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An Empirical Test of the Interval Approach for Estimating Risk Preferences

Paul N. Wilson and Vernon R. Eidman

Previous attempts to measure agricultural decision makers' risk preferences have obtained values of the Arrow-Pratt coefficient in the range of approximately −.0002 to .0012. The recently developed interval approach for elicitation of risk preferences was used to estimate risk attitudes for Minnesota swine producers. Constant and decreasing absolute risk aversion were predominant among the sample. Seventy-eight percent of the respondents were in the Arrow-Pratt interval of −.0002 to .0003. A discriminant analysis using producer attributes and three estimated risk intervals concluded that 50 percent of the respondents could be classified in the correct risk interval.

Agricultural production decisions are generally made under an environment of uncertainty. Product prices, yields, and to a more limited extent, input prices and quantities are not known with certainty when planting, breeding and investment decisions are made. The farmer's subjective probability distribution of these variables will influence how he allocates resources between and within the production processes. Firm level models developed by Magnusson (1969), Sandmo (1971), Batra and Ullah (1974) and Anderson, Dillon and Hardaker (1977) demonstrate how uncertainty will influence the resource allocation process. Knowledge of the value of the appropriate measure of risk attitudes is required in these models to compare the levels of input use and output for various types of producers.

Knowledge of risk preferences has two principal uses in the agricultural sector. First, some agricultural policy analysis is of limited use if it does not take risk into account. However, microeconomic policy research has not been completely successful in incorporating risk into predictive models. Needed measures of risk aversion have been expensive to obtain, in terms of both time and money. Those that have been measured have been from non-representative samples of farms. This is especially true for the research efforts in the United States. Therefore, estimates of risk aversion by class or type of farm operation have not been developed. This constrains the ability of the policy analyst to predict the effect that agricultural policy initiatives or changes might have on a particular target group.

Extension programs are the second potential user of measures of risk preferences. Production, marketing and investment recommendations often are made to farmers without acknowledging the risk inherent in each strategy. Producers can be placed into one of several risk aversion categories using the interval approach for

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estimating risk preferences. A set of risk efficient farm plans could be developed for each risk aversion category. The decision maker could then decide which of the farm plans in the relatively small efficient set is best for him. It can be argued that extension programs could become more effective and responsive to the needs of their primary client group with more accurate empirical measures of risk aversion.

We had several objectives in this research effort. First we wanted to test the feasibility of eliciting risk preferences of a relatively large group of agricultural producers by using the interval approach. Secondly we wish to test the sensitivity of the risk attitude estimates to intransitivities or inconsistencies in the respondents' ordering processes. A third objective was to compare our estimates with those obtained by researchers using both different and similar elicitation techniques over various types of respondents. Our fourth objective was to attempt to test whether the estimated risk measure was correlated with producers' socio-economic attributes (e.g., age, education, net worth).

The first section of this paper briefly reviews the empirical estimates of risk attitudes found in previous studies using three methods of elicitation. This discussion is followed by a summary of the interval approach developed by King and Robison (1981a, b) and how it was modified to elicit risk attitudes of Minnesota swine producers. The third section reports our findings with specific references made to the stated objectives of this paper. Finally we present several suggestions for further research.

Empirical Measures of Risk Aversion

More recent research involving the elicitation of risk preferences has been done in low income countries than in the industrialized nations. This could be due to the lower cost of eliciting responses on a person-to-person basis in the developing nations and the availability of financing from international development institutions to fund these efforts. Measures of risk aversion for American farmers are limited in number and represent, for the most part, risk preferences of individuals operating large commercial farms.

There are three principal methodologies which have been used to estimate risk preferences: direct elicitation of utility functions, observed economic behavior using econometric and programming methods, and the experimental approach. These methods have been summarized in detail in the literature (Young, 1979). A comparison of the empirical measures of risk aversion obtained from studies by Officer and Halter (1968), Lin, Dean and Moore (1974), Halter and Mason (1978) and Knowles (1980) reveals that Arrow-Pratt coefficients, $r(\cdot)$, have ranged from $-.0002$ to .0012 for the farmers surveyed. Recent work with the interval approach by King and Robison (1981b) produced risk coefficients within this same range for Michigan farmers. This literature indicates that farmers in the United States and Australia demonstrate varying degrees of risk preference and aversion. The evidence also suggests that the majority of the actual empirical values of the Arrow-Pratt function at average income levels fall within a range of $-.0002$ to .0003. This range is in sharp contrast to the longer continuum of Arrow-Pratt values used by Kramer and Pope (1981). They chose values from $-.04$ to .03 which are not supported by the empirical measurements of previous research.

