Measuring Producers' Risk Preferences: A Global Risk-Attitude Construct

Joost M.E. Pennings and Philip Garcia

In applied agricultural economic research various risk-attitude elicitation techniques are used. Here, we investigate whether risk-attitude measures rooted in the expected utility framework are related to measures rooted in the multi-item scale framework. Using a second-order factor analytical model, and data obtained from personal computer-guided interviews with 373 farmers, we investigate whether the common variance among the (latent) risk-attitude measures can be accounted for by a global risk-attitude construct. We find that the different risk-attitude measures are related, and that the global risk-attitude construct is significantly related to farmers' intention to use futures contracts. Our research suggests that farmers' risk attitude is a higher-order characteristic that cannot be effectively extracted by a single measure.

Key words: expected utility, futures usage, global risk-attitude construct, multi-item scale, second-order factor analysis, validity.

In empirical studies dealing with risk, risk attitudes and producers' market behavior various risk-attitude measures are used. Two major approaches to quantify directly farmers' risk attitudes can be distinguished: measures derived from the expected utility framework, and measures derived from responses to multi-item scales (e.g., Antle; Chavas and Holt; Goodwin and Schroeder; Saha, Shumway, and Talpaz; Smidts).

The purpose of this research is to test whether risk-attitude measures rooted in the expected utility framework are related to the risk-attitude scales rooted in the multi-item scale approach and, if so, whether these risk-attitude measures share a common variance that can be attributed to a higher-order factor, a "global risk-attitude construct" (GRAC). Here, we assess the validity and the relationship among these different risk-attitude measures using recent developments in statistics and psychometrics. These procedures, higher-order factor analytical models, allow us to assess whether the different risk-attitude measures are components of a GRAC, that is, whether the correlations among the different types of risk-attitude measures can be accounted for by a GRAC. We hypothesize that the GRAC is related to actual farmers' behavior, a property that does not always holds for single risk-attitude measures.

In this article we use four methods to directly elicit farmers' risk preferences (Roe).[1] Two risk-attitude measures are derived from the expected utility framework and two measures are derived from responses to a multi-item scale. Within the expected utility framework we use the certainty equivalence technique for assessing the utility function. Using both the negative exponential and power functions, we measure the curvature of the utility function as a measure of risk attitude (Arrow; Pratt). Several studies have shown that there is a theoretical

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[1] We focus on directly elicited risk-attitude measures as opposed to risk-attitude measures that are quantified indirectly from observed behavior (Moscardi and de Janvry).

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and empirical difference between the utility function $u(x)$ and the strength of preference function $v(x)$ (e.g., Dyer and Sarin; Ellsberg; Smidts). It is argued that utility function $u(x)$ measures must be adjusted by the strength of preference $v(x)$ in order to obtain a more accurate measure of risk attitude, the intrinsic risk attitude. We include both the risk attitude obtained by $u(x)$ and the intrinsic risk attitude obtained by relating $u(x)$ to $v(x)$. Within the scaling approach we develop two risk-attitude scales based on farmers' responses to statements dealing with risk.[2]

We test the different risk-attitude measures for convergent and nomological validity using statistical tools recently developed in statistics and psychometrics.[3] The convergent validity of the four measures is tested using a first-order factor analytical model. This technique allows us to assess the extent to which the different measurements reflect the same risk-attitude construct (i.e., are positively correlated) (Churchill).[4] We then introduce a second-order factor analytical model to investigate whether the risk-attitude measures are components of a GRAC.

We find that the different risk-attitude measures used by researchers can be accounted for by a GRAC. Furthermore, we find that the GRAC is a better predictor of farmer's behavior than the single measures. Our research suggests that farmers' risk attitudes are a higher-order characteristic that cannot be effectively extracted by a single measure.[5]

Risk-Attitude Measures

Expected Utility Framework

The expected utility model has been used extensively to investigate behavior under risk. Von Neumann and Morgenstern are the major contributors to a large body of work that provides the justification for the use of the expected utility model by a rational decision maker. The expected utility model views decision making under risk as a choice between alternatives. Decision makers are assumed to have a preference ordering defined over the probability distributions for which a number of axiom's hold (Fishburn). Risky alternatives can be evaluated under these assumptions using the expected utility preference function, $u(x)$. The curvature of the utility function is a measure of risk attitude. Pratt and Arrow defined measures that are independent of a linear transformation of x. In this article we measure the utility function by means of the certainty equivalence method.

Ellsberg introduced the concept of intrinsic risk attitude to separate marginal value from attitudes toward uncertainty, two factors that are confounded when eliciting risk attitudes in the expected utility framework. Several researchers, among others Dyer and Sarin, Krzysztofowicz, Keller, and Smidts, have elaborated on this concept. They contend that the assessment of a person's risk attitude must be done indirectly. That is, it is derived from the assessment of a utility function $u(x)$ and a riskless strength of preference function $v(x)$. They argue that only after removing the nonlinearity in the utility function that is the result of the nonlinear strength of preference for increased outcomes can a person's preference for risk be identified. The intrinsic risk-attitude concept can be translated into terms of the certainty equivalence technique. The valuation of a lottery is the result of a two-phase process. First, the outcome in a lottery is transformed into subjective values under certainty by the strength of preference function $v(x)$ (the strength of preference function describes the intensity of preference a decision maker has for an outcome). Then, the subjective values are taken as the consequences in the lottery which are evaluated under risk, resulting in the utility function $u(x)$. Hence, differences between the utility function and the strength of preference function are attributed to the influence of risk on preferences. Empirical evidence supports the distinction between utility and strength of preference. Smidts found strong evidence for the hypothesis that risk attitude and strength of preference are two distinctive constructs, in a real economic

[2] Our purpose is not to determine whether risk-attitude measures rooted in the expected utility model are better than the risk-attitude scales (e.g., Pennings and Smidts). Instead, we investigate whether a combined measure is more useful than its components in explaining behavior.

[3] Convergent validity identifies whether different measurements reflect the same construct (i.e., are positively correlated). Nomological validity examines whether measures are related to other constructs in a theoretically meaningful way (Churchill).

[4] A construct is a theoretical notion that can be defined conceptually but cannot be directly measured or measured without error.

[5] In spirit, our research follows Robison's call for further research on risk-attitude measurement. Robison suggests the use of a function rather than single parameterizations of risk attitudes. We use a GRAC that is a function of different risk-attitude measurements.

setting with a large sample size and a longitudinal design. Keller, and Weber and Milliman, also identified empirically a nonlinear relationship between value and utility functions.

