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Assessing Farmers' Attitudes Toward Risk Using the "Closing-in" Method

Sharon K. Bard and Peter J. Barry

The 1996 Farm Bill and low commodity prices have regenerated interest in the impact of risk and farmers' risk attitudes on production agriculture. Previous research has used expected utility theory (EUT) and direct elicitation of utility functions (DEU) for eliciting risk attitudes. To overcome the criticisms of EUT and DEU, a recently developed technique called the "closing-in" method is adapted for eliciting farmers' risk attitudes. This method is applied to Illinois farmers by using a computerized decision procedure, and is validated by comparing the results to the farmers' self-assessment of their risk attitudes and score to a risk attitudinal scale.

Key words: "closing-in" method, computerized decision procedure, farmers' self-assessment, probability-space framework, risk attitudes, risk attitudinal scale, scientific elicitation

Introduction

Agricultural producers make decisions in a risky environment resulting from production (weather, disease, pests, etc.), market and price (input and output), and financial (interest rates) uncertainty. How farmers manage these risks is greatly influenced by their attitudes toward or willingness to take risk. In turn, research has found that farmers' risk attitudes influence aggregate commodity supply response (Chavas and Holt 1990, 1996; Holt and Moschini), financial structure (Gwin, Barry, and Ellinger), marketing decisions (Eckman, Patrick, and Musser), enterprise organization, and a host of other agricultural characteristics (Barry; Hardaker, Huirne, and Anderson). Globalization of the agricultural markets, innovations in the technological base of the food system, changes in the government farm program, and low commodity prices have changed the risk farmers face and regenerated interest in the impact of risk and farmers' risk attitudes on production agriculture.

Knowing how farmers react to risk is important to farmers, educators, industry members, and policy makers. If farmers' risk attitudes are known, risk management strategies and educational programs about risk and risk management strategies can be tailored to the farmers' tolerance for risk. Industry participants such as insurance providers, seed companies, lenders, and financial counselors benefit from knowing farmers'

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risk attitudes when developing insurance policies, marketing new seed varieties, and creating financial services. Policy makers like to know how much risk farmers are willing to take when evaluating the demand for or the effectiveness of programs that address risk.

Considerable research has addressed farmers' attitudes toward risk by using different underlying theories and elicitation methods such as the modified von Neumann-Morgenstern and the Ramsey procedures (e.g., Halter and Mason; Anderson, Dillon, and Hardaker; Young; Collins, Musser, and Mason). Expected utility theory (EUT) has been the most widely used theoretical framework for eliciting farmers' risk attitudes. However, its validity has been questioned due to observed violations of the von Neumann-Morgenstern axioms (Kahneman and Tversky; Machina 1982, 1987; Schoemaker) and observed difficulty of accurate utility measurement (Robison). To overcome these EUT violations and elicitation criticisms, generalized utility theories (Camerer 1989) and alternative methods for eliciting risk attitudes have been developed (Camerer 1992; Hey and Strazzera; Hey and Di Cagno; Abdellaoui and Munier 1994a).

We apply a recently developed elicitation technique called the "closing-in" method for eliciting farmers' attitudes toward risk (Abdellaoui and Munier 1994a). The methodology incorporates a generalized utility theory framework and an elicitation process to overcome the criticisms of EUT and the limitations of the methods traditionally used in eliciting risk attitudes. The following sections discuss the study's background, the theoretical framework adapted to address EUT criticisms, and the "closing-in" method. This new technique is implemented by eliciting farmers' attitudes toward risk using a computerized decision procedure.

Eliciting Risk Attitudes

Expected utility theory is probably the most widely used theoretical framework in economic modeling of decision making under uncertainty. The theory originated from Bernoullian utility analysis and was more fully developed by von Neumann and Morgenstern. The objective function for the Bernoulli utility function is stated as:

$$E(U) = \sum_{i=1}^{n} p_i U(x_i), \tag{1}$$

where p_i is the probability that the ith outcome will occur, and x_i is the value of the ith outcome.