Efforts to correlate risk measures with producer attributes have not produced conclusive results. Studies measuring risk preferences in developing countries (Dillon and Scandizzo, 1978; Moscardi and de Janvry, 1977; and Binswanger, 1980) have attempted to correlate producer attributes with the estimated level of risk aversion in order to gain insights into the factors

which influence risk attitudes. Halter and Mason have made similar calculations for 44 Oregon farmers. Their general linear regression results show a positive relationship between ownership and risk aversion and a negative association with age and schooling. Halter and Mason's results, and a follow-up study by Whittaker and Winter (1980), show that (1) the interaction between producer attributes is important and produces nonlinearities in the relationship between risk and certain producer attributes; (2) these relationships may not be stable over time, that is, their direction of influence on risk preferences may change; and (3) the correct specification of the functional relationships and independent variables is not certain and may bias the results. The procedures presented in this paper provide a new opportunity to explore the relationship between risk attitudes and decision maker attributes.

Methodology

King (1979) and King and Robison (1981a, b) have developed an operational approach for eliciting risk attitudes which draws heavily on the theoretical developments of stochastic dominance by Meyer (1975, 1977a, b). A description of Meyer's stochastic dominance with respect to a function would be repetitious but a brief description of King and Robison's interval approach is useful.

The decision maker is assumed to have a utility function which demonstrates constant absolute risk aversion over a narrow range of the performance indicator, π.[1] Using this utility measure, pairs of distributions of π are ordered for a given upper and lower bound of $r(\pi)$. The pseudorandom distributions are generated using a simulation model for a specific distributional form, e.g., a normal, beta or gamma distribution. King and Robison use a normal distribution which can be simulated by supplying mean and standard deviation values to the program. Each distribution has a specified number of elements: six elements were used in this study.

Once the pairs of distributions are ordered for various upper and lower bounds of $r(\pi)$, a rather straightforward questioning procedure is constructed to measure the interval of the respondent's Arrow-Pratt coefficient. The questionnaire is in the form of a programmed learning text, directing the respondent to a specific question based on the individual's answer to the preceding one. By working through the questioning process the researcher can obtain an interval measurement of $r(\pi)$ for that individual at a given level of π, π_1. By repeating the process for π_2 and π_3 where $\pi_1 < \pi_2 < \pi_3$ an estimate of the decision maker's risk aversion function can be obtained. King and Robison (1981a) and Wilson and Hwang (1982) provide detailed descriptions of the mechanics of these procedures.

This interval approach methodology was tested on two groups of agricultural decision makers before the final survey was conducted. The first test asked eleven graduate students and faculty to rank distributions of hypothetical income earned from a $5,000 investment. Some of the agents found it difficult to rank distributions in a consistent manner. This implies that two pairs of distributions for the same interval were ranked differently. That is, when asked to rank two pairs of distributions, (A, B) and (C, D) for the same interval (r_1, r_2), the agent chose A over B when according to Meyer's criterion A is preferred to B for all $r > r_1$ but then chose D over C when C is preferred to D for all $r > r_1$. Inconsistent responses occurred most frequently for distributions being ranked near the agent's final estimated risk interval. It was also observed that these inconsistencies occurred more frequently

[1] The constant absolute risk aversion utility function can be written as

$$U(\pi) = -e^{-r\pi}.$$

at the beginning of the questioning procedure and less towards the end. Using this methodology, it appeared that the axiom of transitivity of preferences was not met for some individuals when they were asked to order distributions near their estimated interval for $r(\cdot)$. Also it appeared that agents developed a method to process data (i.e., distributions) as the questioning progressed.

The second test involved a mail survey of twenty swine producers in the Southeastern Minnesota Farm Management Association. These producers were asked to rank distributions of after-tax net income. This performance indicator was selected to add an important degree of realism to the inquiry by reflecting the income available to the farm operator for consumption by the family and for business investment. Three representative income levels were selected based on farm record data. Sixteen measurement intervals were used and 4 consistency checks were included in the questionnaire. We found that sixteen measurement intervals for 3 income levels produces a lengthy questionnaire from the point of view of the respondent. Four of the 13 respondents apparently became impatient and failed to follow directions properly in part, or in all of the last section of the questionnaire. With regard to the consistency checks, we found that all of the respondents passed the first check where the measurement interval was high in risk aversion space (.0003, .0004). However, eight of the thirteen agents failed the check for the interval (−.0001, 0) which indicated a transitivity problem in ordering distributions for the 16 interval experiment.

Using what was learned from these preliminary efforts, a final questionnaire was developed to survey swine producers in the Southwestern Minnesota Farm Management Association. Those members who were swine producers and who had recorded their tax payments on their farm records for 1977, 1978 and 1979 were selected. Fifty-seven of the 107 swine producers in the association qualified by this criterion. A measure of average after-tax net income for these three years was calculated for each individual using income data from their farm records as follows:

$$\pi_t = I_t - T_t + R_t \qquad t = 1, 2, 3 \tag{1}$$

$$\Sigma\pi_t/3 = \pi. \tag{2}$$

The measure of after-tax net incomes for year t, (π_t), is obtained by subtracting taxes paid (T_t) or adding tax refunds (R_t) received to the returns to management and equity capital (I_t). I_t represents the closest approximation of before-tax net farm income and is determined on the accrual basis by,

$$I_t = \sum_{i=1}^{n} Y_i - \sum_{j=1}^{n} X_j \pm \Delta\text{Inv.} \tag{3}$$

where Y is the sales from enterprise i, X is the expense items; and ΔInv. is the change in inventories.