Multi-item Scale Approach

In the psychometric approach, risk attitude is a latent construct (i.e., a not directly observable variable) that is measured by a set of observable variables (so-called indicators, i.e., questions or items). Guttman, Likert, and Thurstone and Chave proposed different multi-item scaling procedures (see, e.g., Nunnally and Berstein). Because the Likert procedure has performed well with respect to reliability and validity, it is most commonly used. In the agricultural economics and management literature, several risk-attitude measures based on responses to scales have been developed and used successfully. Goodwin and Schroeder measured farmer's risk attitudes with a binary variable reflecting whether a producer has a preference for business risk or not. Kunreuther and Ginsberg, MacCrimmon and Wehrung, and Shapira used several multi-item risk-attitude scales and related them to managers' attitudes and behavior.

Research Method: Measurement of Producers' Risk Attitudes

The Risk Context

MacCrimmon, Wehrung and Shapira have demonstrated that risk attitude is context specific. In this article we examine price risk faced by Dutch hog farmers.[6] The Dutch hog industry, one of the most important industries in the Dutch agricultural sector, is faced with substantial revenue risk. Because of the confinement production process prevalent in the industry, the main source of risk is price risk. Consequently, we measure risk in the price domain, using hog price fluctuations to generate risk attitudes.

Information on the producers' risk attitudes was obtained by interviews with 373 Dutch hog farmers in 1997. A personal interview was computerized, taking care to build a user-friendly interface. The software written for this interview was tested extensively, and fifteen test interviews were conducted to ensure that the interface was understood by the farmers and was perceived as "very user-friendly." The interviewers were thoroughly trained and were very knowledgeable about the elicitation procedure. Since the elicitation procedure was fully computerized the interviewer was only there to answer questions in case of a misunderstanding. Nine points of the utility curve were assessed, corresponding to utilities of 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875 (plus two consistency measurements on utilities 0.500 and 0.625). No time constraint was imposed on the elicitation process which lasted about thirty-five minutes.

The interview consisted of several parts. After background questions (e.g., size of enterprise, previous price-risk management behavior), the farmers participated in two experiments which measured risk attitude by means of the certainty equivalence technique, and strength of preference by means of a rating technique. This was followed by questions (items) to measure farmers' risk attitude with the Likert scaling procedure.

The Certainty Equivalence Method

In the certainty equivalence method the researcher asks the farmer to compare the lottery $(x_l, p; x_h)$ with a certain outcome, where $(x_l, p; x_h)$ is the two-outcome lottery that assigns probability p to outcome x_l and probability $1-p$ to outcome x_h, with $x_l < x_h$. The researcher then varies the certain outcome until the respondent reveals indifference between the certain outcome denoted by $\mathrm{CE}(p)$. Substituting in the expected utility model with the von Neumann–Morgenstern utility u we obtain $u(\mathrm{CE}(p)) = pu(x_l) + (1 - p)u(x_h)$ (Keeney and Raiffa).

Several authors have provided conditions to minimize response biases when eliciting a decision maker's utility function. In the agricultural economics literature Binswanger, Robison, and Robison et al. offer useful guidelines. In the management literature Hershey, Kunreuther, and Schoemaker, and Tversky, Sattath, and Slovic provide useful guidelines and conditions as well. Robison et al. argue that biases in the elicitation procedure may come from different interviewers, negative preferences toward gambling, absence of realism in the game setting, and compounding of errors in the elicitation process. Robison stresses the importance of construction of the choice sets in order to

[6] This implies that farmers might show different risk preferences when asked about the risk regarding chemical use in production than when asked about price risks faced in selling hogs.

obtain the decision maker's utility function. Hershey, Kunreuther, and Schoemaker, and Tversky, Sattath, and Slovic provide similar conditions and guidelines. They argue that the response bias is minimized if the following two conditions are met: (1) decision makers have well-articulated preferences and beliefs, and (2) decision makers use a consistent algorithm. We designed the elicitation procedure in accordance with these guidelines.

The certainty equivalence technique was designed to resemble the hog producer's decision whether or not to fix their price in advance. We constructed choice sets that closely matched the farmer's daily decision-making process, and hence our choice set reflects the actual choice set facing a farmer (Robison). An important research design issue involves the dimensions of the choice set. Specifically, what probability and outcome levels should one use in eliciting risk preferences? The outcome levels were chosen so that all hog price levels that had occurred in the last five years were within the upper and lower outcome levels. Since it has been argued in the financial literature that commodity prices follow a random (walk) path, we decided to choose a probability of 0.5, expressing a random walk (prices can go up or down with equal probability).

Farmers were instructed to "read carefully," and "to put themselves in the situation of selling their hogs."[7] They were given a choice between three alternatives. Alternative A consisted of a 50/50 lottery (reflecting a spot transaction) where the initial upper and lower bounds were set by the researchers. Alternative B consisted of a fixed price where the initial fixed price was randomly generated by the computer within the initial upper and lower bounds. Alternative C consisted of the statement that they were indifferent between alternative A or B. The outcomes in the lotteries were denoted in Dutch Guilders per kilogram live weight of hogs. The first lottery presented to the farmers was a 50/50 lottery with outcomes of 2.34 and 4.29 Dutch Guilders as the minimum and maximum price of hogs. The assessment of the certainty equivalent was an iterative process. If the farmer chose alternative A, the computer would generate a higher fixed price (alternative B) than the previous one, hence making alternative B more attractive. If the farmer chose alternative B, the computer would generate a lower fixed price (alternative B) than the previous one, hence making alternative A more attractive. At some point, the farmer would become indifferent between A or B and would choose alternative C. The next measurement (the next lottery) started after the farmer had chosen C.

Our choice set was perceived as realistic by the farmers, and straightforward. The decision situation was very transparent and unambiguous. They had clear preferences in choosing between options A [receiving a relative high price or low price (the "lottery"), reflecting sales in the spot market] and B (the fixed price, reflecting a fixed price contract).