The von Neumann-Morgenstern axioms state that the utility function must be ordered, continuous, and independent. Ordering implies that a numerical scale exists which represents a person's preferences over gambles (more preferred gambles have higher numbers). The ordering property implies stronger properties: completeness and transitivity. Continuity requires that for each outcome, x_i, between x_1 and x_n, the person can name a probability, p_i, such that he or she is indifferent between getting x_i with certainty and playing a lottery [in a two outcome case, the lottery is represented as px_1 and $(1-p)x_2$]. Independence assumes that if two gambles (e.g., X and Y) are equally preferable, then the lotteries composed of a p chance of X (or Y) and a $1-p$ chance of Z (a third gamble) are also equally preferable. This implies that $X \sim Y$ and $pX + (1-p)Z \sim pY + (1-p)Z$ (where $\sim$ indicates indifference). The continuity and independence axioms make the numerical utility of a gamble equal to the expectation of the utilities of the gamble's possible outcomes:

$$EU = pU(x_1) + (1 - p)U(x_2). \tag{2}$$

If a decision maker's behavior is consistent with the von Neumann and Morgenstern axioms, she will weight outcomes of action choices according to a personalized and unique function $U(x)$, with the highest value being most preferred. The EUT provides a single-valued index that orders choices according to the decision maker's preferences or attitudes toward risk (Robison et al.). If the axioms hold, von Neumann and Morgenstern's theorem follows that an optimal risky choice is based on the maximization of expected utility.

Subsequent research questioned the validity of the EUT model due to observed violations of its axioms such as Allais' paradox which violates the independence axiom (Allais). Young, and King and Robison also cite operational problems with the application of EUT to the direct elicitation of risk attitudes. Criticisms include bias arising from different interviewers, complexity of the elicitation process, and selection of inappropriate functional forms of the utility function resulting in undesirable implications. These problems prompted the development of alternative theories that relax one or more of the axioms (Schoemaker; Machina 1982). These theories, including Machina's generalized expected utility, Chew and MacCrimmon's weighted utility, and Becker and Sarin's lottery-dependent expected utility, have been presented in probability space utilizing a unit triangle (Camerer 1989).

Within the probability-space framework, a range for the decision maker's indifference curve is measured and a range of risk aversion can be calculated. Because this method does not require a specific functional form for the utility function to be specified, it avoids the problems inherent in parametric tests of both the functional form and the original hypotheses. Researchers have developed various methods for measuring one's indifference curve, but, except for Bar-Shira, the implementation of their methods has been limited to the economics field (Camerer 1989, 1992; Hey and Strazzera; Hey and Di Cagno; Abdellaoui and Munier 1994a, 1994b, 1998).

Elicitation of Risk Attitudes in Probability Space

The probability-space approach to analyzing risk attitudes was first presented by Marschak in 1950, and further developed by Machina (1982, 1987). Consider three outcomes: x_L, x_M, and x_H (low, medium, and high) with objective probabilities p_L, p_M, and p_H, such that $x_L \prec x_M \prec x_H$. Outcomes are represented by degenerate lotteries that give a certain result with probability one ($\Sigma p_i = 1$). Since the sum of the probabilities cannot exceed one, and p_M is implicitly represented by $p_M = 1 - p_L - p_H$, the set of feasible probabilities can be represented by points in the unit triangle in the p_L:p_H plane as in figure 1. The set is bounded by the lines $p_L = 0$ (left edge), $p_M = 0$ (the hypotenuse), and $p_H = 0$ (the lower edge). Upward movements in the triangle increase p_H at the expense of p_M (i.e., shift probabilities from outcome x_M up to x_H), and leftward movements decrease p_L to the benefit of p_M (shift probabilities from outcome x_L up to x_M). These movements (and more generally all northwestern movements) lead to stochastically dominating lotteries and would accordingly be preferred.

