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Developing a scale for assessing risk attitudes of agricultural decision makers

Sharon K. Bard*, Peter J. Barry

Department of Agricultural and Consumer Economics, University of Illinois, 326 Mumford Hall, 1301 Gregory Drive, Urbana, IL 61801

Abstract

This study adapts a methodology formulated in the social sciences to develop a scale for measuring an economic agent's attitude toward risk. The scale assesses risk attitudes by eliciting farmers' opinions towards risk management tools using a Likert procedure. The methodology validates the scale with a scientific risk attitude measure and compares the scale to the farmers' self-assessment of their risk attitudes. The resulting scale methodology could be administered to people without the need for personal interviews. The subjects for this study were Midwestern farmers, but the methodology can be applied to any sector of the agricultural industry.

1. Introduction

Recent changes in the structure and technology base of the food system and in the policy environment affecting agricultural production have heightened the value of decision analysis under risk (Boehlje and Lins, 1998). The problems and issues now include uncertainties about the markets for GMO products, other food safety concerns, industrialization of the food system, environmental hazards and, for farmers, too low prices and too much ambiguity in farm price and income policy from the Federal government. In response, the established concepts and tools of risk analysis have received renewed application in the current risk environment (Harwood et al., 1999). The key components remain much the same: identifying and measuring sources of risk, evaluating risk management alternatives, and tailoring risk advice to the risk attitudes of agri-business people, farmers, lenders, and consumers.

A major component of decision analysis under risk in a small business environment is reliable knowledge about the risk attitudes of key decision makers. Farmers' risk attitudes,

* Corresponding author.
E-mail address: s-bard@uiuc.edu (S. Bard).

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for example, have been studied using different theories (e.g., expected utility theory, prospect theory, safety-first) and elicitation techniques (direct elicitation of utility functions, experimental methods, and observed economic behavior) (Anderson, Dillon, and Hardaker, 1977; Barry, 1984). The theories, however, have been criticized due either to violations of their assumptions or to results not supporting the hypotheses (Robison, 1982; Schoemaker, 1991; Machina, 1987; Kahneman and Tversky, 1979). Moreover, the elicitation techniques often experience costly and time consuming implementation. As Young observed in the late 1970s, the devotion of substantial time, resources, and effort to obtaining direct, scientifically based measures of a limited number of farmers' risk attitudes was not considered a productive activity. In other settings, by contrast, financial planners and counselors began to develop sets of preference-based interview questions that enable them to tailor portfolio advice to the risk profiles of their customers. Single self-assessment questions have also been used to generate risk attitude information.

Our goal in this study is to apply a methodology formulated by other social sciences (DeVellis, 1991; Spector, 1992; McIver and Carmines, 1981) to develop a ranking procedure for peoples' risk attitudes using an attitudinal scale approach. The technique consists of defining a scale of statements that reflect the respondent's attitude toward an underlying variable (here, risk attitudes proxied by various responses to risk) and establishing a score reflecting a quantitative measurement of the attitude. The method does not attempt to explain the behavior that drives the attitude, thereby, circumventing the criticism of the traditional theories. Developing an attitudinal scale is a multi-step process requiring the initial sampling of subjects, but once developed, the scale can be administered to a large number of people through less costly and time-consuming media forms than personal interviews. For comparisons, the scale technique is contrasted with scientifically based and self-assessment methods using responses from a panel of Illinois grain producers.

2. Developing attitudinal scales

Eliciting individuals' attitudes with a scale has been implemented for various attributes (referred to as constructs or underlying latent variables in the psychometric literature). Examples include investment risk (Hube, 1998), self-esteem (McIver and Carmines, 1981), locus of control issues such as work and health (Spector, 1992), depression (DeVellis, 1991), and personality traits (DeVellis, 1991). The objective of these scales is to measure quantitatively a construct that is difficult to evaluate directly. Measurement scales can take several forms, but a unidimensional rating scale applies to one construct that has an underlying, quantitative continuum. The scales consist of either questions or statements (called items) that correspond to or are influenced by the social-psychological attribute. Respondents rate each item, thus conveying their attitudes toward the underlying variable. The respondents' ratings of the multiple items are summed to yield a score for the individual. The score can then be scaled for comparison to other respondents' scores.

The psychometric literature provides a rich set of guidelines for developing a unidimensional rating scale. The development process begins with clearly defining the underlying latent variable. Items that reflect attitudes toward the construct are then identified, and an item pool is generated. The measurement format (scale type, number of choices, etc.) is determined, and the initial item pool is then reviewed by experts and pretested. Details of these steps are found in Spector, 1991; McIver and Carmines, 1981; and DeVellis, 1991.