After obtaining the certainty equivalents, a utility function is fit to the observations for each farmer to determine their risk attitude. In the expected utility framework the functional form of the utility function $u(x)$ is left open. Tsiang refers to Arrow who provides four conditions for an acceptable utility function: (1) marginal utility of wealth is positive, (2) marginal utility of wealth decreases with increasing wealth, (3) marginal absolute risk aversion is constant or decreasing with increasing wealth, and (4) marginal proportional risk aversion is constant or increasing with increasing wealth. The negative exponential, power, and logarithm functions meet all four conditions. Keeney and Raiffa, and Fishburn and Kochenberger have demonstrated that the negative exponential and power functions perform well relative to the logarithm function. Moreover, both functions are easy to work with. After scaling the boundaries of the functions, the estimation of only one parameter suffices to characterize a farmer's risk attitude. We applied both the power and negative exponential function to specify the utility function $u(x)$. The negative exponential function can be expressed as

$$(1)\quad u(x_i) = \frac{1 - e^{-c(x_i - x_L)}}{1 - e^{-c(x_H - x_L)}}$$

where x_L and x_H denote the lower and upper bound of the outcome range of the 50/50 lottery, respectively, x_i stands for the assessed certainty equivalent, and the parameter c is the risk-attitude coefficient. The negative exponential function implies a constant absolute risk attitude and an increasing proportional risk attitude. The power function can be expressed as

$$(2)\quad u(x_i) = \frac{(x_i - x_L)^a}{(x_H - x_L)^a}$$

[7] The validity of scenarios and role-playing is well documented (Bem) and is particularly successful when individuals are asked to "play themselves" rather than unfamiliar roles.

where the parameter a measures risk attitude. The power function implies a decreasing absolute risk attitude and a constant proportional risk attitude.

Because the certainty equivalents are measured with error and not the utility levels, the inverse functions are estimated. The inverse exponential function can be expressed as

$$(3) \qquad x_i = \frac{\ln(0.5(e^{-cx_l} + e^{-cx_h}))}{-c} + e_i$$

where x_l and x_h represent the low and high outcomes of the 50/50 lottery, respectively. The inverse power function can be expressed as

$$(4) \qquad x_i = (x_H - x_L)\left(0.5\left(\left(\frac{x_l - x_L}{x_H - x_L}\right)^a + \left(\frac{x_h - x_L}{x_H - x_L}\right)^a\right)^{1/a}\right) + x_L + e_i.$$

The Rating Technique

The strength of preference function $v(x)$ was assessed by means of a rating technique. The producers were asked to value nine price levels on a scale from 1 to 10 to reflect the attractiveness of the price to their operations (with 10 being the most attractive). Producers were also permitted to specify their value in terms of fractions 0.25, 0.50, and 0.75. Before the producer started this task, the price range from which the price levels were drawn and were shown. The price levels were drawn over the same range as the lotteries. This task also was straightforward for our farmers because the rating scheme resembled the grading system used in Dutch schools and was consistent with how our farmers refer to prices. Frequently, they speak of "excellent," "good," and "bad" prices which is similar to excellent, good, and bad grades in Dutch schools.

The strength of preference function $v(x)$ was also formulated in terms of negative exponential and power function as reflected in (1) and (2).[8]

The Intrinsic Risk Attitude

The assessment of the intrinsic risk attitude is indirect, i.e., it is derived from the assessed utility function $u(x)$, by means of the certainty equivalence technique, and the strength of preference function $v(x)$ by means of the rating technique. The intrinsic risk attitude is determined by relating the functions such that $u(x) = f(v(x))$. The intrinsic risk-attitude measure is defined as $-u''(v(x))/u'(v(x))$ (the analogue to the Pratt–Arrow coefficient of risk aversion). It represents the remaining nonlinearity in the utility function, after eliminating the nonlinear effect related to the strength of preference function $v(x)$.

The intrinsic risk attitude is estimated by relating the utility function $u(x)$ to the strength of preference function $v(x)$ by the exponential and power functions, which are expressed as

$$(5) \quad u(x) = \frac{1 - e^{-cv(x)}}{1 - e^{-c}} \quad \text{and} \quad u(x) = v(x)^a$$

respectively.

The Risk-Attitude Scales

We adhered to the iterative procedure recommended by Churchill to obtain reliable and valid scales.[9] First, a large pool of questions (i.e., indicators) was generated. The indicators were based on the literature available, and care was taken to tap the domain of the construct. The indicators were tested for clarity and appropriateness in personally administered pretests. The farmers were asked to complete a questionnaire and indicate any ambiguity or other difficulty they experienced in responding to the items, as well as any suggestions they deemed appropriate. Based on the feedback received from the farmers, some items were eliminated, others were modified, and additional items were developed. Farmers were asked to indicate on a Likert scale from -4 ("I strongly disagree") to 4 ("I strongly agree") the extent to which they agreed with the items (statements) displayed in table 1.

Results of the Risk-Attitude Measurements

Expected Utility Framework

In table 2, descriptive statistics of the measured certainty equivalents are shown. The

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[8] Because the order of prices was random during the rating process, the measurements can be viewed as independent, and estimation of the inverse functions is not necessary.

[9] Reliability identifies whether variables are consistent with what they are intended to measure. Validity identifies the extent to which a set of measures correctly represents a concept.

Table 1. Items Representing Farmers' Risk Attitude

Items	
1.	When selling my hogs, I prefer financial certainty to financial uncertainty.
2.	I am willing to take higher financial risks in order to realize higher average returns.
3.	I like taking financial risks.
4.	When selling my hogs, I am willing to take higher financial risks in order to realize higher average returns.
5.	I like "playing it safe."
6.	With respect to the conduct of business, I am risk averse.
7.	With respect to the conduct of business, I prefer certainty to uncertainty.

order in which the lotteries were presented to the producer is indicated by the number in the first column. The second and third columns show the outcomes used in each lottery. With the exception of the first lottery in which the outcomes are 2.34 and 4.29 Dutch Guilders for all producers, the outcomes of the lotteries depend upon the producers' answers in previous lotteries. Consequently, the expected value of the lottery and range of the lottery for each level of expected utility vary among producers.

We had two measurements at $u(x) = 0.5$ and two measurements at $u(x) = 0.625$ in order to test the internal consistency of the assessments. If farmers respond in accordance with expected utility theory, the same certainty equivalents should result except for random response error. When tested, the differences between the assessed certainty equivalents for the same utility levels were not significant ($p > 0.99$; pairwise test) for both consistency measurements. We also calculated the mean absolute deviation between the two consistency measurements (at both $u(x) = 0.5$ and $u(x) = 0.625$) relative to the outcome ranges X_L and X_H, which were only 0.05 and 0.07 Dutch Guilders/kg, respectively. These findings support the notion that farmers use an EU framework in their decisions and are consistent in their choices. This further substantiates that the design closely resembles the real business context of the farmers, thereby minimizing response mode effects (Payne; Shapira).

Table 2 also identifies the difference between the lottery's expected value $E(x)$ and the certainty equivalent CE. A positive difference indicates risk-averse behavior, while a negative difference points to risk-seeking behavior. Of the farmers, 64.5% show risk-seeking behavior in lotteries with relatively low utility [e.g., $u(x) = 0.125$, $u(x) = 0.250$ and $u(x) = 0.375$]. When utility is relatively high [$u(x) = 0.75$ and $u(x) = 0.875$], 39.8% of the farmers show risk-averse behavior which is in accordance to Kahneman and Tversky's prospect theory.