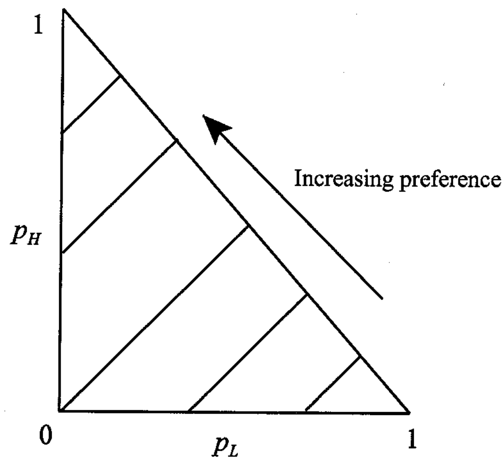

Figure 1. Indifference curves assuming expected utility

Individuals' indifference curves in the $(p_L:p_H)$ diagram are given by the solution to:

(3) $$EU: U^* = p_L U(x_L) + p_M U(x_M) + p_H U(x_H).$$

Substituting $p_M = 1 - p_L - p_H$ and rewriting the above in slope-intercept form produces:

(4) $$p_H = \frac{U^* - U(x_M)}{U(x_H) - U(x_M)} + p_L \frac{U(x_M) - U(x_L)}{U(x_H) - U(x_M)}.$$

The slope of the line tangent to an indifference curve at a point is given by:

(5) $$\frac{dp_H}{dp_L} = \frac{U(x_M) - U(x_L)}{U(x_H) - U(x_M)}.$$

Since the slope dp_H/dp_L is a constant, depending only on the relative utilities of the three outcomes, the indifference curves are straight lines with the same slope as shown in figure 1.[1] The indifference curves express attitudes toward risk. The slope measures by how much p_H a person needs to be compensated for an increase in p_L (or the "price" of risk) (marginal rate of substitution of p_H for p_L or the shadow price of probabilistic units of the highest valued gamble in terms of probabilistic units of the lowest valued gamble). The more preferred indifference curves lie to the northwest (due to $x_L \prec x_M \prec x_H$), implying that in order to know an expected utility maximizer's preferences over the entire triangle, it suffices to know the slope of a single indifference curve.

One way to look at measuring risk attitudes in probability space is to consider a gamble, G, and a transformation of G with a probability mass p_M of 0.10 shifted from the middle outcome, x_M, to each of the extreme outcomes, x_L and x_H, so that the choices are either G or $(p_L + 0.10; p_M - 0.20; p_H + 0.10)$. Four gamble pairs are listed in table 1 and portrayed in figure 2.

[1] This presentation draws from the expected utility axioms of completeness, transitivity, and continuity. The axioms imply that any two points in a triangle are either on the same indifference curve or on two different indifference curves (completeness), indifference curves do not cross within the triangle (transitivity of preferences), and there are no open spaces in the indifference map (continuity).

Table 1. Gambles with Outcomes

Pair No.	G (Less Risky)			H (More Risky)		
	p_L	p_M	p_H	p_L	p_M	p_H
1	0	0.6	0.4	0.1	0.4	0.5
2	0	0.6	0.4	0.2	0.2	0.6
3	0.1	0.4	0.5	0.3	0	0.7
4	0.2	0.2	0.6	0.3	0	0.7

