Assessing the Construct Validity of Risk Attitude

Joost M.E. Pennings • Ale Smidts
Wageningen University, Department of Social Sciences, Marketing & Consumer Behavior Group, Hollandseweg 1, 6y06 KN Wageningen, The Netherlands, and University of Illinois at Urbana-Champaign, Department of Agricultural & Consumer Economics, Urbana, Illinois 61801
Rotterdam School of Management, Erasmus University Rotterdam, The Netherlands
joost.pennings@alg.menm.wag-ur.nl • asmidts@fbk.cur.nl

Two major approaches to measuring risk attitude are compared. One, based on the expected utility model is derived from responses to lotteries and direct scaling. The other measure is a psychometric approach based on Likert statements that produces a unidimensional risk attitude scale. The data are from computer-assisted interviews of 346 Dutch owner-managers of hog farms, who made decisions about their own businesses. While the measures demonstrate some degree of convergent validity, those measures based on lotteries were better predictors of actual market behavior. In contrast the psychometric scale showed more agreement to self-reported measures of innovativeness, market orientation, and the intention to reduce risk. In light of the higher predictive validity of lottery-based measurements, we recommend elicitation methods based on the expected utility paradigm.
(Managerial Decision Making Under Risk; Risk Attitude; Utility Theory; Psychometric Scaling; Nomological Validity; Price Risk)

1. Introduction

Unpredictability of market prices implies that risk attitude plays an important role in understanding managerial decision-making behavior (Tversky and Kahneman 1981, Tufano 1996). Several authors have shown that decision makers can be simultaneously risk seeking and risk averse in different domains, implying that risk attitude is context specific (Slovic 1974, Payne et al. 1980, MacCrimmon and Wehrung 1990, Schoemaker 1990, March and Shapira 1992, Shapira 1997, Payne 1997). Context specificity not only relates to the substantive domain (e.g., health outcomes versus financial outcomes), but also to measurement procedures (e.g., response modes or question framing).

In the literature, two major measurement approaches can be identified: those derived from the expected utility framework (von Neumann and Morgenstern 1974, Schoemaker 1982, Fishburn 1988), and those constructed using psychometrics (e.g., Miller et al. 1982, MacCrimmon and Wehrung 1986, Shapira 1995). The goal of this research is to compare the validity of measures derived from both approaches.

The expected utility (EU) model formulates decision making under risk as choices among lotteries, each represented by a probability distribution. Decision makers are assumed to have a preference ordering defined over the probability distributions, represented by the utility function $u(x)$. The curvature of the utility function reflects risk attitude for a specific domain (e.g. monetary outcomes of a business) (Keeney and Raiffa 1976).

Within the expected utility approach, one can also adjust for strength of preference, in order to obtain a potentially more accurate measure of risk attitude: the intrinsic risk attitude (Ellsberg 1954, Dyer and

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Sarin 1982, Bell and Raiffa 1982). This approach assumes that an individual's preference for risky choice alternatives is a combination of: (1) the strength of preference the individual feels for certain outcomes, and (2) attitude towards risk (cf. Smidts 1997). The outcomes of a lottery are transformed into subjective values under certainty by the strength of preference function $v(x)$, and these subjective values are subsequently evaluated under risk. A difference between the utility and the strength of preference function is attributed to the influence of risk preference. Significant differences between $u(x)$ and $v(x)$ were found by Krzysztofowicz (1983a, 1983b) and by Keller (1985). Recently, Smidts (1997) used a real economic setting and a longitudinal design to find empirical support that risk attitude and strength of preference are two distinct constructs. Another recent study by Weber and Milliman (1997) also provides empirical support for the intrinsic risk construct. These studies suggest that the intrinsic risk measures may be more valid than risk attitude obtained by utility functions only.

In the standard psychometric approach, constructs such as risk attitude are measured by asking respondents to indicate the extent to which they agree or disagree with a set of statements (Nunnally and Bernstein 1994). Kunreuther and Ginsberg (1978), MacCrimmon and Wehrung (1986), and Shapira (1995), amongst others, conducted large-scale surveys and interviews investigating risk preferences using psychometric scaling procedures. We concentrate on risk attitude measures in the domain of financial risk faced by managers of Small- and Medium-Sized Enterprises (SMEs), specifically price risk when selling output. Several researchers have developed risk attitude scales and tested their psychometric properties (Miller et al. 1982, Jaworski and Kohli 1993, Childers 1986), but they did not consider financial risks faced by owner-managers of SMEs. Therefore, we develop a new risk attitude scale. A personal-computer-guided interview was conducted with 346 Dutch hog farmers making decisions regarding selling their hogs forward or selling them in the risky spot market.