In table 3, the descriptive statistics of the average parameter estimates are presented [e.g., (1)–(6)].[10] Both the negative exponential

[10] The parameters in (1)–(6) are estimated with the nonlinear least squares routine ZXMIN from the IMSL library that employs the Fletcher's quasi-Newton method.

Table 2. Results of the Assessment of the Certainty Equivalence Technique (Guilders/kg)

Measurement	Lottery		Expected	Certainty Equivalent			Range of		$E(x)-$
x_i	x_l	x_h	Utility	Mean	Median	St. Dev.	Lottery	$E(x)$	CE
1	2.34	4.29	0.5	3.35	3.34	0.44	1.95	3.32	−0.040
2	2.34	x_1	0.250	3.03	2.91	0.45	1.86	2.85	−0.178
3	x_1	4.29	0.75	3.72	3.78	0.40	1.70	3.82	0.098
4	2.34	x_2	0.125	2.82	2.63	0.42	1.82	2.68	−0.135
5	x_2	x_1	0.375	3.21	3.20	0.44	1.86	3.19	−0.022
6	x_1	x_3	0.625	3.57	3.59	0.43	1.73	3.54	−0.033
7	x_3	4.29	0.875	3.99	4.05	0.29	1.42	4.01	0.023
8	x_2	x_3	0.5	3.44	3.45	0.46	1.90	3.37	−0.065
9	x_5	x_7	0.625	3.65	3.70	0.40	1.84	3.60	−0.054

Note: x_l is the relative low price in the lottery, x_h is the relative high price in the lottery, $E(x)$ is the expected value of the lottery, and CE is the certainty equivalent.

Table 3. Average Results of Estimating the Risk Attitude and Strength of Preference for the Negative Exponential Function and the Power Function ($N = 373$)

	Certainty Equivalence Technique			Rating Technique	
	Exponential	Power		Exponential	Power
Parameter[a]	c	a		c	a
Mean	−0.742	−1.211		0.332	0.127
Median	−0.274	−0.225		0.371	0.202
St.dev.	2.545	3.915		0.583	0.412
Fit indices					
Mean MSE	0.027	0.028		0.011	0.011
Median MSE	0.018	0.018		0.007	0.007
Mean R^2	0.883	0.855		0.903	0.904
Median R^2	0.916	0.921		0.938	0.941
Classification of respondents on the basis of the t-value[b]					
Risk averse	34%	31%	Decreasing SP	73%	73%
Risk neutral	6%	7%	Constant SP	5%	5%
Risk seeking	60%	62%	Increasing SP	22%	22%

Note: SP is the marginal strength of preference.

[a] In the case of the certainty equivalent technique, if c or $a > 0$ the producer is said to be risk averse and if c or $a<0$ the producer is said to be risk seeking. In the case of the rating technique, c and $a > 0$ (< 0) reflect a decreasing (increasing) marginal strength of preference.

[b] A producer is classified risk neutral when the parameter is not significantly different from 0 at the 0.01 level. Note that to perform this test, the residuals must be normally distributed as well as independently and identically distributed for each individual. Because it is questionable whether the residuals fit the assumptions, the analysis performed serves illustrative purposes only.

and the power function fit the data equally well; i.e., the mean sums of squared errors (MSE) are almost equal for both specifications. The similarity of functional fit was further verified by pairwise comparisons of the MSEs for the negative exponential and power functions.

The negative parameter estimates for both the negative exponential and power function for the farmer's utility function obtained in the certainty equivalence technique imply that 60% of the Dutch farmers are (price) risk seeking.[11] This finding is in line with various studies in the management literature in which a large number of risk-seeking owner–managers have been detected. For example, Brockhaus; Keller; March and Shapira; MacCrimmon and Wehrung; Miller, Kets de Vries, and Toulouse; Shapira; and Smidts found risk-seeking behavior. Smidts' study was based on Dutch crop farmers using a longitudinal research design and a large sample ($N = 253$) to study farmers' decision-making behavior in light of their price risk attitude. Several explanations of risk-taking behavior have been advanced depending on the specific domain. For example, Jaworski and Kohli found that responding to market developments entails some degree of risk taking. Han, Kim, and Srivastava found that greater market orientation leads to higher degrees of risky, innovative behavior.

The positive parameter values obtained for the strength of preference function obtained by the rating technique indicate that 73% of the producers are value averse; that is, a farmer values a given increase in Dutch Guilders in a relatively low price range more than the same increase in a relatively high price range. All ratings of the randomly presented prices were consistent; that is, higher prices were consistently rated higher.

Table 4 shows the estimation results for the intrinsic risk attitude. The hypothesis of intrinsic risk attitude, implying that risk attitude and strength of preference are different concepts, is confirmed in our data (the correlation between the strength of preference and risk attitude is 0.09 for the negative exponential function with $p = 0.1$, and 0.07 with $p = 0.2$ for the power function). As was the case for the risk-attitude and strength of preference functions, both functions fit the data equally well.

[11] A reviewer identified that our finding of risk-seeking behavior may have been influenced by the fact that decision makers do not always weight probabilities linearly when evaluating a lottery. This can lead to a skewness in the perceived price distribution such that producers who are risk neutral or risk averse may identify a certainty equivalent that is greater than the expected value of the lottery.

Table 4. Average Results of Estimating the Intrinsic Risk Attitude for a Negative Exponential Function and a Power Function ($N = 373$)

	Exponential	Power
Parameter	c	a
Mean	−2.084	−1.580
Median	−1.278	−0.640
St.dev.	5.198	4.620
Fit indices		
Mean MSE	0.013	0.012
Median MSE	0.007	0.006
Mean R^2	0.901	0.903
Median R^2	0.944	0.945
Classification of respondents on the basis of the t-value		
Risk averse	28%	25%
Risk neutral	1%	3%
Risk seeking	71%	72%

Note: Divide the parameter estimates here by 1.95 (which is the range of price levels, i.e., $x_H - x_L$) to compare with those in table 3. See table 3 for a discussion of the terms and caveats with the analysis.

