, whilst most studies have concentrated on farmers in low income populations, the focus of this study is on large scale commercial sugar farmers of KwaZulu-Natal, South Africa.

Knowledge of farmers' risk preferences is useful in development of farm management strategies, development of technologies and policy formulation (Babcock & Shogren, 1995). Developing appropriate methodology for assessing risk attitudes then becomes an important goal for research. The specific objectives of this study are a) to demonstrate the impacts of the scale and range of the data on AP's and to develop a methodology to standardise the expression of risk preferences, rendering it comparable across studies and utilisable in secondary studies without requiring prior adjustment; and b) to empirically analyze how gamble characteristics affect revealed risk preferences. Results should be important to researchers in selecting appropriate measures of risk preferences for use in secondary studies.

2. MEASURING RISK PREFERENCES

The Arrow-Pratt absolute risk aversion coefficient (AP), defined as -U"(x)/U¢(x), has appeared extensively in the literature. Although AP's are invariant to linear transformations of U, they are not invariant to arbitrary rescalings of x or changes in the range of x (Raskin & Cochrane, 1986), rendering AP's neither employable in secondary studies, nor comparable between studies without prior adjustment. Scale of the outcome variable is affected by units of measurement (currencies, measures of pollution, etc...) and also inflation. Range of the outcome variable is important except in special cases where the lower or upper bound is equal to zero. This is unlikely in many cases including farm income, yields and rates of soil erosion. Although the scale problem has been raised by Pratt (1964), Cochran (1986), Raskin & Cochran (1986), King (1986), and Babcock *et al* (1993), less informed readers may use published AP's in the context of secondary studies without adjusting appropriately for the scale and range of the data used in the primary study. None of the studies reviewed account for both these problems.

The following example demonstrates the effect of a positive linear transformation of the outcome variable on the AP. It will simplify the presentation to assume the following negative exponential utility function, U(x) = -exp{-lx}, since it has a constant AP = l. The distribution (x_{min} £ x £ x_{max}) is converted into a distribution (0 £ x^* £ 1) where x_{min} and x_{max} are the minimum and maximum values on the x-scale. Let x^* = (x-x_{min})/(x_{max} - x_{min}), \f1 x = x_{min} +

$x^*(x_{max} - x_{min})$, where $U(x) = -e^{-lx}$ and $U(x^*) = -e^{-l^*x^*}$, \f1 $l^* = l(x_{max} - x_{min})$ since lx_{min} = constant. Thus, as the range or scale of the data $(x_{max} - x_{min})$ increases, so l decreases to hold the level of risk aversion, l^*, constant.

Raskin & Cochran (1986:206) propose the theorem that if there is "a transformation of scale on x such that w = x/c, where c is a constant,..then r(w) = cr(x)," where r = l and x is the outcome variable. This procedure only applies in special cases, for instance, it applies to a scale that includes x = 0 as its lower or upper bound, that is if either x_{min} or x_{max} is zero. Further, applications of this theorem frequently only account for differences in units of measurement of the outcome variable (change of currencies, per acre analyses and for discounting, as illustrated by Raskin & Cochrane (1986)), but not for differences in gamble range $(x_{max} - x_{min})$. Babcock *et al.,* (1993) suggested that the risk premiums be expressed as a fraction of the gamble size and used as measures of risk preference in lieu of AP. A similar approach was adopted by Kachelmeier & Shehata (1992). A drawback is that results cannot be directly applied to some stochastic efficiency techniques, eg mean-variance programming models and stochastic dominance with respect to a function.

3. METHODOLOGY

A direct elicitation of utility (DEU) through preset choices approach was employed to elicit farmers' risk preferences. Budgetary constraints precluded use of actual monetary incentives. Certainty equivalents were elicited for hypothetical lotteries considered separately. Subjects were presented with five hypothetical but realistic lotteries of the form (x_{max}, x_{min}, p), promising a monetary prize of x_{max} with probability p or x_{min} with probability 1-p. Table 1 summarises these lotteries. Lottery ranges varied from R20000 to R100000, which subject reactions ensured us were considered as being large. Probability of a win (loss) was described as the flip of a coin to overcome probability preference, and all lotteries had positive expected values to encourage participation, despite the chance of a hypothetical loss in wealth in lotteries 2, 4 and 5. To begin a trial, subjects were required to choose between a lottery and a certain monetary amount, initially its expected value. Deductions (increments) from (to) the certain monetary alternative were made as appropriate and the question reasked. This was repeated until a point of indifference was reached, determining each subject's certainty equivalent for that gamble.