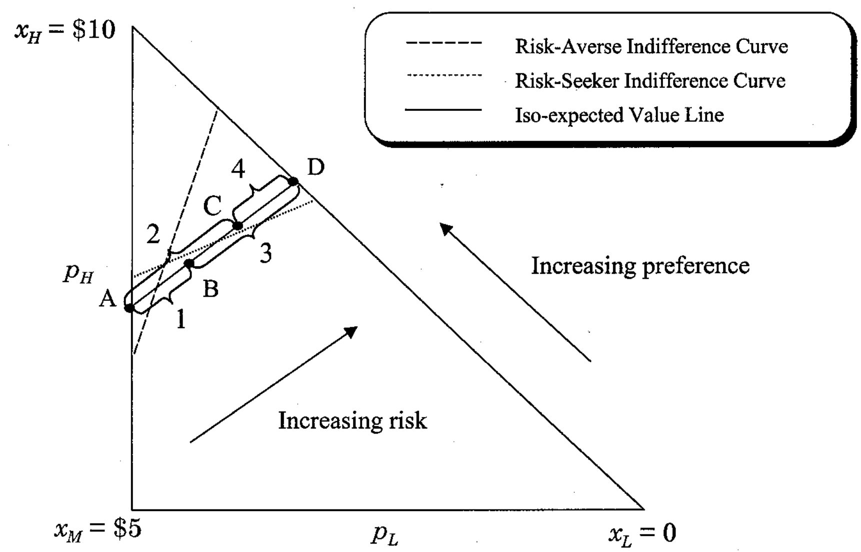

Figure 2. Indifference curves and iso-expected value line

The original gamble (G) is the less risky set, and the transformed gamble (H) is the more risky set. A payoff level (x_L, x_M, x_H) of (0; \$5; \$10) is used. Since these gambles are a mean-preserving spread (same expected value), the straight line connecting the gambles is the iso-expected value line. The brackets indicate the less and more risky gambles in each pair. If a person, when presented with the first pair of gambles, $G\{0; 0.6; 0.4\}$ and $H\{0.1; 0.4; 0.5\}$, selects G, she is selecting the less risky gamble. Her indifference curve must start below point A and end above point B in the triangle (the dashed line in figure 2). This condition implies that her indifference curve is steeper than the iso-expected utility line, and that she is risk averse. If another person, when presented with the third pair of gambles, $G\{0.1; 0.4; 0.5\}$ and $H\{0.3; 0; 0.7\}$, selects H, he is selecting the more risky gamble. His indifference curve must start below point D and end above point B in the triangle (the dotted line in figure 2), implying that his indifference curve is flatter than the iso-expected value line and that he is a risk seeker.

The relationship between indifference curves presented in probability space and the Arrow-Pratt coefficient of absolute risk aversion (ARA) is presented in Bar-Shira. In the case of one choice set, two lotteries, and three outcomes for each lottery, Bar-Shira stated there is a one-to-one relationship between the slope of the indifference curve and ARA:

$$(6) \qquad -\frac{U''(x)}{U'(x)} \approx 2\left(\frac{s-1}{s+1}\right),$$

where s is the slope of the indifference curve [equation (5)]. This result is derived under the assumption that outcomes are equally spaced and close to each other. By using the relationship between the slope of the indifference curves and the coefficient of absolute risk aversion, Bar-Shira calculated a range for the coefficient of absolute risk aversion for each farmer.

The "Closing-in" Method for Eliciting Farmers' Risk Attitudes

The "Closing-in" Method

Using the probability-space framework as the foundation, Abdellaoui and Munier (1994a) designed a direct and systematic estimation method of deriving indifference curves by experimental investigation called the "closing-in" method. The method requires an interior point (e.g., L) and a segment $L'L''$ in the triangle to be identified (figure 3). It is possible to find a lottery equivalent to L on $L'L''$ if the decision maker has preferences following the principle of first-order stochastic dominance. To determine the point lottery equivalent to L, a point such as L''' on $L'L''$ is identified. If $L''' \succ L$, the indifference curve intersects between L''' and L''. Another point between L'' and L''' is identified and a preference is indicated. A sufficient number of iterations, assuming continuity, will lead to a satisfactory approximation of the point being searched.

This method utilizes point lotteries inside the triangle—an important issue because the framework on which violations of the independence axioms were built utilizes lotteries where one of the probabilities equals zero (i.e., the lotteries were located on one of the boundaries of the triangle) (Machina 1987). Conlisk found that if the lotteries were located in the triangle's interior, a certainty effect (termed by Kahneman and Tversky) disappeared and the systematic inconsistencies did not exist.