Scaling Framework

Exploratory factor analysis on the items of table 1 yielded eigenvalues for the first two factors of 3.04 and 1.34. The results strongly support a two-factor model where the first factor explained 39% of the variation in the data and the second 17%. All the factor loadings of the items exceeded 0.4 (Bartlett's test of sphericity = 649, $p = 0.00$, and KMO measure of sampling adequacy = 0.8).[12] The first four terms in table 1 make up Scale 1; the last three terms make up Scale 2. The reliability of Scale 1 was 0.75 and that of Scale 2 was 0.70, indicating a good reliability for the construct measurement.[13]

Based on these risk-attitude scales, we divided the sample into risk-averse farmers and risk-seeking farmers. The split was based on the average sum of the score on the items of the two scales. Farmers who had a negative sum score are risk seeking and those who had a positive sum score are risk averse. Farmers who had a sum score of zero are risk neutral.

[12] The null hypothesis in the Bartlett test is that the correlation matrix of the items in the scale is an identity. Rejecting the null hypothesis supports a factor model. The Kaiser–Meyer–Olhin statistic also assesses the appropriateness of factor analysis. It ranges from 0 to 1, reaching 1 when each item is perfectly predicted by the other items.

[13] The reliability scale ranges from 0 and 1, with higher values indicating greater reliability. With repeated measurement, more reliable scales show greater consistency (Hair et al.).

Table 5. Classification of Respondents Based on the Sum Scores of the Risk-Attitude Scales

Scale	Risk Averse	Risk Neutral	Risk Seeking
Scale 1	62%	6%	32%
Scale 2	43%	5%	52%

Note that some of the scale's items had to be recoded, so that a negative score on the items is associated with risk seeking and a positive score is associated with risk aversion. Table 5 presents these results. Again, we find a relatively large group of farmers that exhibit risk-seeking behavior, consistent with our findings of the risk-attitude measures rooted in the expected utility approach.

When comparing tables 3 and 4 with table 5, we observe that the classification based on Scale 2 is similar to the classification proposed by the certainty equivalence method, in that more farmers may be considered to exhibit risk-seeking behavior than risk-averse behavior. However, for Scale 1 more farmers exhibit risk-averse behavior than risk-seeking behavior.

Testing for the Global Risk-Attitude Construct

To examine whether the four risk-attitude measures can be viewed as components of a more comprehensive representation of risk, a GRAC, we use the following procedure. First, we assess the bivariate correlations between the different measures to determine whether they are related. This provides some measure of convergent validity but assumes that each measurement is equally reliable which is unlikely. Second, in the presence of positive correlations, we estimate a confirmatory factor analysis model that permits the identification of the relationship between the indicators taking measurement error into account (Bollen). Confirmatory factor analysis differs from the standard factor analysis, which combines variables based solely on common correlation, because the structure of the relationship among the (latent) risk-attitude measures and their particular indicators is specified. For example, items 1–4 in figure 1 only are permitted to influence Scale

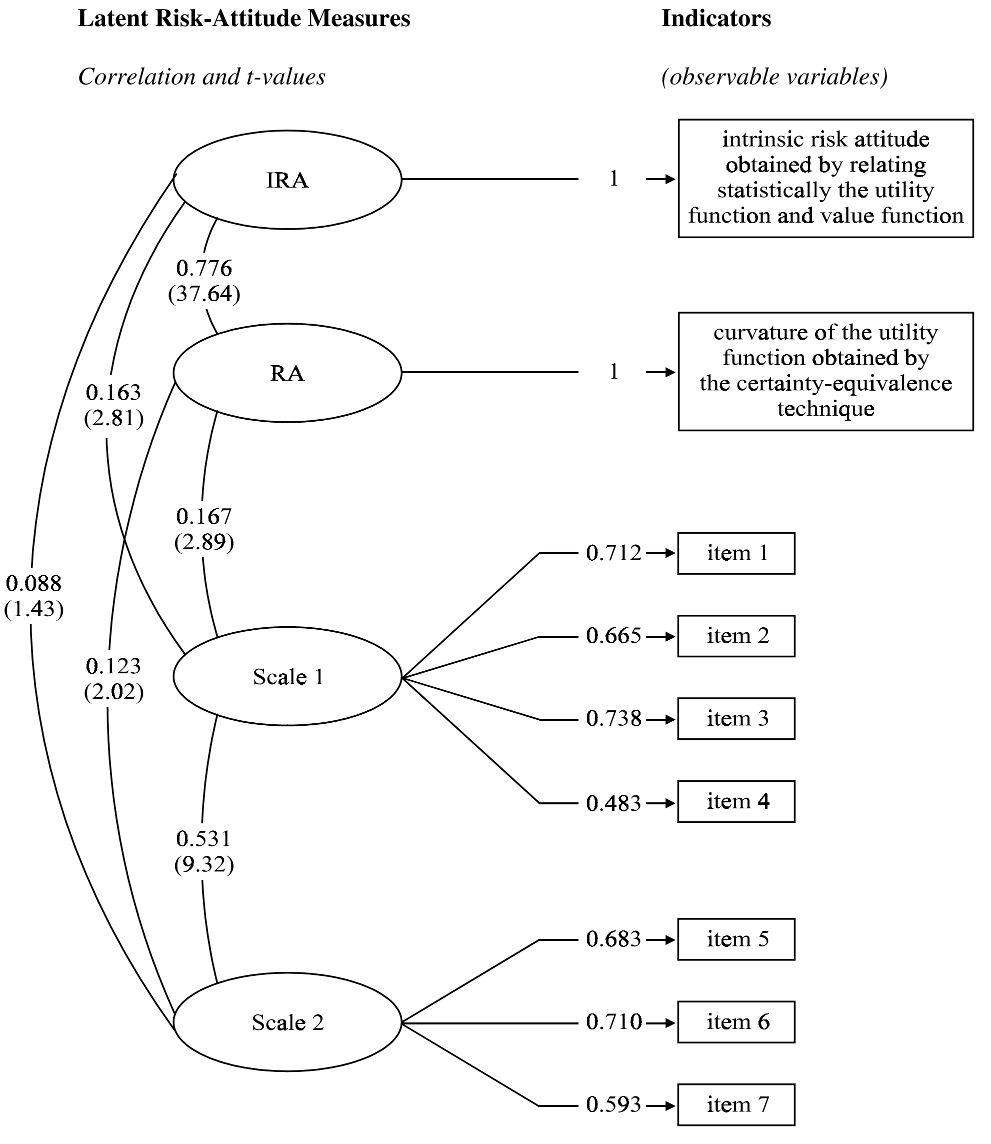

Figure 1. First-order confirmatory factor model
IRA is the instrinsic risk-attitude measure, and RA is the risk-attitude measure.