During the design phase of scale development, hypotheses are formed about relationships between the underlying latent variable and items it influences, with the objective of eliciting the "true score". Error can stem from two sources—measurement error and incorrect theoretical formulation. The analytical phase of scale development attempts to minimize error sources and maximize the chance of a "true score." Reliability testing addresses measurement error whereas validity analysis evaluates the scale's theoretical foundation. An important validation method is the comparison of the scale to other measurements of the same construct.

The preliminary scale and the validation measurements are then administered to a development sample. As previously mentioned, the empirical analysis consists of reliability and validity testing and optimizing the scale length. Scale validation can be based on construct validity, convergent validity, and exploratory factor analysis (DeVellis, 1991). Construct validity addresses the theoretical relationships of the score to other variables or constructs. Theory postulates behavioral differences between groups of people, and construct validation determines if the scale differentiates between groups based on their scores. The known-groups method uses ANOVA to test for the hypothesized differences. If ANOVA rejects the null hypotheses of no significant differences, construct validation of the scale is implied. An additional dimension to the known-groups method is to perform parallel ANOVA on the results of other assessment methods.

Convergent validity evaluates how different measures of the same construct relate to one another. It is tested by evaluating the true product-moment correlations and the consistency of the different measurement scores. If the scale is positively and significantly correlated to another valid and reliable measurement, the result provides evidence that the scale has convergent validity (DeVellis, 1991). Consistency evaluation of the scores identifies the methods that exhibit consistent or inconsistent rankings (Ellinger, Splett, and Barry, 1992). The threshold level for valid score consistency across the methods is subjective. The researcher must determine consistency standards based on the study's objective while considering the empirical, theoretical and design issues.

Exploratory factor analysis can validate a proposed scale and determine if more than one latent variable is causing a set of items to vary. Factorial validation identifies hypothetical latent variables (factors) that can account mathematically for the patterns of covariation among the items. If the analytical results indicate that the items' variation is primarily due to one underlying construct, the scale is validated.[1]

Reliability testing evaluates how well the individual scale items reflect the common underlying construct. One measure used to evaluate reliability is Cronbach's coefficient alpha (DeVellis, 1991; Nunnally and Bernstein, 1994). Coefficient alpha measures the proportion of total variation due to true differences in a person's attitude towards the construct being measured. It is measured as:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_y^2}\right) \tag{1}$$

where α is Cronbach's coefficient alpha, k is the number of items in the scale, σ_i^2 is the variance of the ith item, and σ_y^2 is the variance of the k-item scale. The coefficient alpha ranges from 0 to 1, and the objective is to have alpha as high as possible. The assessment of a minimally acceptable coefficient alpha is subjective and varies based on the developer's objectives (DeVellis, 1991).

The final step in developing a scale is its refinement. If the known-groups analysis results in construct validation, the correlation and consistency evaluation indicates convergent validation, and the exploratory factor analysis does not reveal other factors significantly and systematically influencing the scores, the preliminary scale has achieved acceptable validation. Corrected item-scale correlation relates individual statements to the remaining items in the scale and is represented as:

$$r_{1(y-1)} = \frac{r_{y_1}\sigma_y - \sigma_1}{\sqrt{\sigma_1^2 + \sigma_y^2 + 2\sigma_1\sigma_y r_{y_1}}} \tag{2}$$

where r_{y_1} is the correlation of item x_1 with the total score y, σ_y is the standard deviation of the total score y, σ_1 is the standard deviation of item x_1, and $r_{1(y-1)}$ is the correlation of item x_1 with the sum of scores of all the items, y, exclusive of item x_1.

The more correlated is the individual statement's response to the remaining statements' responses, the more desirable is the item as part of the scale. The scale is optimized by eliminating items that have negative or low item-scale correlations. Deleting these items increases the coefficient alpha for the remaining statements or questions. Attaining as high a coefficient alpha as possible improves the statistical quality of the scale, and the optimal number of items in a scale is a function of the developer's objectives and the statistical performance of the items. The resulting product is a summated scale that reliably measures the defined underlying construct.

3. Developing a risk attitude scale for farmers

3.1. Construct definition and scale design

The methodology for developing an attitudinal scale is applied to assessing farmers' attitudes toward the risk in production agriculture. One's risk attitude is a unique reflection of a person's personality. It is influenced by socio-economic factors and life experiences. The risk attitude also influences how a farmer manages his business. Due to these interactions and how these interactions manifest their influences, "true risk attitudes" are not always apparent. Therefore, risk attitudes must usually be measured indirectly.