To implement the "closing-in" method, Abdellaoui and Munier (1994a) developed interactive software called "Maclabex" to allow subjects to select preferences between two lotteries of three outcomes at different locations in the triangle. This approach permits fields of indifference curves to be estimated. In their two subsequent papers, Abdellaoui and Munier (1994b and 1998) implemented the "closing-in" method consistent with the methodology presented in their earlier work.

Application to Eliciting Farmers' Risk Attitudes

The "closing-in" method developed by Abdellaoui and Munier (1994a) is used to elicit risk attitudes from farmers based on the direct and systematic estimation of a slope range within which each subject's indifference curve will fall. Once the slope range is calculated, a range for the coefficient of absolute risk aversion can be calculated using equation (6).

To elicit risk attitudes from farmers, an elicitation process was designed to create a "familiar" decision setting for grain marketing that would enhance the realism of a farmer's decision process and the reliability of the resulting risk attitude measure. The

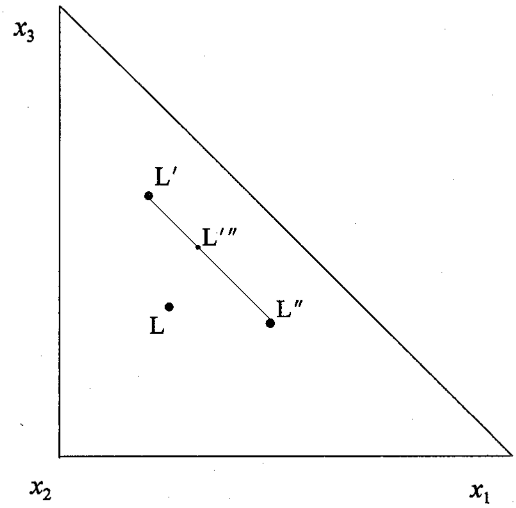

Figure 3. The "closing-in" method: Constructing an indifference curve

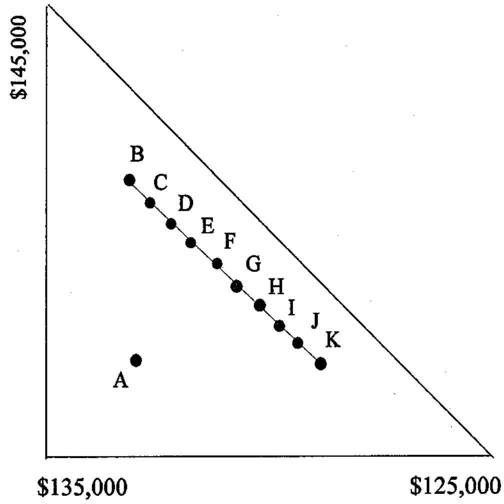

Figure 4. The "closing-in" method with lottery points

participating farmer was presented with two options for marketing 320 acres of corn. The farmer was told to assume a 150 bushel/acre yield, the decision time to market was just prior to harvest, and the two options differed due to the methods for pricing the crop (i.e., forward contracting, hedging with options, and cash sales).

Each marketing option represented a lottery, denoted by probabilities that summed to one. The payoffs for the lotteries were ($125,000; $135,000; $145,000), and the two marketing options differed in expected value and risk. The first marketing option was represented by the lottery $A = \{0.20; 0.60; 0.20\}$ (comparable to the interior point L in figure 3). The more risky gambles lay on the segment connecting gambles $B = \{0.20; 0.15; 0.65\}$ and $K = \{0.65; 0.15; 0.20\}$ (figure 4). The farmers could not indicate indifference between marketing plans (they had to decide how to market their crop); therefore, an exact slope of the indifference curve was not calculated. To determine the upper and lower bounds into which each farmer's indifference curve fell, an initial point, $F = \{0.40; 0.15; 0.45\}$, was defined. The subject had to indicate a preference between A and F. If $A \succ F$, the subject's indifference curve lay above F.