Table 1: The hypothetical lotteries

LOTTERY (i)	x_{max}	x_{min}	RANGE	p
1	R20 000	R0	R 20 000	0.5
2	R15 000	-R1 000	R 20 000	0.5

3	R40 000	R0	R 40 000	0.5
4	R30 000	-R10 000	R 40 000	0.5
5	R75 000	-R25 000	R100 000	0.5

A methodology combining the approaches used by Raskin & Cochrane (1986) and Babcock *et al* (1993) is used to calculate risk preferences from elicited certainty equivalents. Data are standardised to uniform scale and range prior to calculating an "adjusted Arrow-Pratt absolute risk aversion coefficient" by expressing the certainty equivalent as a percentage of the gamble range. For simplicity, utility functions of the form $U_{ij}(x^*_{ij}) = \exp\{-l^*_{ij}x^{*ij}\}$ are assumed, where $x^*_{ij} = (x_{ij} - x_{j\text{-}min})/(x_{j\text{-}max} - x_{j\text{-}min})$, normalising the x^*_{ij} range from 0 to 1. l^*_{ij} is the adjusted AP for the *i*th individual, $i = 1,..., I$, for the *j*th lottery, $j = 1,..., J$, and is calculated by fitting the function $f = 0.5 + 0.5 \exp(-l^*_{ij}) - \exp(-l^*_{ij}x^*_{ij})$.

Calculated l^*_{ij} were used to analyze how gamble range and risk of a loss in wealth on revealed risk preference. Panel data sets usually consist of observations over a number of individuals, say n = 1, 2, ..., N, over several time periods, say t = 1, 2, ..., T. Following Kachelmeier & Shehata (1992) repeated measures from the same individual, in this case the *j* lotteries are used in place of time periods. Clearly, systematic differences between individual subject's risk preferences would induce correlated errors in an ordinary linear regression testing gamble characteristic effects in panel data. Consequently, individual subject effects are included in the model as dummy variables such that the (*i,j*)th observation on the dummy variable model with which we are concerned can be written as

$$y_{ij} = B_{1i} + \sum_{k=2}^{K} \beta_k \chi_{kij} + e_{ij}$$

where b_{1i} represents the intercept coefficient for the ith individual, the b_k represents the slope coefficients that are common to all individuals, l^*_{ij} is the dependant variable, the x_{kij} are the *k* explanatory variables, and the e_{ij} are independent and identically distributed random variables with $E[e_{ij}] = 0$ (Judge *et al*, 1988: 469). This model parcels out the effect of each individual subject on the overall regression.

4. DATA COLLECTION

Data are based on a stratified random sample consisting of 53 large scale commercial sugar cane growers in the Eston, Sezela and Mzimkulu sugar mill areas of KwaZulu-Natal, South Africa. The sample was drawn from a list of growers obtained from the South African Cane Growers' Association. The survey collected information on attitudes towards and adoption of soil conservation practices as well as on attitudes towards risk. Data requirements on soil conservation provided motivation for the choice of study population, however, it is also appropriate for a study of risk preferences. Farmers were visited on their farm during May and June of 1996. Only one investigator was used to minimise investigator bias.

5. RESULTS

Two farmers refused to participate stating moral reasons for their refusal to gamble. A further five cases contained missing values due to non response where farmers refused to hypothetically pay to avoid risk in lotteries 2, 4 and 5. Considering that disparity between willingness-to-pay and willingness-to-accept measures of value have been frequently observed in the literature (Kachelmeier & Shehata, 1992), it is likely that risk aversion is underestimated for some of the more risk averse farmers for lotteries 2, 4 and 5.

Mean estimated coefficients and their standard deviations are presented in Table 2. Analysis of mean l^* values indicate that sugar farmers are in aggregate risk averse, shown by two tailed t-tests to be significant at the 10 percent (for lottery one) and 1 percent levels of confidence (for lotteries 2, 3, 4 and 5 respectively). Mean l^* coefficients suggest relationships of increasing aversion towards possible loss in wealth and increases in gamble size, both consistent with *a priori* expectations. Table 2 also shows the percentages of respondents classified as being risk preferring, risk neutral or risk averse for each of the lotteries. Proportions of farmers classified as risk loving decrease from 19,6 percent in lotteries 1 and 3 to 8,5 and 4,3 percent for lotteries 4 and 5. Risk averse classifications are all larger than 40 percent and increase to 66 and 70 percent for lotteries 4 and 5 respectively. The majority of respondents may be classified as being risk neutral to moderately risk averse with a small proportion being either risk loving or extremely risk averse.