Farmers may not accurately report taxes paid in a university-supported record system. Hanson (1981) checked the reliability of this record data for twenty-eight of the members of the Southwestern Minnesota Farm Management Association. He regressed the actual tax paid as reported in the Federal 1040 and the Minnesota M-1 forms with the estimated tax paid as reported in the farm records. He found no statistically significant difference between taxes reported in the records (T_t) and the actual federal and state income tax paid. Thus the tax payments recorded were accepted as accurate for this study.

Producers then were ordered from lowest to highest level of π calculated in equation (2). This ranking of average after-tax net income was divided into 3 equal, numbered groups and the median of each group was selected. These medians represented the midpoint values for the 3 sections of the risk elicitation questionnaire. Five percent of the base value for each section was chosen as the standard deviation used as an input parameter for gen-

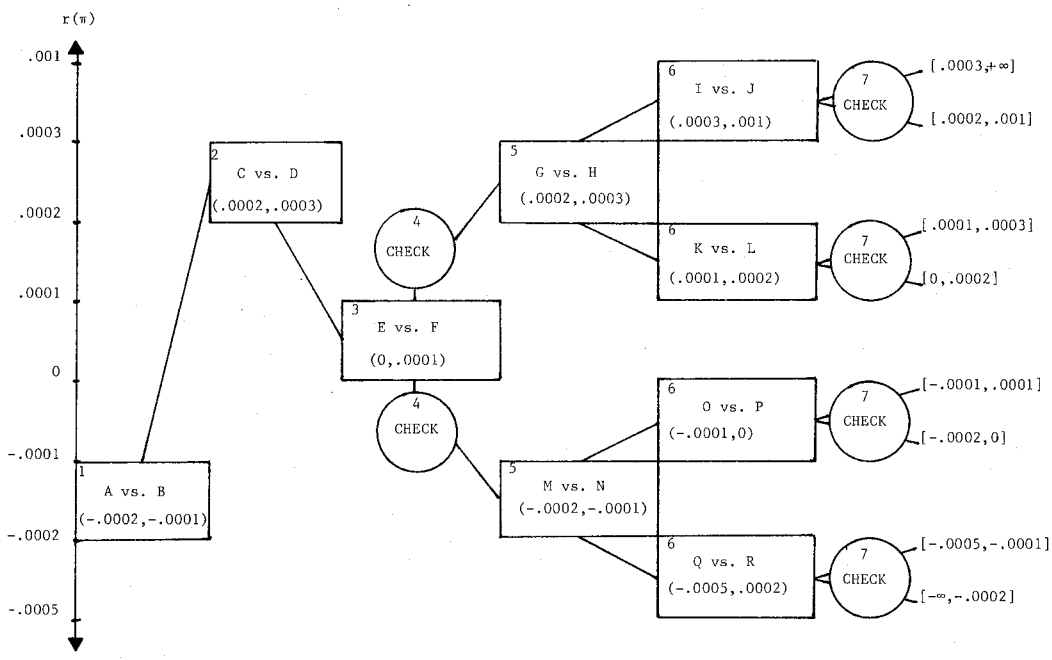

Figure 1. Questioning Procedure for Minnesota Swine Producers.

erating the distribution of after-tax net income. The parameters were:

	Section of the Questionnaire		
	II	III	IV
Median Income	$16,500	$31,000	$55,000
Standard Deviation	800	1,600	2,750

Since we used a mail survey, an effort was made in drafting the cover letter and the instructions so that the highest level of producer cooperation could be obtained. Emphasis was given to presenting a scenario which the agent could understand in a decision making framework. The questioning procedure is outlined in Figure 1 and incorporates the experience gained from the earlier elicitation efforts. Eight measurement intervals were chosen. These levels of risk aversion reflect the range of relevant intervals obtained by King and Robison and by our two previous empirical tests.

Figure 1 represents the ordering of questions for Section II of the questionnaire.[2] The methodologies used in Sections III and IV are identical except the first two learning questions are eliminated. In Section II the respondent is asked to rank distributions of after-tax net income for the lowest median income level, $16,500. Questions 1 and 2 are learning questions which are used to check for the existence of a learning process and also serve as consistency checks. After responding to these initial questions the respondent is asked to order distributions E and F in question 3. For this illustration, suppose the individual prefers F. The instructions then direct the respondents to a fourth question which checks the individual's ordering of E and F using two other distributions for the interval (0, .0001). The fifth question asks the producer to choose between distribution M and N. This response can be checked by the first question. If A was

[2] Section I contained the instructions and questions asking for socio-economic information.

preferred in question one, M should be preferred in the fifth question. Depending on his response to the fifth question, the producer is directed to a sixth question. The ordering in this question is then checked in a final question. The distribution selected in the sixth question determines the measured risk aversion interval.