1. When the (latent) risk-attitude measures are not orthogonal, it is possible to investigate the presence of a common factor across the measures, our global risk-attitude construct, through the use of a second-order factor model. The second-order model quantifies the presence of a common (latent) factor based on the correlations across the risk-attitude measures. The second-order model is more restrictive than standard factor analysis models as we impose the structure of how the indicators can influence the risk-attitude measures, and how the risk-attitude measures are combined to form the global risk-attitude construct. Nevertheless, it is more theoretically pleasing in that it can provide a rationale for correlations. Specifically, if each of the four first-order factors (our risk-attitude measures) can be effectively incorporated into the second-order model, the four factors can be treated as items representing the GRAC (Benson and Bandalos). Assessment of the effectiveness of the second-order model is based on statistical measures of fit of both the first- and second-order factors. The appendix specifies the first- and second-order models.

Results

Table 6 shows the correlation matrix for the different measurement methods. Note that in the correlation analysis we used the average sum of the score on the items of Scale 1 and Scale 2. Except for the correlation between Scale 2 and the intrinsic risk attitude, we find that all measurement methods for risk attitude show a significant correlation.

Table 6 establishes convergent validity of the four different measurement methods. That is, the measures are reflecting similar dimensions of risk attitude. Although the observed correlations can give us an indication of convergent validity, this procedure assumes that each indicator has an equal weight in their respective risk-attitude measure which is not likely the case. Therefore, we use a first-order factor model to relate these four measures.

Figure 1 visualizes the first-order factor model. The right hand side shows the partial regression coefficients between the indicators and the risk-attitude measures. The left hand side shows the correlations between the (latent) risk-attitude measures and their t-values in parentheses. The first-order factor model has a good fit with a χ^2/df of 3.2 ($p =$ 0.0), a root mean squared error of approximation (RMSEA) of 0.07, a goodness-of-fit index (GFI) of 0.96, and a Tucker Lewis Index (TLI) of 0.92, and it indicates that the four risk measures are related, suggesting the presence of a common variance and the strong likelihood of an overall (second-order factor) GRAC. The RMSEA estimates how well the fitted model approximates the population covariance matrix per degree of freedom, the GFI represents the overall degree of fit, that is, the squared residuals from prediction compared with the actual data, and the TLI is an incremental fit measure that combines a measure of parsimony into a comparative index between the proposed and null model.[14]

The hypothesis that the common variance of the four risk-attitude measures is attributed to a higher-order factor, the GRAC, is tested using a second-order factor analysis. The second-order factor model is estimated in the maximum likelihood LISREL framework developed by Jöreskog and Sörbom.[15] The second-order factor model had a good fit, with a χ^2/df of 3.14 ($p = 0.00$), a RMSEA of 0.07, a GFI of 0.96, and a TLI of 0.92. Focusing on the relationship between the risk-attitude measures and global risk-attitude measure, the second-order confirmatory factor model is depicted in figure 2.

The right hand side of figure 2 shows the loadings (partial regression coefficients) of the first-order factors (the risk-attitude measures) on the second-order factor (the GRAC). These loadings (which are all significant) reflect the contributions of the different risk-attitude measures to the GRAC. Figure 2 reveals the important contribution to GRAC that measures derived from the expected util-

[14] For the RMSEA, Browne and Cudeck suggest that a value below 0.08 indicates a close fit. The GFI ranges from 0 (poor fit) to 1.0 (perfect fit). For the TLI Hair et al. recommended a value of 0.9 or greater.

[15] Prior to using LISREL we tested the data for univariate and multivariate normality. The coefficient of relative multivariate kurtosis was 1.08, indicating that the assumption of multivariate normality is tenable (Steenkamp and Van Trijp).

Table 6. Correlation Matrix between the Different Risk-Attitude Measurements

	Scale 1	Scale 2	CE Technique	Intrinsic
Scale 1	1.000 $p = .$			
Scale 2	**0.3841** $p = 0.00$	1.000 $p = .$		
CE technique	**0.1449** $p = 0.01$	**0.1087** $p = 0.04$	1.000 $p = .$	
Intrinsic	**0.1502** $p = 0.00$	0.0773 $p = 0.14$	**0.7761** $p = 0.00$	1.000 $p = .$

Note: A correlation in bold indicates that the correlation is significant at $p < 0.05$, where CE technique indicates that the risk-attitude measure is obtained using the certainty equivalence technique.

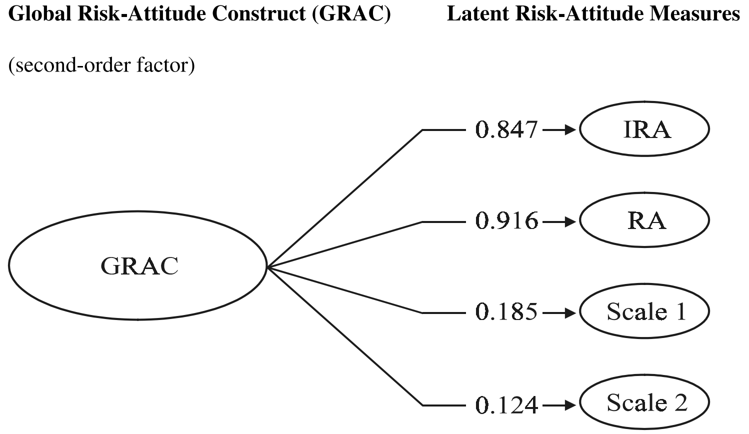

Figure 2. Second-order confirmatory factor model
IRA is the intrinsic risk-attitude measure, and RA is the risk-attitude measure.

ity framework make. The target coefficient T (first introduced by Marsh and Hocevar), which is the ratio of the chi-square of the first-order model to the chi-square of the second-order factor model, is 0.99, which is quite large, the upper value of T being 1. This indicates that the relations among the first-order factors can be accounted for in terms of the more restrictive second-order factor model. From the estimation results, it can be concluded that risk attitude can be conceptualized as a generalized response of farmers in evaluating different situations, which is explained by the four first-order risk-attitude measures.

We hypothesize that the global risk attitude is related to farmers' risk-management practices, and that the global risk-attitude construct is better in explaining farmers' behavior than the single risk-attitude measures. In order to test this hypothesis we introduce a structural equation model in the next section that includes the global risk-attitude construct and farmers' futures usage.