It is hypothesised that l^*_{ij} = f(gamble range, downside risk, probability of win, and individual effects). Probability of a win is consistent across all five lotteries and is thus omitted from the model. The following model was estimated:

$$E\{ SAP_{ij} \mid p = 0.5 \} = \beta_{1i} + \beta_2 RANGE_j + \beta_3 RANGE_j^2 + \beta_4 LOSS_j + e_{ij}$$

Where l^*_{ij} = the standardized absolute risk aversion coefficient of the *i*th agent for gamble *j*, RANGE = the range of the *j*th gamble (x_{max} - x_{min}) (R1000's), $LOSS_j$ = 1 if $x_{min,j} < 0$, otherwise 0, b_{1i} = the intercept for the ith individual, and p = probability

Table 2: Mean estimated l* coefficients and percentage distributions of respondents selecting risk averse, risk neutral of risk loving choices

Lottery	N	Mean l*	S.D.	Preference (%)	Neutrality (%)	Aversion (%)
1	51	0.768*	0.469	19.6	37.2	43.2
2	50	1.660**	0.350	14.0	28.0	58.0
3	51	1.492**	0.567	19.6	31.4	49.0
4	47	1.823**	0.280	8.5	25.5	66.0
5	46	1.718**	0.260	4.3	26.1	69.6
AVERAGE				13.2	29.6	57.2
OTHER STUDIES:						
Tauer (1986)				26	39	34
Gunjal and Legault (1995)				17	11	72
Wilson and Eidman (1983)				22	34	44

Note: * and ** indicate significance at the 10 and 1 percent levels of significance respectively.

of a win. Cases with missing values were excluded from the model. The estimated regression equation is presented below with t statistics in parenthesis:

$$SAP_i| \, p = 0.5 \;=\; \underset{(10.47^{***})}{6.656E\text{-}02\,RANGE} \;\underset{(-8.450^{***})}{-4.976E\text{-}04\,RANGE^2} \;\underset{(6.717^{***})}{+1.089\,LOSS} \;+\text{individual effects}$$

$$F = 41.020^{***} \quad R^2 = 0.8719 \quad \overline{R^2} = 0.8586 \quad dw = 2.057^{***}$$

where *** indicates significance at the 1% level. The model shows good statistical fit of the data, despite no inclusion of interaction between factors and between subjects and factors, indicated by an adjusted R^2 of 0.8506 and the high statistical significance the estimated coefficients for gamble range, gamble range squared and LOSS. Although not reported in the estimated equation for the sake of brevity, a high proportion of the individual effect dummy variables were significantly different to zero and showed large variability, indicating large heterogeneity of risk preferences within the sample. This indicates that the model is better suited to analyzing the effects of lottery characteristics on risk preferences, rather than for predicting an individuals risk preferences. Results indicate, firstly, that subjects respond with increasing risk aversion, albeit at a decreasing rate, to increasing gamble range, indicating increasing absolute risk aversion. Secondly that risk aversion increases where there is risk of a loss in wealth relative to initial wealth. These results are important by showing absolute risk aversion to be affected in a manner consistent with *a priori* expectations, despite absence of actual monetary rewards.

6. CONCLUSIONS

While Raskin & Cochrane showed as early as 1986 that the AP does not provide information without details about scale and range, many authors have continued to report the AP. It is shown that rescaling the data to a range of 0 £ x £ 1 prior to calculating AP's provides measurements that convey adequate information about risk preferences in research programmes. It appears important to these authors that risk aversion should be reported in a consistent manner such that studies can be compared to one another.

An empirical analysis reveals that there is a highly diversified spectrum of risk preferences among KwaZulu-Natal SUGAR CANE farmers. The percentage of risk preferring farmers ranged from 23.5 percent to 4.3 percent depending on gamble characteristics. Over all gambles more than forty percent of the farmers responded in a risk averse manner. On average they are significantly risk averse. These results suggest that policies or technologies providing a mean preserving reduction (increase) in risk will be preferred (disliked) by a majority of farmers. On average, risk aversion was found to increase as the gamble range increased, but at a decreasing rate, indicating increasing absolute risk aversion. Revealed risk preferences became more risk averse in the face of a possible loss in wealth. This may be partially due to disparities between willingness-to-pay and willingness-to-accept, but may also indicate safety constraints in decision making. Knowledge of the distribution of risk preferences in the population and how risk preferences change according to the risk environment may be useful for future policy analysis.

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