This questioning procedure represents a modification in King and Robison's original methodology. Officer and Halter as well as Halter and Mason identified a learning process during the elicitation interviews where the agent developed a decision criterion for making choices as the questioning progressed. A process can be identified with this modified methodology. By measuring the frequency of consistency check failures between question 1 (and 2) and question 5 as compared to the failure frequency of the other 6 checks, we were able to gain insights into the nature and extent of a learning process and the sensitivity of the interval methodology to transitivity conditions.

Empirical Results

The response rate to the mail survey surpassed expectations. Eighty-two percent (47) of the 57 swine producers responded to the questionnaire. Risk intervals could be assigned to 45 of the 47 respondents. Two individuals failed to follow directions in the section of the questionnaire which represented their income level. Fifteen percent of the respondents did not complete one question or section of the questionnaire correctly but only the two mentioned above made errors at their relevant income levels.

The estimated risk intervals are presented in Table 1. The estimated absolute risk aversion coefficients for the respondents fell into all but one of the measurement intervals. There appears to be a definite tendency for the respondents to be risk neutral or risk averse. The individuals falling into intervals 1 and 8 chose distributions as if they were using a maximax and maximin decision criterion respectively. That is, producers in interval one chose the distribution with the highest value, although it only had a one-sixth probability of occurring (maximax). Farmers in category 8 selected the distribution with the highest low value which produces extremely risk averse behavior (maximin).

TABLE 1. Estimated Risk Intervals for Minnesota Swine Producers at Their Average After-Tax Net Income Level.

Interval No.	Interval Value ($r(\pi)$)	Number of Respondents	Percent of Total Respondents
1	$(-\infty, -.0002)$	5	11
2	$(-.0005, -.0001)$	0	0
3	$(-.0002, 0)$	5	11
4	$(-.0001, .0001)$	16	34
5	$(0, .0002)$	7	15
6	$(.0001, .0003)$	3	6
7	$(.0002, .001)$	3	6
8	$(.0003, \infty)$	6	13
Unknown	—	2	4
	Total	47	100%

The results substantiate the hypothesis that the majority of the producers fall within a relatively narrow band in risk aversion space. Sixty-nine percent of the producers with identifiable risk intervals fall in groups 3, 4, 5, and 6 which represent approximately an aggregate interval of $(-.0002, .0003)$. Assuming the fourth interval represents risk neutrality, the results show that 78 percent of the swine producers represent risk neutral and risk averse behavior.

Risk Aversion Functions

Arrow (1971) has supported the concept of decreasing absolute risk aversion over an increasing level of wealth. "Everyday observation" seems to show that decision makers are more willing to