Theory suggests that risk attitudes influence the way farmers manage risk (Robison et al., 1984; Hardaker, Huirne and Anderson, 1997). Therefore, it is hypothesized that attitudes towards mechanisms or tools used for managing risk reflect the producer's underlying construct of a risk attitude.[2] For example, a farmer without adequate liability insurance must be willing to risk paying for injury and/or damages if found liable for an incident. Although an individual's level of agreement towards a risk management tool such as liability insurance explicitly expresses an attitude towards the tool, the response also suggests a tolerance level for risk. Drawing upon previous research (Patrick et al., 1985; Patrick and Ullerich, 1996; Patrick and Musser, 1995; Blank and McDonald, 1995), 25 statements addressing different methods for managing risk were formulated. Responses to the statements indicate the degree to which a farmer agrees or disagrees with the tool's utilization.

A Likert scale was selected as the measurement format, due to its appropriateness for assessing attitudes (Spector, 1992; DeVellis, 1991). Each scale item (statement or question) for a Likert scale measures something that has an underlying, quantitative measurement continuum, thus measuring the hypothesized relationship between the item and the underlying latent. The responses are then summed to form a total score. The Likert procedure does not concern itself with the location of individual items on the underlying attitude continuum; therefore, an interpretation of respondents' absolute scores in terms of that continuum is difficult to conduct (McIver and Carmines, 1981). Nonetheless, the respondents' scores can be grouped in broad descriptive categories and scaled for comparison to other respondents' scores.[3]

An item for a Likert scale is a declarative sentence with responses indicating varying degrees of agreement with, or endorsement of, the statement. The number of responses must be broad enough to co-vary, provide the respondent with the ability to discriminate meaningfully, and be odd numbered to permit a neutral attitude. In this study, the responses consisted of five levels of agreement ranging from strongly agree to strongly disagree.

In designing the statements, consideration was given to their total number and their wording. Numerous statements were initially written with the intent of eliminating those statements that do not reflect the underlying construct. The length and understandability of each statement were also considered. Some statements are very similar (i.e., medical and life insurance), but such redundancy allows summing across the items while their irrelevant idiosyncracies cancel out. To prevent response bias, some statements are worded so that strong agreement implies that the farmer will accept more risk than if he or she disagrees with the statement (i.e., "I never purchase multiple peril crop insurance."). Other statements utilized the opposite phrasing (i.e., "I always spread the sale of my commodities over the year.").

3.2. Validation items

Researchers have developed numerous ways to ascertain risk attitudes including self-assessment and empirical methodology based on economic theory. This study two utilized other methods to measure farmers' risk attitudes with the objective of determining the consistency between the scale, self-assessment and scientific elicitation methods. A higher degree of consistency would imply that the true degree of risk attitude is better represented, thus validating the scale approach.

The risk attitude scale, the self-assessment question, and the scientific method used in this study attempt to capture or measure the "true" construct. However, measurement error occurs with each method. One source of error for all three methods is random measurement error. The scale consists of statements about the management of three sources of agricultural production risk—financial, marketing, and production. Besides risk attitude, other factors that may influence responses to the statements could be management policies the farmer chooses to implement, marketing strategies driven by the industry, or production constraints. One's self-assessment score could also be influenced by what the person feels is socially desirable. The scientific method could be affected by the underlying theoretical foundation. Despite these potential sources of error, these methods for ascertaining farmers' risk attitudes will provide insight about the relative effectiveness of the scale approach.

The self-assessment question asked the participants to assess their attitudes toward accepting risk on a scale of 0 to 10, defined over highly risk averse to highly risk seeking attitudes. Considered a "single-item" scale, a self-assessment is frequently used as a proxy for risk aversion. The Kastens and Featherstone (1996), Patrick and Ullerich (1996), and Schurle and Tierney, Jr. (1990) studies are examples in agricultural economics. However, McIver and Carmines (1981) state that single-item measures are not merely less valid, less accurate, and less reliable than their multi-item equivalents, but they also provide a single measurement with insufficient measurement properties.

The technique used for scientifically eliciting risk attitudes was the "closing-in" method developed by Abdellaoui and Munier (1994). Based on expected utility theory (EUT), it systematically estimates a slope range within which each subject's indifference curve falls. Inferences can then be made about the person's attitude towards risk.

The "closing-in" method begins by presenting two lotteries from which the subject indicates a preference.[4] The lotteries have the same payoffs ($125,000; $135,000; $145,000), but with different probabilities. Lottery A has the probabilities (.20; .60; .20), and Lottery B has the probabilities (.40; .15; .45). The subject then indicates his or her preference between additional lotteries; for the subsequent questions, the payoffs and Lottery A's probabilities remain the same, but Lottery B's probabilities change, depending on whether the subject preferred Lottery A or B in the previous question. The series of questions "closes-in" on a range of the respondent's indifference curve, thus identifying a range for the risk attitude.

An Excel macro was developed to implement the "closing-in" method for this study. It presented a grain marketing situation where the farmers chose between two marketing plans representing the two lotteries. Depending on their degree of risk aversion or seeking behavior, the farmers responded to three to five iterations of the lottery until sufficient closure occurred.