The Global Risk-Attitude Construct and Risk-Management Practices

The adoption of the portfolio theory approach in the 1960s to decisions in futures markets sets risk at the center of why individuals hedge (e.g., Stein, Johnson). Several (hedging) models in different disciplines (agricultural economics, finance, and economics) have been used in the past to show that increasing risk attitude leads to an increase in futures usage. Further, this literature suggests that an increase in risk aversion will lead to an increase of the use of price risk-management instruments. Empirical research by Géczy, Minton, and Schrand; Koski and Pontiff; Mian; and Nance, Smith, and Smithson found a significant relationship between risk aversion and derivatives usage. Based on this theoretical and empirical research we expect to find a positive relationship between farmers' intention to use price-risk management instruments and farmers' risk aversion.[16]

We focus on futures contracts as means to reduce the price risk of hogs. In the Netherlands hog futures contracts are traded at the Amsterdam Exchange. During the interview the farmers were asked to identify their attitude toward futures use by responding to three questions (items). These items reflect what we call the farmers' intention to use futures contracts scale. The first item measured the attitude toward futures (i.e., whether in general they viewed futures as an attractive marketing strategy), by asking the farmer to distribute 100 points between using futures or not using futures, with more points assigned to futures indicating a more positive attitude toward futures. The second item, the intention to use futures, was measured by asking the farmer to identify their probability of using futures by distributing 100 points between futures or not using futures. We chose to measure the attitude and intention toward futures by means of distribut-

[16] A negative relationship between risk aversion and hedging activity may exist. However, the weight of the evidence is more consistent with our discussion.

ing 100 points between futures and not using futures, in light of the study by Putte van den, Hoogstraten, and Meertens that empirically demonstrates that relative measurements of constructs such as attitude and intention are superior when obtained as direct comparisons of competing alternatives. Finally, in the third item, the producers were asked, "suppose you have to market your hogs today; would you use futures or not?" The reliability of this scale, consisting of these three items, was 0.8, reflecting high reliability and indicating that the answers to all the items are highly related (Hair et al.).

Our measure was added to the model displayed in figure 2 to relate the GRAC to farmers' intentions to use futures contracts. Specifically, a full (latent) model, including the indicators for the four different risk-attitude measures, GRAC, and the use of futures, was estimated in a structural equation model framework to identify the effect of risk attitudes on intentions to use futures. See the appendix for the specification of the structural equation model (also, Pennings and Leuthold).

This model was estimated in the maximum likelihood LISREL framework (Jöreskog and Sörbom). The model had a good fit with a χ^2/df of 2.01, ($p = 0.0$), a RMSEA of 0.06, a GFI of 0.95, and a TLI of 0.93. Further, all the hypothesized relations were supported by significant t-values [the partial regression coefficients, reflecting the relationship between the (latent) risk-attitude measures and the GRAC, were similar to the ones as displayed in figure 2 and were all significant]. The model showed that the farmers' GRAC significantly influenced the use futures ($\beta = 0.115$, $t = 2.70$, $p = 0.004$), thereby supporting the hypothesis that risk attitude is an important influence behind farmers' use of futures, and that risk attitude can be measured by a set of measures rooted in different disciplines. The β coefficient indicates that as the producers become more risk averse the likelihood that they will increase their use of futures increases.

The model fit further substantiates that the GRAC is able to describe the latent attitude toward risk and that it affects farmers' use of futures. The GRAC explains 60% of the variance in the farmers' intentions to use futures measure. In order to gain more insight into the contribution of using the GRAC to understand risk-management behavior, we estimated the relationship between the farmers' use of futures measure and each (latent) risk-attitude measure separately. Scale 1 and Scale 2 were able to explain 9% and 11% of the variance, respectively. The risk-attitude measures rooted in the expected utility model showed higher explained variance. The risk-attitude measures obtained by the lottery explained 25% of the variance, while the intrinsic risk attitude performed slightly better with 27%.[17] The fact that the measures rooted in the expected utility framework performed best was expected since their contribution to GRAC was relatively large. We also regressed using least squares the intent to use futures markets on the four independent variables (risk-attitude measures) and compared the adjusted R-squares with the regression where GRAC is the explanatory variable. As expected, the GRAC performs (45% compared to 58%) better, further substantiating the role of the GRAC as a framework to analyze farmers' behavior.

The analysis demonstrates that the four risk-attitude measures reflect dimensions (higher-order factors) of producers' risk attitudes, and that their combined use in a GRAC framework explains producer behavior in a manner consistent with theoretical expectations. Results further suggest that risk attitude, measured as a second-order factor (i.e., GRAC), can be an important variable in explaining farmers' risk-management behavior.

Conclusions

In this article, we have presented an approach to relate the effect of risk attitudes on management decisions. Using (second-order) factor analysis and structural equation modeling which account for measurement error, we develop a global risk-attitude measure that is based on risk-attitude measures developed in the expected utility and the multi-item scale frameworks. Based on our GRAC, the hypothesis that farmers' risk attitudes influence their adoption of risk-management practices is confirmed. Further, our global measure based on the results from the LISREL framework is able to explain 60% of the variability in producers' intentions to use futures contracts, while the measures considered separately explain between 9% and

[17] The details are available on request.

27%. It is clear that our research suggests that farmers' risk attitudes are a higher-order characteristic that cannot be effectively extracted by a single measure. For applied economists interested in measuring the effect of risk attitudes on producer decisions, this may mean that it is necessary to consider various risk-attitude measures, and that the obtained GRAC may be a more accurate measure for risk attitude than the single measures. In our view the usefulness of our procedure is most apparent in developing an understanding of the factors (e.g., risk attitude) that influence decision-maker behavior. Inappropriate or incomplete formulation of the decision-making process may lead to inaccurate inferences about behavior. A clearer understanding of the factors affecting behavior may lead to an improvement in predictiveness of behavior and may identify the areas where theoretical development is needed.

Several points should be mentioned that affect the use of our procedure. First, nonlinearities between the elicitation procedure in the certainty equivalence technique and the farmer's existing portfolio can influence the obtained risk-attitude coefficients (Robison and Barry). Here, this would imply the possible presence of a nonlinear relationship between hog prices and the farmer's end-of-period revenue due to insurance or taxes. While a potential problem, in all likelihood, the influence of these factors in our sample is limited since in the Netherlands no income insurance exists, and for a large portion of the producers in the sample the tax rate would be relatively flat.

Second, care seems warranted in developing and interpreting the individual risk measures, particularly the measures from the certainty equivalence method. Here, the certainty equivalent technique was conducted with probability equal to 0.5. Tversky and Wakker among others have shown that response bias is minimized when these probabilities are used. However, these probabilities may not have coincided with the actual probabilities used by the farmers in the experiments based on their experiences. For example, when prices were near the minimum of the price range, farmers may have consciously or subconsciously assigned a lower probability than specified in the experiment to the low price, leading to skewness in their price probability distribution and to more risk-seeking responses. Further, the individual risk measures may be influenced by factors not explicitly included in the experimental design. For example, financial constraints may have affected the response to a level of price risk. Following Robison and Barry, Shapiro and Brorsen, and Turvey and Baker, farmers under limited financial stress (low debt-to-asset ratios) may be more risk taking in the price domain. Our risk-attitude coefficients are indeed negatively correlated with the debt-to-asset ratio ($\rho = -0.15$, $p = 0.045$); producers with lower debt-to-asset ratios demonstrated a higher willingness to accept risk.