To further narrow the location of the indifference curve above F, another lottery point, D, was then identified, and the subject was asked to indicate his preference between A and D. The participant continued to indicate a preference between two lottery points until the upper and lower bounds were identified. Depending on the degree of risk-averse or risk-seeking behavior, a subject answered three to five questions. The probabilities were reported in 0.05 increments to avoid difficulties of considering probabilities in smaller denominations (i.e., $\{0.22; 0.56; 0.22\}$). The lotteries for each point are shown in table 2.

Abdellaoui and Munier implemented their "closing-in" method by presenting questions in a diagram of two urns representing each gamble. To implement the scientific elicitation method to farmers, an Excel macro written in Visual Basic was developed to consider the grain decision marketing situation. The program opened with an introduction to the elicitation process, described the hypothetical marketing situation, stated the

Table 2. Point Lotteries

	LOTTERIES										
Payoff	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*
$125,000	0.20	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
$135,000	0.60	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
$145,000	0.20	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20

Table 3. Summary of Participating Farmers' Demographics

Category	Description
Number of participants	86 farmers
Average age	46 years old
Average number of years farming	22 years
Average number of years in school	15 years
Average number of dependents	4 dependents
Most frequent category for gross farm income	$200,000 to $499,999
Number of the following farm types:	
▸ Field crops	71 farms
▸ Livestock (beef, hogs, etc.)	13 farms
▸ Other	2 farms
Average number of acres cropped	1,144 acres
Average percentage of off-farm income	21%
Most frequent category for net worth	$250,000 to $500,000
Most frequent category for debt-to-asset ratio	30% to 50%

assumptions, and offered an example. For each decision between the two marketing plans, a written description and a column bar chart were provided for each marketing option. After the bounds of the indifference curves were identified, the program concluded with a thank you for the farmer's participation. This elicitation technique was implemented on laptop computers.

The "closing-in" method was applied to 86 Illinois farmers participating in Illinois' Farm Business Farm Management program during January and February 1998. Table 3 gives an overview of the participating farmers' demographics. The average farmer participating in this study was in his mid-40s, had four dependents (including himself), had some college education, farmed 1,144 acres, and had a net worth ranging from $250,000 to $500,000. Approximately 83% of the farmers were cash grain producers.

The "closing-in" method generated 11 ranges in which the indifference curves could fall. Two extreme ranges imply negatively sloped indifference curves. These alternatives were included in the program to provide the complete universe of potential answers. However, a negatively sloped indifference curve is counter to economic theory. Three respondents selected a series of marketing plans implying their indifference curves lay beyond *B*, and two farmers selected marketing plans implying their indifference curves lay beyond *F*. Despite the attempt to explain clearly the concept of probabilities and the questions' objectives, it is possible that the respondents did not clearly understand the

Table 4. Summary Statistics for Three Risk Assessment Methods

Item	Average	Median	Mode	Standard Deviation	Maximum	Minimum	CARA[a] Range
Self-Assessment Score	5.31	5.00	4.00	1.55	8.00	2.00	—
Attitudinal Scale	3.80	3.80	3.80	0.69	5.30	2.10	—
Scientific Elicitation	3.98	4.00	4.00	1.64	7.00	1.00	0.795–0.367[b]

[a] Coefficient of absolute risk aversion.
[b] The range of CARA in which the average response for the scientific elicitation fell.

objective of the questions or the implications of their choices. Therefore, due to the highly unlikely event of negatively sloped indifference curves and the potential of misunderstanding the concept of probabilities and gambles, the five observations with negatively sloped indifference curves were excluded from the remainder of the analysis.