3.3. Testing the preliminary scale

The three approaches for determining the farmers' risk attitude scores were based on responses to the Likert-based statements about their risk management practices, the self-assessment score, and the score resulting from the scientific elicitation method. These approaches required responses to written survey and computerized questions. Questions seeking demographic information about the respondents in order to control for their effects in the analysis were also included in the survey.[5] The data were collected by conducting personal interviews with the participants.

Eighty-six farmers cooperating in Illinois's Farm Business Farm Management (FBFM) program were interviewed for this study.[6] Table 1 summarizes the participating farmers' demographics. The average participant was in his mid-40s, and had four dependents includ-

Table 1
Summary of participating farmers' demographics

Category	
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 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 percent 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%

ing himself, some college education, around 1,100 acres to farm, and a net worth ranging from \$250,000 to \$500,000. About 83% of the farmers were cash grain producers.

3.4. Risk attitude scale

Table 2 presents statistics for the risk management statements. As previously mentioned, the statements were worded such that they did not always imply the same direction of agreement. Some of the statements presented in Table 2 are altered from the original survey so their responses imply the same direction of agreement with the underlying construct. These altered statements are indicated in the table. The statements are negatively worded, and the response choices range from strongly disagree to strongly agree with a numeric scale of 1 to 5, respectively. The higher the individual statement score, the less likely the farmer agreed with the implementation of, or utilized, the tool. Analysis of the correlation coefficients between the statements indicated 42 coefficients (15% of the 289) were statistically significant to another statement at the 5% level. The statements that had more than two significant coefficients were Statements 1, 3, 9, 10, 16, 18, 19, and 21.

The statements with the highest level of agreement addressed the following risk management tools: forward contracting, liability insurance, a credit line, health insurance, and life insurance. These statements' average scores were between 1.60 and 1.84 which correlates to disagree to strongly disagree on the scale for the negatively worded statements. This group of farmers either utilized or agreed with the importance of using these risk management methods.

The responding farmers disagreed most strongly with the use of enterprise diversification, hedging and/or option utilization, off-farm investments, timely purchase of farm machinery and other capital items, and off-farm income. Scores for these statements range from 3.11 to 3.91. A score of 3 implies that the respondents neither agree nor disagree with the statement, and a score of 4 indicates that the respondents agree with statement; therefore, this group of

Table 2
Summary of risk management statements for Risk Attitude Scale

Statement	Average	Median	Mode	SD	Maximum	Minimum
1. I never purchase multiple crop insurance.	2.94[a]	3	1	1.62	5	1
2. I am always one of the first producers in my area to adopt new technology.	3.01	3	3	0.80	5	1
3. I never have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	2.09	2	2	1.14	5	1
4. The crops and/or livestock I produce are concentrated in one or two enterprises (e.g., corn and soybeans.	3.91	4	5	1.26	5	1
5. I never keep a line of credit open at my primary lender. (**Reversed**)	1.67	1	1	0.95	5	1
6. I never hire custom work to be done.	2.60	2	2	1.20	5	1
7. I never hedge by using futures and/or options in marketing my crops or livestock. (**Reversed**)	3.56	4	4	0.98	5	1
8. I do not have adequate life insurance.	1.84	2	1	0.94	4	1
9. I never spread the sale of my commodities over the year. (**Reversed**)	2.12	2	2	0.87	4	1
10. I do not rely heavily on market information (for example government reports, private market news services) in making my marketing decisions. (**Reversed**)	2.33	2	2	0.88	5	1
11. Off-farm income is not important for the financial survival of my family.	3.11	3	5	1.49	5	1
12. My farming operation does not have adequate liability insurance. (**Reversed**)	1.62	2	2	0.54	3	1
13. I never use forward contracting for commodities I produce.	1.60	1	1	0.79	5	1
14. Off-farm investments are not important sources of income for me and my family. (**Reversed**)	3.53	4	4	1.13	5	1
15. I do not have adequate health insurance.	1.77	2	1	0.84	5	1
16. Maintaining a low debt-to-asset ratio is not important to me.	2.10	2	2	0.86	4	1
17. Most of my machinery is not new or in good repair. (**Reversed**)	1.88	2	2	0.75	4	1
18. The geographic concentration of my farming operation substantially increases my total yield risk.	3.00	3	2	1.06	5	1
19. In case of emergency, I do not have sufficient back-up management/labor to carry on production. (**Reversed**)	2.46	2	2	1.00	4	1
20. I use very specialized machinery for my production practices.	2.73	3	2	0.99	5	1
21. I do not have adequate hail/fire insurance. (**Reversed**)	1.88	2	2	0.94	5	1

Table 2 *(Continued)*

Table 2 *(continued)*

Statement	Average	Median	Mode	SD	Maximum	Minimum
22. I always postpone needed purchases of farm machinery and other capital items. (**Reversed**)	3.36	3	4	0.95	5	1
23. I never forward price agricultural inputs or contract with other producers for inputs. (**Reversed**)	2.38	2	2	0.78	4	1
24. The changes caused by the 1996 farm bill (FAIR Act) have substantially increased the risks of my farming operation.	3.07	3	3	1.05	5	1
25. I do not consider myself to be a low-cost producer. (**Reversed**)	2.40	2	2	0.80	4	1

[a]The range of responses was from strongly disagree (1) to neither disagree nor agree (3) to strongly agree (5).

farmers, on average, did not strongly agree with the implementation of these risk management tools.