Third, in response to the issue of bias when using the certainty equivalence technique King and Robison introduced the interval technique as a measurement procedure to elicit a decision maker's absolute risk-aversion function. The interval technique is based on the premise that under certain conditions, a choice between two distributions defined over a relatively narrow range of outcome levels divides the absolute risk-aversion space over that range into two regions: one consistent with the choice and one inconsistent with it. This method can reduce the operational problems of the certainty equivalence technique, and in a general context its use should be considered when the researcher is likely to be confronted with large, uncontrollable response bias. However, its potential use with our procedure may be somewhat limited. The interval technique does not provide an exact representation of preferences, rather a band of risk attitudes over a range of potential outcomes, which would make comparisons across individuals and across risk-attitude measures as we do here exceedingly problematic. Further, its theoretical and empirical relationship to the concept of intrinsic risk attitude is not readily apparent. This all suggests that the use of our procedure requires the development of an effective research design, including consistency checks and validity procedures, to ensure the measurement of meaningful risk-attitude measures.

Fourth, we assume that risk attitude is a stable construct that does not change over stimuli ranges, in our case price ranges. Kahneman and Tversky, in their prospect theory, argue that risk attitude would change over the price range (individuals in a loss situation would exhibit risk-seeking behavior). To gain further insight into farmers' risk-taking behavior we investigated within the expected utility framework for each lottery the percentage of respondents that showed risk-averse, risk-neutral, or risk-seeking behavior. We observed a slight tendency of a growing number of risk-averse farmers as utility increased. Measures in the scaling framework cannot be tested for this tendency as they are measured independently of a price range. In a similar context, due to the nature of the data, we assumed stability of the GRAC over time. Combining the global risk-attitude construct with work recently conducted (Barry, Robison, and Nartea; Lence) on intertemporal risk analysis may lead to a promising area for further research.

Finally, a disadvantage of measuring a GRAC in empirical studies, using four risk-attitude measures from two different disciplines, is the high costs when conducting the research with a large sample. The disadvantage has to be weighed against the advantage of obtaining more accurate risk-attitude measures. The source of the high costs is the measures rooted in the expected utility framework, as they can only be obtained by means of personal interviews (i.e., experiments). The risk-attitude measures obtained by the scaling framework can be measured by a mail questionnaire and hence are relatively inexpensive tools for researchers. Recent developments in statistics and psychometrics in new methods that take measurement error into account and that are able to model higher-order factor models provide an opportunity and a challenge to identify and develop a GRAC that is based solely on the scaling framework. However, the likelihood of such a breakthrough may not be large, since our study shows that it is precisely the measures derived from the expected utility framework that contribute most to the global risk-attitude construct.

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Appendix

The appendix gives the specification of the first-order factor model, the second-order factor model, and the structural equation model.

First-order factor model. Let y be a $p*1$ vector of observed variables (i.e., items), let η a $n*1$ vector of latent (i.e., unobserved) variables or factors underlying the observed variables, and let ε be a $p*1$ vector of error variables. The measurement model, representing the relationship between the items and factors, can be expressed as

$$\text{(A.1)} \quad y = \Lambda_y \eta + \varepsilon$$

where it is assumed that that η's and ε's are random variables with zero means, y is measured in deviations from its means, and the ε's are uncorrelated with the η's. Λ_y is a $p*n$ matrix of partial regression coefficients for the regression of y on η, commonly referred to as factor loadings. The implied covariance matrix of y can be expressed as

$$\text{(A.2)} \quad \Sigma = \Lambda_y \Psi \Lambda_y' + \Theta_\varepsilon$$

where Ψ is the covariance matrix of η and Θ_ε is the covariance matrix for ε.

For a given specification, and a given identification of the parameters in Λ_y, Ψ, and Θ_ε, maximum likelihood procedures have been developed for estimation, and various goodness-of-fit measures are available for evaluating these models (Bagozzi, Yi, and Nassen; Jöreskog and Sörbom).

Second-order factor model. In the second-order factor model, the $q*1$ vector of second-order factors is represented by ξ, the first-order factors by the $m*1$ vector η, and the observed variables by the $p*1$ vector y. The $p*m$ matrix Λ_y contains the loadings of the observed variables on the first-order factors, and Γ contains the loadings of the first–order factors on the second-order factors. The covariance matrix of the second-order factors is represented by Φ. The vector of residual variables in the first-order factors is represented by ζ, the unique factors (i.e., error terms) in the observed variables are represented by ε, the variance–covariance matrices of residuals and unique factors are denoted Ψ and Θ_ε, respectively. The relationship between the observed variables in terms of the first-order factors can be expressed as

$$\text{(A.3)} \quad y = \Lambda_y \eta + \varepsilon$$

with the first-order factors in terms of the second-order factor as

$$\text{(A.4)} \quad \eta = \Gamma \xi + \zeta.$$

This second-order factor model in (A.3) and (A.4) hypothesizes a general (second-order) risk-attitude construct, based on the specific risk-attitude measures identified in the confirmatory analysis.

The implied variance–covariance matrix of the second-order factor model can be expressed as

$$\text{(A.5)} \quad \Sigma = \begin{bmatrix} \Lambda_y(\Gamma\Phi\Gamma' + \Psi) + \Theta_\varepsilon & \Lambda_y \Gamma \Phi \\ \Phi \Gamma' \Lambda_y' & \Phi \end{bmatrix}.$$

Equation (A.5) relates the variances and covariances of the observed variables to the parameters of the model. Estimation of the second-order factor model involves finding values for the parameter matrices that produce an estimate of Σ according to equation (A.5) that is as close as possible to the sample matrix S (e.g., the covariance matrix of the raw data). The covariance structure in equation (A.5) can be estimated by one of the full information methods: unweighted least squares, generalized least squares, and maximum likelihood (Bollen). The fitting function measures show how close a given $\hat{\Sigma}$ is to the sample covariance matrix S. Because of its attractive statistical properties we use the maximum likelihood procedure (Bollen).

Structural equation model. The structural equation model resembles (A.3) and (A.4) but adds the relationship between the GRAC and the farmers' intentions to use futures which is reflected as

$$\text{(A.6)} \quad \eta = B\eta + \Gamma\xi + \varsigma$$

where B is a $(1 * 1)$ matrix of the coefficient relating the GRAC to the measure of farmers' intentions to use futures.