Table 4 presents statistics on the remaining 81 observations for the "closing-in" method, as well as two additional methods utilized to validate the "closing-in" technique.[2] The mean for the scientific elicitation is 3.98, while both the mode and median are 4. A score of 4 for the scientific elicitation portion indicates that the respondent preferred gamble A, implying that his indifference curve intersects the line BK somewhere between points E and F (figure 5). An indifference curve intersecting the line between F and G implies risk neutrality; therefore, this sample of farmers was on average moderately risk averse. The coefficient of absolute risk aversion for each indifference curve is calculated from equation (6). The range of coefficient values in which the average response fell is from 0.795 to 0.367, also indicating moderate risk aversion.

Gambles A, E, and F have expected values of \$135,000, \$136,500, and \$135,500 with respective standard deviations of \$6,325, \$9,096, and \$9,206. In selecting gamble E over A, the farmer is choosing a gamble with a larger expected value but with greater risk. This is consistent with the first-order stochastic dominance efficiency criterion.

Validation

Self-Assessment and Attitudinal Scale

To compare and validate the "closing-in" method, two additional techniques for eliciting risk attitudes were implemented: (*a*) a self-assessment of the farmer's risk attitude, and (*b*) a risk attitude score resulting from an attitudinal scale. These measures were elicited from the sample farmers through a written questionnaire completed by the participants at the same time as the scientific elicitation.

The self-assessment question was included to further the understanding of the relationship associated with self-assessment, an attitudinal scale, and a scientifically elicited measure. The self-assessment question scale was from 0 to 10, with 0 representing an attitude of "wanting to avoid risk as much as possible," and 10 representing an attitude of "willing to take as much risk as possible." A score of 5 implied risk neutrality. A respondent's self-assessment could be influenced by what that individual feels is socially

[2] The results for the other methods are discussed in a subsequent section.

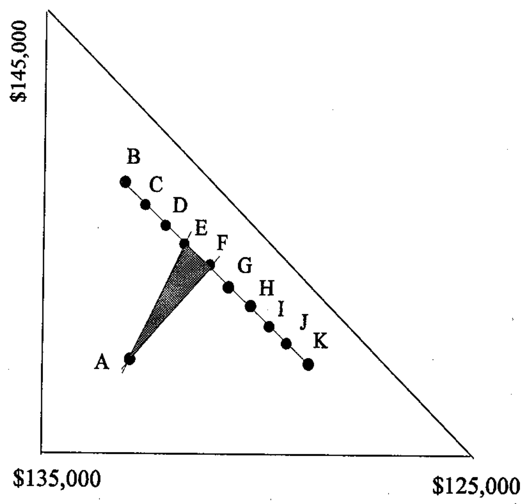

Figure 5. Average range of indifference curves

desirable or may be a reflection of what the person wishes to be. Consequently, a self-assessment measure may not be an accurate measure of a respondent's true attitude toward risk.[3]

The third method for eliciting farmers' attitudes toward risk was an attitudinal scale. The scale consisted of statements that empirically correspond to a single social-psychological dimension (in this case, risk attitude). Theory suggests that risk attitudes influence the way farmers manage the risk inherent in production agriculture. Therefore, it is hypothesized that attitudes toward mechanisms or tools used for managing risk reflect the producer's risk attitude. Based on previous research (Patrick et al.; Patrick and Ullerich; Patrick and Musser; Blank and McDonald), 25 questions addressing different methods for managing financial, production, and marketing risk were formulated. Scores to the statements were summed to represent a final score for the individual's risk attitude.[4] The overall score could span from highly risk-averse (a score of 0) to risk-neutral (5) to highly risk-seeking (a score of 10).

Comparison of Elicitation Methods

As indicated in table 4, the sample farmers, on average, self-assessed themselves to have significantly lower risk aversion (risk-preferring on average) than under the attitudinal scale or scientific elicitation approaches (5.31 versus 3.80 or 3.98, respectively). While the scientific elicitation scores exhibited the widest range of scores, the responses to the attitudinal scale displayed the narrowest range of variation.