3.5. Other elicitation methods

Table 3 contains summary statistics on the three elicitation methods across the sample and by demographic groups. The self-assessment and scientific elicitation statements have an available range of responses of 0 to 10, whereas the risk attitude scale is scored from 0 to 100. Five and 50 are the midpoints for the assessment categories, and larger scores for each assessment imply lower degrees of risk aversion. The range for all three methods for measuring risk aversion spans from highly risk averse (score of 0) through risk neutral (5 or 50) to highly risk seeking (score of 10 or 100).

The sample average for the self-assessment statement was 5.3 with high and low scores of 8 and 2, respectively. This result shows that, on average, the farmers assessed themselves as willing to accept a little more risk than a risk neutral person. The sample average score for the risk attitude scale was 38; these responses lie in the risk averse range of the scale.[7] The average score for the scientific elicitation method was 3.9, indicating that the sample farmers behave in a moderately risk averse manner (a score of 5 implies risk neutrality).

3.6. Construct validity testing

Construct validation using the known-groups method employs ANOVA to test hypotheses regarding differences of risk attitudes between demographic groups. ANOVA was conducted for each of the demographic classifications (e.g., age, farm size) and each of the elicitation methods. The results indicated that while scores differ significantly between some categories (e.g., the younger age group had a significantly lower risk attitude scale score than did the older farmers), no clear patterns of significant differences emerge for any of the elicitation

Table 3.
Summary of all responding farmers

Demographic Categories	Number of Farmers	Self-assessment Question			Risk Attitude Scale			Scientific Elicitation		
		Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest
All respondents	86	2	5.3	8	21	38.1	54	0	3.9	10
Age Category:										
Less than 40 years	21	3	5.6	8	21	35.0	47	2	4.1	7
40 years or more	65	2	5.2	8	21	39.2	54	0	3.9	10
Number of years farming:										
Less than 15 years	21	3	5.7	8	21	35.95	47	1	4.3	7
More than 15 years	65	2	5.1	8	21	38.8	54	0	3.8	10
Number of dependents:										
1 or 2 dependents	18	3	5.6	8	31	41.8	54	0	4.0	10
More than 2 dependents	68	2	5.2	8	21	37.2	53	1	3.9	10
Number of years education:										
12 years or less	22	3	5.4	8	21	39.7	48	0	4.4	10
More than 12 years	64	2	5.3	8	21	37.6	54	0	3.8	10
Gross farm income:										
$500,000 or more	12	2	5.4	7	27	38.0	49	2	4.5	7
$200,000 to $499,999	42	3	5.2	8	21	37.4	54	0	3.7	10
$100,000 to $199,999	25	2	5.2	8	27	39.4	53	0	3.8	10
Below $100,000	7	4	5.8	8	22	38.2	48	2	4.5	7
Farm type:										
Field crops	71	2	5.2	8	21	38.5	53	0	4.1	10
Livestock	13	3	5.6	8	29	36.2	54	0	3.0	5
Other	2	7	7.0	7	27	37.5	48	5	5.5	6
Farm size:										
Less than 500 acres	12	3	5.3	8	22	40.0	54	0	3.4	7
501 to 750 acres	14	3	5.2	8	22	37.1	53	2	3.1	6
751 to 1000 acres	19	2	5.3	8	27	38.7	48	0	4.2	10
1001 to 1500 acres	24	4	5.6	8	21	37.7	48	1	4.4	10
More than 1500 acres	17	2	4.8	7	27	37.7	49	2	4.1	7
Off-farm income										
Farms with <25%	59	2	5.1	8	21	38.6	54	0	4.0	10
Farms with >25%	27	2	5.7	8	22	37.0	49	0	3.8	10
Net Worth:										
Under $250,000	10	4	5.4	8	31	39.4	49	0	3.0	5
$250,001 to $500,000	23	2	5.6	8	22	37.3	45	2	4.1	7
$500,001 to $750,000	22	3	5.1	8	21	38.5	54	0	3.4	7
$750,001 to $1,000,000	12	3	4.6	7	29	38.4	47	1	5.1	10
More than $1,000,000	19	2	5.4	8	22	37.8	48	0	4.1	7
Debt-to-asset ratio										
Under 15	20	2	4.4	7	21	38.2	54	0	4.1	10
.15 to .3	25	3	5.6	8	27	39.2	49	2	4.2	7
.3 to .5	30	3	5.2	8	21	37.4	53	1	4.1	10
Over .5	11	4	6.3	8	22	37.5	45	0	2.8	7

methods.[8] These results are similar to other studies' findings. King and Oamek (1983), Bond and Wonder (1980), and Tauer (1986) found no systematic relationship between farmer characteristics and risk attitudes, even with sample sizes of up to 217. This lack of empirical