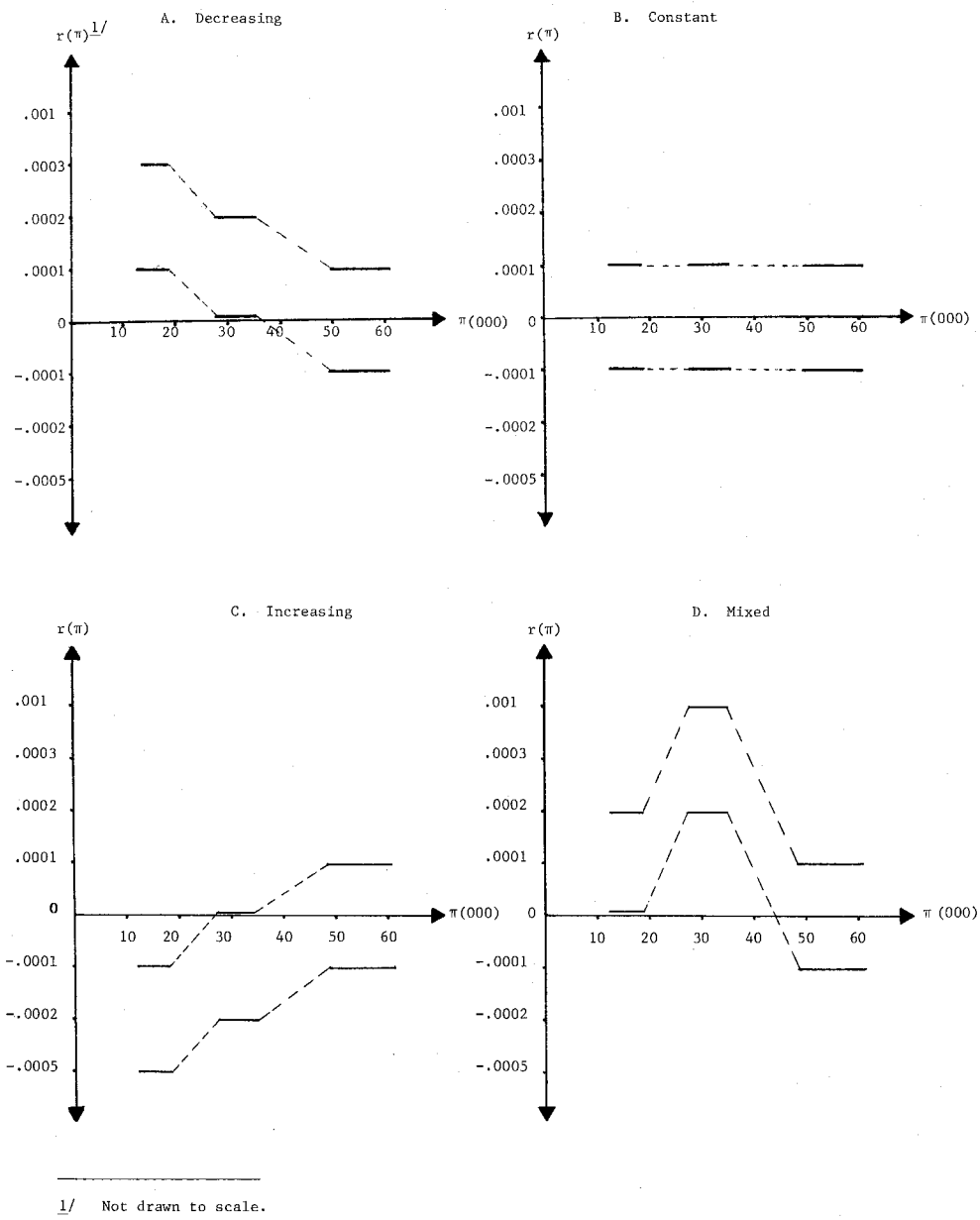

Figure 2. Observed Types of Risk Aversion Functions.[1]

engage in a bet of fixed size as they become wealthier. Empirical support for this intuitively appealing hypothesis is sparse at best. With the interval approach to estimating risk preferences, a rough test of this hypothesis, that is $r'(\pi) < 0$, can be obtained. This test represents a "rough" approximation of Arrow's hypothesis because income instead of wealth is being used as the argument in the utility function.

Figure 2 represents four types of absolute risk aversion "functions" obtained from the survey. The graphs were con-

structed by connecting the income range for which an estimated risk interval is relevant, using the median and standard deviation data presented earlier. For example, in Panel A the individual's risk interval is (.0001, .0003) for an income range used in the questioning procedure of approximately $14,900 to $18,000. Panel A represents decreasing absolute risk aversion. Panels B, C and D demonstrate constant, increasing and mixed absolute risk aversion functions respectively. The mixed function can take two forms. Either the function will increase and then decline as in Panel D or it will have a negative slope to the middle income level and a positive slope to the third income level.

Respondents to the survey demonstrated all four types of risk aversion functions with respect to after-tax net income. The results are presented in Table 2. Of the 39 respondents who answered all 3 sections of the questionnaire correctly, 33 percent of the producers exhibited decreasing absolute risk aversion. Twenty percent demonstrated the same risk preferences over all three income levels. Eighteen percent of the respondents developed an aversion to risk as their incomes increased while 28 percent demonstrated mixed preferences. An alternative measure of the prevalence of decreasing absolute risk aversion is to look at the functions of the lower income group. These individuals were asked to rank distributions of after-tax net income which had values several times greater than their income levels. As shown in Table 2 these agents demonstrated a higher degree of decreasing absolute risk aversion than the respondent group as a whole. These results provide some support for Arrow's hypothesis but they also indicate the variability in utility functions over a range of possible outcomes.

TABLE 2. Estimated Slopes of Risk Aversion Functions.

Income Level	Slope	Frequency	Percentage of Total
All Three Groups	Decreasing	13	33.3
	Constant	8	20.5
	Increasing	7	18.0
	Mixed	11	28.2
	Total	39	100.0
Lowest Income Group	Decreasing	6	46.2
	Constant	3	23.0
	Increasing	2	15.4
	Mixed	2	15.4
	Total	13	100.0

Consistency Checks

Earlier test results indicated that agents developed a decision rule or criterion for ordering distributions as they responded to the questionnaire. In addition, we found in these preliminary tests that agents had difficulty ranking distributions consistently when the measurement interval for the distributions was near the agent's estimated risk aversion interval.

Consistency checks were incorporated into the questioning procedure to measure the learning process and the validity of the transitivity axiom. The pass rate for each of these checks was:

Check No.	Pass Rate (%)
1	76.1
2	46.7
3	76.1
4	79.6
5	59.1
6	80.9
7	78.3

Check number one tested the agent's consistency in ordering the pair of distributions presented in the third question of Section II. Three out of four respondents were consistent in their ordering. The second check evaluates the consistency of the agent in responding to the first or second pair of distributions in the same section. Less than 50 percent passed this test. When compared to the other pass rates, this low rate seems to substantiate the fact that agents develop a more consistent ordering

criterion as they respond to more questions.