Table 5 presents the correlation coefficients associated with the three elicitation methods. While all three correlations for the scores are positive, the correlation between the attitudinal scale and the scientific elicitation was the only significant statistic. The

[3] Schurle and Tierney compared farmers' self-assessment score to a score resulting from an interval survey approach and found the farmers assessed themselves to be more risk-seeking than their behavior indicated.

[4] Details of the methodology implemented for the scale and the self-assessment method are presented in Bard and Barry.

Table 5. Correlations Associated with the Three Risk Assessment Methods

Elicitation Measure	Self-Assessment	Attitudinal Scale
Attitudinal Scale	0.027	—
Scientific Elicitation	0.175	0.317*

* Significant at the 99% level.

low correlations between the farmers' self-assessment and the attitudinal scale and the scientific elicitation scores imply that farmers' perceptions of themselves are not highly consistent with their implementation of risk management tools or scientifically based attitudes toward risk.

Schurle and Tierney compared risk attitude measures elicited from a self-rank question, the interval method, and a set of 20 true-false questions designed by Farley to create a risk attitude score. Their sample of 90 farmers assessed themselves as being slightly risk-seeking, while the Farley scores and the interval survey results indicated the farmers were slightly risk-averse. In addition, Schurle and Tierney found a positive but insignificant correlation between the self-assessment and the Farley score, and a negative and insignificant correlation between the interval measure and the Farley score. The correlation between the Farley score and the self-rank question was positive and significant. Our result of a higher average self-assessment score than the other two methods (more risk-seeking) is consistent with Schurle and Tierney. However, while Schurle and Tierney found significant and positive correlation between the Farley score and the self-ranking, we found that the attitudinal scale was significantly correlated to the "closing-in" method, not the self-assessment score.

Conclusions and Implications

Due to the criticisms of expected utility theory (EUT) and previously developed methods of direct elicitation of utility functions (DEU), a new elicitation technique called the "closing-in" method has been adapted to elicit farmers' attitudes toward risk. Because this scientific elicitation method does not require that a functional form for the utility function be specified, it avoids some of the shortcomings of the expected utility hypothesis as the underlying theory. In addition, the elicitation technique utilizes a methodology that addresses some of the criticisms of EUT and DEU.

The "closing-in" method was applied to Illinois farmers to elicit their attitudes toward risk. The participating farmers were also asked to self-assess their attitudes toward risk and responded to an attitudinal scale about risk management tools. The responding farmers, on average, self-assessed their risk attitudes as slightly risk-seeking. However, their responses to utilization of risk management tools and the "closing-in" method indicated mild degrees of risk aversion. The higher self-assessment score and insignificant correlation coefficients for the self-assessment question and the other elicitation methods further indicate that a respondent's self-perception is not an accurate measurement of the underlying attitude or belief. Psychometricians also caution against the use of single-item measurements such as the self-assessment question due to their insufficient measurement properties. Therefore, it appears that the risk attitude scale and the "closing-in" method are more valid measurements of risk attitudes than self-assessment. If a self-assessment question is used to measure risk attitudes, the practitioner should keep in mind its measurement weaknesses.

The "closing-in" results are comparable to previous studies of farmers' risk attitudes. In general, studies using DEU, the interval approach, observed economic behavior, and the experimental approach have found risk aversion to be the most prevalent risk attitude among farmers, and the "closing-in" method results are consistent with those findings. However, the similarity of the results at the aggregate level does not diminish the potential contribution of the "closing-in" method to research and education of risk in agriculture. This elicitation method is applied using a computer and can be implemented without lengthy explanation and within a short time frame. Thus, it allows for wide-scale, low-cost application in areas traditionally not possible, such as the Internet, and for large groups of participants. This new elicitation method can provide an opportunity to gain further insight into the behavior exhibited by farmers facing risk and uncertainty in agriculture going into the 21st century.

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