Table 4
Ranking consistency between scores

Categorization Method	S1 = S2 = S3	S1 = S2	S2 = S3	S1 = S3
Quartile	12.3%	11.1%	27.2%	14.8%
<5; 5; >5	25.9%	7.4%	37.0%	16.0%

S1 - Self-assessment score; S2 - Risk attitude scale score; S3 - Scientific elicitation score.

relationships found between socio-economic factors and risk attitudes implies that the relationships are very complex and often difficult to quantify. The consistency between this study's results with previous work validates the complexity of the relationships.

3.7. Convergent validity

The first measure used to evaluate convergent validity is the correlations between the three scores. Although all three correlations for the scores are positive, the correlation between the risk management statements and the scientific elicitation method (0.317) is the only significant statistic at the 99% level. The low correlations between the farmers' self-assessment score and the risk management (0.027) and the scientific elicitation scores (0.175) imply that farmers' perceptions of themselves are not highly consistent with their responses about the risk management tools or scientifically based risk attitudes. This result provides additional evidence that a single-item self-evaluation score may not be an accurate measure of risk attitudes. However, the significant correlation between the risk management statements and the scientific elicitation method, which directly measures risk attitudes, provides some evidence that the scale is indirectly measuring the underlying construct.

Convergent validity also assesses consistency between the techniques by comparing each method's ranking of the 81 farmers. An equivalent ranking of the farmers by the methods would be another indicator of convergent validity. To test for consistency, the scores are categorized in two ways: 1) the first way places the score into one of the four quartiles of the scores' distributions, and 2) the second way defines three categories for each score: a) scores less than 5, b) scores of 5, and c) scores greater than 5. Table 4 reports the percentage of scores that ranked in similar categories for the classifications.

Twelve percent of the respondents score in the same category for all three methods when their scores are categorized by quartiles. When the scores are ranked by the second way, 25.9% of the respondents fall into the same classification, and the attitudinal scale and scientific elicitation scores fall into the same category 63% of the time (see Table 4: 25.9% plus 37%). A higher percentage of participants is consistently classified via the attitudinal scale and the scientific elicitation method than the self-assessment statement with the other two scores.

Significant and positive correlations and consistency between the different assessment methods indicate convergent validation. The three assessment methods were positively correlated. However, the low correlation between the self-assessment and attitudinal scale scores was not surprising due to the statistical properties of the self-assessment score and the cited problems inherent with self-evaluation. Although a higher correlation score is always desired, the significant and positive correlation and the consistent ranking about two-thirds of the time between the attitudinal scale and scientific elicitation scores imply an acceptable degree of convergent validity. Nunnally and Berstein (1994) state that research has shown that validation is difficult, and that there is no way to validate an instrument purely by mathematical proof.

3.8. Factor analysis

The key objective of exploratory factor analysis is to determine if more than one factor (or construct) best represents the items. Sources of risk in agriculture are frequently categorized into production, marketing and financial elements, and farmers may have varying degrees of tolerance towards risk in each of these categories. In addition, other issues could contribute to the variation seen in the responses to statements about risk management tools. Exploratory factor analysis could ascertain if these other issues contributed to the variation in a random or systematic manner.

The factor analysis results indicated 10 factors with eigenvalues greater than one, with the ten factor solution explaining 69.01% of the variance. However, evaluation of the factor loadings did not reveal any clear influence of more than one underlying construct. For example, the statements with the highest factor loadings for the first factor were statements 19 (back-up labor), 12 (liability insurance), 9 (spread commodity sales), and 21 (hail/fire insurance). These statements addressed all three sources of risk. The second through fifth and the eighth factors had a similar mixture of production, finance, and marketing response statements. The sixth, seventh, and tenth factors had two and one high factor loadings, respectively, pertaining to financial responses to risk. The ninth factor had two high factor loadings addressing marketing responses.

The large number of factors retained, instead of two or three retained factors, and the absence of clear definition for the factors imply that only one latent variable contributes to the total variation. When comparing the statements selected for a refined thirteen statement scale to the individual statements contributing the highest factor loadings, eleven of the selected statements appear in the first five factors. This further validates the statements selected for the refined scales.