The fifth check evaluates the respondent's consistency in ordering the final pair of distributions in the third section. Respondents seemed to have some difficulty in ranking distributions in the range around $31,000. Sixty percent of the swine producers passed the check but this percentage is low relative to the other checks. Overall, approximately 3 out of 4 respondents passed each consistency check. Because of the intervals used, we would expect that the degree of consistency would improve using a 4 interval experiment but decline for a 16 interval questionnaire. Therefore, there is a tradeoff between the degree of accuracy demanded in the elicitation process and the transitive nature of the responses.

Prediction of Risk Attitudes

A discriminant analysis was performed to explore quantitatively the possible relationships between producer attributes and the estimated risk aversion groups.[3] The 7 estimated intervals were grouped together into 3 categories. Intervals, 1, 2, and 3 were combined to form a "Risk Preferring" category with an aggregate interval of $(-\infty, 0)$. Interval 4 was designated as the "Risk Neutral" group because the interval surrounds in a narrow band $r(\pi) = 0$. Finally, intervals 5, 6, 7, and 8 represent the "Risk Averse" group with an interval of $(0, \infty)$. Seven producer attributes or socio-economic variables were measured for each producer. These variables are summarized in Table 3 for the three risk groups.

The signs on the producer attributes for the first estimated discriminant function were:

Producer Attribute	Sign
After-Tax Net Income	−
Age	−
Education	−
Debt Ratio	−
Net Worth	+
Size of Hog Enterprise	−
Degree of Diversification	+

The negative sign on after-tax net income implies that higher income producers are associated with more risk preferring behavior. A negative slope of the absolute risk aversion function for a relative large percentage of the respondents supports this sign result. The sign on age expressed in years is negative. Older producers tend to be less risk averse. Halter and Mason found an overall negative sign on their age variable and a negative sign on age for farmers with a high school education. The majority of the respondents in this survey had completed only high school.

A measure of indebtedness was included as an explanatory variable because we believe that financial risk, as discussed by Gabriel and Baker (1980), is an important component of total risk. The ratio of total liabilities over total assets is a financial solvency measure of the farm business. A possible *a priori* expectation is that a high level of indebtedness would be associated with a high level of total risk and risk averse behavior. The negative sign on the debt ratio does not seem to support this reasoning. Respondents seem to be more risk preferring as their debt ratios increase. It appears that risk preference may reveal itself in high debt ratios (high indebtedness) rather than risk aversion revealing itself in low indebtedness.

Wealth as measured by net worth has a positive influence on the estimated value of $r(\pi)$, that is, wealthier individuals are more risk averse. Halter and Mason used the degree of land ownership as a measure of wealth. Assuming this measure is highly correlated with net worth we can compare the signs of their results to our positive sign on net worth. We find that Halter

[3] See Wilson (1982) for a detailed presentation of the discriminant analysis results.

TABLE 3. Producer Attributes by Risk Category.

Risk Category	N	Measure	Average After-Tax Net Income[a]	Age	Education	Debt Ratio[b]	Net Worth	Hogs Produced	Diversification[c]
			($)	(Years)	(Years)		($)	(lbs.)	(%)
Risk Preferring	10	Mean	29,914	43.5	13.6	.33	557,471	154,017	55
		Std. Dev.	16,019	9.8	2.0	.24	270,434	46,558	19
Risk Neutral	16	Mean	29,068	47.5	12.4	.34	669,426	180,434	51
		Std. Dev.	22,510	10.6	2.7	.21	425,279	247,179	14
Risk Averse	19	Mean	39,044	39.8	12.2	.30	901,452	147,727	55
		Std. Dev.	26,507	13.8	3.4	.23	756,487	87,155	16
Total	45	Mean	33,467	43.4	12.6	.32	742,552	160,754	54
		Std. Dev.	23,152	12.2	2.9	.22	575,650	156,857	16

[a] Calculated using 1977–79 data and equations 3.2 and 3.3 in the text.
[b] Represents total liabilities as a percent of total assets, i.e., Total Liabilities/Total Assets = Debt Ratio.
[c] Percentage of total gross sales represented by the enterprise which contributed most to total sales, i.e. $\max_t \frac{X_t}{\Sigma X_t}$ where t is the t^{th} enterprise and X_t is the gross sales of the enterprise.

and Mason have a positive sign on land ownership for their overall measure and for respondents with a high school education. The variable has a negative influence on risk preferences when the agent is college educated.

The negative sign on the size of the hog enterprise indicates that large swine operations are more associated with risk taking behavior than smaller operations. Willingness to invest in large and modern confinement technology indicates a certain degree of confidence in the producer's management abilities. The potential for serious disease problems exists, but the economic benefits from a more intensive production system, given a high level of management may reduce the fear of heavy losses.

Halter and Mason found the degree of diversification to be insignificant in explaining the level of risk aversion. Using stepwise regression procedures this variable was discarded, in their analysis, on statistical grounds. We included this variable because it was statistically important in our earlier tests. The positive sign on the degree of diversification implies that the more specialized farming operation is associated with risk averse behavior. As one enterprise generates an increasing percentage of total gross sales, the producer will become more averse to taking fair bets in his farming operation.

Other than estimating risk intervals and analyzing the direction of influence on selected producer attributes on risk preferences, this research also attempts to test the predictive or classification power of the mathematical model used. If the mathematical model's specification is a reasonable description of the real world, its percentage of correct classification, in the case of the discriminant analysis, is a good measure of its accuracy. However, the estimated discriminant functions classified only 51 percent of the cases which were classified correctly as shown in Table 4, Panel A. Five risk preferring individuals were classified in the risk neutral group. Nine out of 16 risk neutral producers were classified correctly, but 4 risk neutral agents were placed in the risk preferring group and 3 in the risk averse group. The risk averse group was the most difficult to classify properly. Nearly 46

TABLE 4.

Panel A
Predictive Power of Estimated Discriminant Functions

Actual Risk Group	Predicted Risk Group Membership 1	2	3	Total
(1) Risk Preferring	5	5	0	10
(2) Risk Neutral	4	9	3	16
(3) Risk Averse	6	4	9	19
(4) Ungrouped Cases	0	2	0	2
Number of Total Cases				47
Percent of Grouped Cases Correctly Classified				51%

Panel B
Predictive Power of Estimated Discriminant Functions for a Separate Sample of Swine Producers[a]

Actual Risk Group	Predicted Risk Group Membership 1	2	3	Total
(1) Risk Preferring	4	3	0	7
(2) Risk Neutral	3	3	0	6
(3) Risk Averse	0	0	0	0
Number of Total Cases				13
Percent of Grouped Cases Correctly Classified				54%

[a] Caution should be taken in interpreting these results because the identical questioning procedure was not used with both samples.

percent of the misclassifications fell into this group. Six individuals who responded to the questionnaire in a risk averse manner were classified by the mathematical model as risk preferring.

A further attempt to check the accuracy of the prediction process was attempted by using the estimated discriminant functions from the Southwestern Minnesota Farm Management Association and classify the thirteen test respondents from the Southeastern Minnesota Farm Management Association. This type of split-sample validation procedure must be interpreted with some caution however. The questionnaire in the earlier survey used a different number of measurement intervals (16 vs. 8) and different income levels. Nevertheless, this attempt is worthwhile on the grounds that the formulation should be accurate for all swine producers in southern Minnesota. The success of correctly classifying cases from the earlier survey improves slightly as shown in Panel B. Fifty-four percent of the cases were classified in the estimated risk category. In addition, there were no extreme misclassifications, that is, risk preferring individuals were not classified into the risk averse group.

Concluding Remarks

The interval approach of measuring risk preferences is a new technique of directly estimating risk attitudes. Final judgement of this methodology is premature until more theoretical and empirical research analyzes its strengths and weaknesses. The following points attempt to contribute insights to these future discussions.

Measuring risk preferences using the interval approach is a low cost method of estimating risk attitudes for relatively large numbers of farmers. A conservative estimate of $6 per returned questionnaire would cover computer, secretarial, paper and mailing costs. Consideration of the researchers' labor costs in preparation and administration of the questionnaire will raise this cost figure, but total costs will be substantially lower than direct elicitation methods. We also found that response to the mail questionnaire can be over 80 percent when the decision makers have a working relationship with the research organization.

Another advantage of the procedure over other direct elicitation techniques is that interviewer biases are less of a problem. The agent is allowed to respond to the questionnaire within a generous time period and without the presence of an interviewer. Even if an interviewer were present, the nature of the questioning pro-

cess avoids the interviewer biases discussed by Binswanger. However some bias could arise in the construction of the questionnaire and the attached instructions.

We found that swine producers in Minnesota demonstrate all three types of risk behavior: preference, neutrality and aversion. Our estimates show that 76 percent of the respondents fell within the absolute risk aversion interval of (−.0002, .001) demonstrating slight risk preference to moderate risk aversion. We also found that a majority of the respondents exhibited risk aversion functions which revealed both risk aversion and risk preference when a wide spectrum of income is considered. This finding is supportive of the results King and Robison obtained from 17 Michigan farmers.

The results demonstrate that once the agent develops a method for processing the data, the individual is surprisingly consistent in ordering pairs of distributions. Over the entire questionnaire, 3 out of 4 respondents satisfied the transitivity axiom. This does not imply that transitivity or consistency is no longer an important concern in estimating risk preferences. On the contrary, future efforts using this elicitation technique should test the sensitivity of their results to consistency failures.

This research effort was not entirely successful in explaining swine producers' risk preference levels. Only one out of 2 agents was classified correctly by his estimated risk interval although this is an improvement over the 1 in 3 probability with an uninformed classification procedure. We find that these estimation techniques suffer from several difficulties. First, we are forced to summarize risk attitudes into groups which reduces the amount of information available for the analysis. Although discriminant analysis is designed to handle this type of model, greater effort must be taken to narrow the range of the summary risk measure or define a better measure of risk. Secondly, the list of explanatory variables used in this analysis was developed from previous experience. Causality in the model is not a one-way relationship for some variables. Risk attitudes may affect the level of the attributes rather than vice versa. A better understanding of what influences risk attitudes is needed. All we can say from these results is that some associations between risk attitudes and socio-economic variables were obtained.