3.9. Reliability testing and scale refinement

The 25 statements about managing risk were drafted with the objective of reducing the number of statements. The resulting product was to be a refined scale containing the optimal amount of information about risk attitudes. Reliability analysis indicates which statements contribute to the explanation of unique risk attitudes and how removing the statements from the scale affect the overall reflection of risk attitudes.

Table 5 presents each statement's corrected item-scale correlation, the coefficient alpha calculated with that particular statement excluded from the scale of the remaining 24 statements, and the overall coefficient alpha for all 25 statements. The overall coefficient alpha of 0.486 indicates that the 25 statements account for 49% of the total variation.

Table 5
Reliability tests

Statement	Corrected Item-scale Correlation	Coefficient Alpha
1. Multiple crop insurance	0.270	0.442
2. Adopt new technology	−0.189	0.518
3. Adequate cash	0.288	0.446
4. Enterprise concentration	0.179	0.467
5. Line of credit	0.147	0.474
6. Hire custom work	0.305	0.441
7. Hedging	−0.254	0.535
8. Adequate life insurance	0.091	0.483
9. Spread commodity sales	0.365	0.442
10. Use market information	0.168	0.471
11. Off-farm income	−0.018	0.515
12. Adequate liability insurance	0.224	0.471
13. Forward contracting	0.228	0.464
14. Off-farm investments	0.132	0.476
15. Adequate health insurance	0.345	0.446
16. Low debt-to-asset ratio	0.004	0.494
17. New or well-maintained machinery	0.153	0.474
18. Geographic concentration	0.300	0.446
19. Emergency back-up labor	0.246	0.458
20. Specialized machinery	−0.073	0.509
21. Adequate life/fire insurance	0.377	0.437
22. Postpone purchasing decisions	0.164	0.471
23. Forward price inputs	0.133	0.477
24. FAIR Act changes	−0.078	0.512
25. Low-cost producer	−0.065	0.502
Coefficient Alpha for entire 25 statements		0.486

According to DeVellis (1991), this level is too low, thus prompting refinement of the scale to improve its reliability. DeVellis explains that the groupings of coefficient alpha are personal and subjective, and a statistical standard for hypotheses testing has not been found. However, based on DeVellis's experience and other investigators' appraisals, the minimally acceptable range for an aggregate coefficient alpha is between 0.65 and 0.70. The established procedure to improve the reliability of a scale (i.e., raising the aggregate coefficient alpha) is to eliminate items from the scale if the coefficient alpha is higher than 0.486 when excluded from the scale (DeVellis, 1991). For example, deleting Statement 7 about hedging would increase the aggregate coefficient alpha for the remaining 24 statements to 0.515. Based on the alphas reported in Table 5, removal of at least Statements 2, 7, 11, 16, 20, 24, and 25 would increase the coefficient alpha, therefore, increasing the scale's reliability.

With this information, the scale was optimized by eliminating statements that had negative or low item-scale correlations. Table 6 presents a list of statements from the original 25 that provide the highest attainable alpha. Four separate lists of scale statements are provided as examples of a farmer risk attitudinal scale. Based on statistical criteria, the twelve statement scale offers the best explanation of the variance with an aggregate coefficient alpha of 0.686. The 0.686 coefficient alpha falls into the minimally acceptable range (DeVellis, 1991) and indicates that the communal variation of 69% is caused by risk attitudes, the underlying

Table 6
Suggested statements for risk attitude scale

Statement	13-Item Scale		12-Item Scale		10-Item Scale		5-Item Scale	
	Item-scale Correlation	Alpha	Item-scale Correlation	Alpha	Item-scale Correlation	Alpha	Item-scale Correlation	Alpha
1. Multiple Crop Insurance	0.254	0.686	—	—	—	—	—	—
3. Adequate cash	0.429	0.640	0.392	0.654	0.383	0.644	0.314	0.560
6. Hire custom work	0.274	0.668	0.251	0.683	0.184	0.692	—	—
9. Spread commodity sales	0.440	0.644	0.512	0.638	0.553	0.613	0.593	0.454
10. Use market information	0.337	0.657	0.335	0.664	0.354	0.650	0.317	0.586
12. Adequate liability insurance	0.273	0.669	0.337	0.670	0.318	0.661	—	—
13. Forward contracting	0.230	0.671	0.227	0.679	—	—	—	—
15. Adequate health insurance	0.232	0.671	0.201	0.683	—	—	—	—
17. New/maintained machinery	0.291	0.664	0.317	0.668	0.327	0.656	—	—
18. Geographic concentration	0.356	0.653	0.332	0.665	0.328	0.655	—	—
19. Emergency back-up labor	0.315	0.660	0.348	0.662	0.374	0.645	0.322	0.586
21. Hail/fire insurance	0.450	0.641	0.434	0.648	0.387	0.643	0.349	0.572
23. Forward price inputs	0.225	0.672	0.239	0.678	0.275	0.664	—	—
Aggregate coefficient alpha		0.679		0.686		0.676		0.616

latent variable. The proposed twelve statement scale includes financial, production and marketing responses to risk.