The elicitation technique itself can be a source of improved accuracy. Two specific suggestions come to mind. A better understanding of the questioning process might be possible with personal interviews. In fifteen minutes the interviewer could explain the elicitation procedure to the respondent, thereby avoiding the impersonal cover letter and instructions. The questionnaire could be left with the respondent to be answered at the individual's leisure.

Secondly, future efforts might include 4 or 5 income levels in the questionnaire rather than three. By more finely dividing the survey group by income level, a higher degree of differentiation between income groups would be possible. The broad income groups used in this study probably contributed to some of the inaccuracies in classification.

References

Anderson, J. R., J. L. Dillon, and J. B. Hardaker. *Agricultural Decision Analysis.* Iowa State University Press, Ames, 1977.

Arrow, K. J. *Essays in the Theory of Risk Bearing.* North Holland, Amsterdam, 1971.

Batra, R. and A. Ullah. "Competitive Firm and the Theory of Input Demand under Price Uncertainty." *Journal of Political Economy,* 82(1974): 537–48.

Binswanger, H. "Attitudes Toward Risk: Experimental Measurement in Rural India." *American Journal of Agricultural Economics,* 62(1980): 395–407.

Dillon, J. L. and P. L. Scandizzo. "Risk Attitudes of Subsistence Farmers in Northeast Brazil: A Sampling Approach." *American Journal of Agricultural Economics*, 60(1978): 425–35.

Gabriel, S. C. and C. B. Baker. "Concepts of Business and Financial Risk." *American Journal of Agricultural Economics*, 62(1980): 560–64.

Halter, A. N. and R. Mason. "Utility Measurement for Those Who Need to Know." *Western Journal of Agricultural Economics*, 3(1978): 99–109.

Hanson, G. "Income Tax Expenditures and Their Effects on Farm Growth." Unpublished Ph.D. Dissertation, University of Minnesota, St. Paul, 1981.

King, R. P. "Operational Techniques for Applied Decision Analysis Under Uncertainty." Unpublished Ph.D. Dissertation, Michigan State University, 1979.

King, R. P. and L. J. Robison. *Implementation of the Interval Approach to the Measurement of Decision Maker Preferences*. Agricultural Experiment Station Research Report 418, Michigan State University, East Lansing, 1981a.

King, R. P. and L. J. Robison. "An Interval Approach to Measuring Decision Maker Preferences." *American Journal of Agricultural Economics*, 63(1981b): 510–20.

Kramer, R. A. and R. D. Pope. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis." *American Journal of Agricultural Economics*, 63(1981): 119–28.

Lin, W., G. W. Dean, and C. V. Moore. "An Empirical Test of Utility vs. Profit Maximization in Agricultural Production." *American Journal of Agricultural Economics*, 56(1974): 497–508.

Magnusson, G. *Production Under Risk: A Theoretical Study*. Almquist and Wiksells, Uppsala, 1969.

Meyer, J. "Increasing Risk." *Journal of Economic Theory*, 11(1975): 119–32.

Meyer, J. "Choice Among Distributions." *Journal of Economic Theory*, 14(1977a): 326–36.

Meyer, J. "Second Degree Stochastic Dominance with Respect to a Function." *International Economic Review*, 18(1977b): 477–87.

Moscardi, E. and A. de Janvry. "Attitudes Toward Risk Among Peasants: An Econometric Approach." *American Journal of Agricultural Economics*, 59(1977): 710–16.

Officer, R. R. and A. N. Halter. "Utility Analysis in a Practical Setting." *American Journal of Agricultural Economics*, 50(1968): 257–77.

Sandmo, A. "On the Theory of the Competitive Firm Under Price Uncertainty." *American Economic Review*, 61(1971): 65–73.

Whittaker, J. K. and J. R. Winter. "Risk Preferences of Farmers: An Empirical Example, Some Questions, and Suggestions for Future Research." *Risk Analysis In Agriculture: Research and Educational Developments*. Proceedings of a Seminar Sponsored by Western Regional Research Project W-149, Department of Agricultural Economics, University of Illinois, Urbana-Champaign, 1980.

Wilson, P. N. "Structural Characteristics of the Swine Production Industry: A Stochastic Dominance Analysis." Unpublished Ph.D. Dissertation, University of Minnesota, St. Paul, 1982.

Wilson, P. N. and H. Hwang. *User's Guide to Stochastic Dominance Computer Software*. Staff Paper P82-20, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, 1982.

Young, D. O. "Risk Preferences of Agricultural Producers: Their Use in Extension and Research." *American Journal of Agricultural Economics*, 61(1979): 1063–70.