4. Conclusion

This study adapts a methodology formulated in the social sciences to develop a mechanism for measuring an economic agent's attitude toward risk. The resulting tool is a scale that can be administered to people without the need for personal interviews. The subjects for this study were Midwestern farmers, but the methodology can be applied to any sector of the agricultural industry.

The study's methodology consisted of developing a preliminary scale of 25 statements about risk management tools, administering the scale and two comparative methods for measuring risk attitudes to farmers, analyzing the responses, and refining the scale. The outcome was recommendations for refined risk attitude scales. The implications of the resulting scales are limited due to the small size and homogenous nature of the sample. In addition, the statistical results of the validation and reliability analyses and scale refinement are somewhat limiting. However, Nunnally and Bernstein (1994) explain that scale development is not an all-or-none property but an unending process. This study does not propose a final product in itself, but presents an application of a methodology for developing an useful tool to agriculturally-related industries. Most psychological measures need periodic re-evaluation to determine whether new evidence suggests modifications of the existing measure.

A risk attitude scale has broad applicability. Researchers frequently investigate how risk attitudes influence economic decisions. Because a measure of risk aversion is necessary for the analysis, the scale is an easily attained proxy of risk attitudes. Extension educators are interested in helping industry participants understand the consequences of risk, and knowing one's attitude toward risk is a necessary part of the educational process. Agribusiness firms, financial institutions and policy makers benefit from knowing, even in a relative manner, the extent to which their customers and constituents are averse to risk when evaluating the demand for or specifying a product or policy instrument that addresses risk. For example, knowing the extent to which producers are risk averse helps determine the demand for and the specification of crop insurance policies. A risk attitude scale could also be used to segment the market for, or to price, risk management services (i.e., for commodity marketing firms) or to conduct market research for new products or services (e.g., adoption of variable rate technology or financial services).

This study has operationalized a methodology for developing a risk attitude scale. This methodology creates a new analytical tool in agribusiness analysis and will provide opportunities for further scale development and refinement, and application to research, education, and industry and policy analysis.

Notes

1. See DeVellis (1991) and Nunnally and Bernstein (1994) for details on exploratory factor analysis.
2. The farmers' responses also could represent their extent of information, understanding, or biases about the respective methods of managing risk. These possibilities are minimized in this study by selecting commercial-scale, experienced farmers who were familiar with an extensive set of risk responses and by clear instructions about the risk management focus of the interviews. Other validation elements are addressed in the following discussion.
3. A Likert scale is a probabilistic scaling model permitting random measurement errors. All the systematic variation in responses is attributed to differences among the respondents. Assumptions for the Likert scale are: 1) each statement or item is monotonically related to the underlying attitude continuum; 2) the sum of the items' trace lines is monotonic (plus approximately linear) with respect to the attitude being measured; and 3) the items as a group measure only the attribute under observation. All items to be linearly combined should be related to a common construct variable or factor.

   Assumption 3 may be violated in the case of risk analysis. However, Nunnally and Bernstein (1994) state that the model is fairly robust with respect to the assumption, implying that it is not highly sensitive to violations of this assumption. Even a few items with slight nonmonotonicities will not seriously affect the adequacy with which the attribute is measured. Therefore, the potential violation of this assumption does not jeopardize the reliability of the results.
4. A detailed description of the "closing-in" method implemented in this study is in Bard and Barry (forthcoming).
5. A copy of the survey is available from the authors upon request.

6. Limited resources prevented a larger and more demographically diverse farmer group from being attained. The relatively homogenous sample decreases sources of other variation that could have been present in a more heterogenous group. The focus of this study was not to draw inferences about an underlying population, but to test a methodology for developing a new risk attitude assessment tool. Therefore, no attempt was made to draw a representative sample from a population.
7. The total score for the risk management tools is the sum of the scores for the individual statements. A higher score indicates that the farmer does not agree on average with the implementation of the tools. Therefore, the lower the score, the more they disagree with "no use of the tool" or to reverse the logic, the more they agree with the utilization the tool. A lower score implies the farmer is more risk averse. This is because the producer is more likely to agree, on average, with the importance of implementing the risk management tools to decrease his or her overall exposure to risk. Prior research (Robison et al., 1982; Hardaker, Huirne and Anderson, 1997) has indicated a positive relationship between risk aversion and implementation of risk management tools. The greater the risk aversion, the more aggressive the producer is in managing or minimizing his or her exposure to risk.
8. See Bard and Barry (Nov. 1998) for details of the ANOVA results.

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