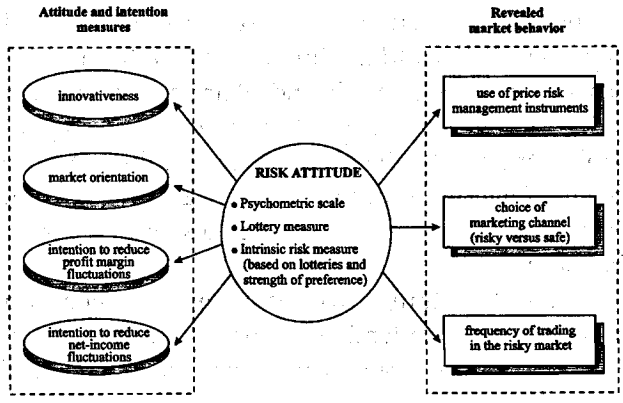
The paper is organized as follows. In §2 we present a framework for testing construct validity and formulate hypotheses about the relationship between risk attitude and other variables. The research method is described in §3, while §4 provides findings. We conclude with a discussion of the implications of our findings.

2. Framework for Testing Construct Validity

Construct validity is the extent to which an operationalization measures the construct it is supposed to measure (Peter 1981, Nunnally and Bernstein 1994). It is investigated by testing for convergent, discriminant and nomological validity. Convergent validity refers to the degree to which *different* measurements reflect the *same* construct (i.e., are positively correlated) (Campbell and Fiske 1959, Cook and Campbell 1979, Churchill 1979). Discriminant validity is achieved when there is a *divergence* between measures of one construct and a related but conceptually *distinct* construct.

Nomological validity refers to whether measures are related to other constructs in a way that is theoretically meaningful. Since we measure risk attitude in a real economic setting, we include variables that express both managerial attitude and intentions, as well as actual behavior in the market place (see Figure 1). One category of attitudinal variables is the manager's responsiveness to dynamic market conditions as reflected in market orientation and innovativeness. A

Figure 1 Nomological Net of Risk Attitude



second category is the expressed intention to actively reduce fluctuations in profit margins and net income. Three behavioral variables reflect efforts to reduce risk: the use of price risk management instruments (such as futures and options), the choice of marketing channel (safe vs. risky), and the frequency of trading in the risky market.

2.1. Attitude and Intention Variables

Innovativeness. Attitude toward innovation refers to whether managers are open to new experiences and novel stimuli, are willing to use information about new concepts, ideas, products or services, and readily recognize the potential application of new ideas (Leavitt and Walton 1975). Innovators are predisposed to adopt new or different products, rather than remain with previous choices (Bhoovaraghavan et al. 1996). Empirical research shows that risk-taking behavior is a typical characteristic of innovative managers (Nakata and Sivakumar 1996). Shapira (1995, p. 54) found that executives unequivocally described risk-prone managers as innovative. Therefore, we hypothesize that a risk-averse manager will be less innovative than a risk-prone manager. More formally:

HYPOTHESIS 1A. *Risk aversion will be negatively correlated with innovativeness.*

Market orientation. Market orientation consists of three components: customer orientation, competitor orientation, and interfunctional coordination (Narver and Slater 1990). An organization's market orientation is shaped by its manager's attitudes and behavior. Kohli and Jaworski (1990) argued that the greater the risk aversion of top managers, the lower the organization's market orientation. For instance, if managers are risk averse, they will be less likely to respond to changes in customer needs. Jaworski and Kohli (1993) found that responding to market developments entails some degree of risk taking. Han et al. (1998) found that greater market orientation leads to higher degrees of risky, innovative behavior. We therefore hypothesize that more risk-averse managers will be less market oriented. More formally:

HYPOTHESIS 1B. *Risk aversion will be negatively correlated with market orientation.*

The manager's intention to reduce income risk. Risk-averse managers should desire to reduce fluctuations in profit margins. In the context of this study, this can be achieved by means of cash forward contracts and by means of insurance products. Therefore, we hypothesize that:

HYPOTHESIS 1C. *Risk aversion will be positively correlated with the intention to use forward contracts and insurance products.*

2.2. Revealed Market Behavior Variables

We expect risk attitude to be an important determinant of a manager's actual market behavior. A risk-averse manager can effectively reduce price risk exposure by using instruments such as futures and options (Stoll and Whaley 1993). We hypothesize that:

HYPOTHESIS 2A. *Risk aversion will be positively correlated with the use of price risk management instruments.*

Typically, a manager will have the opportunity to sell output via different marketing channels that differ in the price risk they generate. Selling to a spot trader implies price risk exposure with each and every sale. In contrast, selling to a cooperative will yield an average price over a certain period, thereby spreading spot price risk. We hypothesize that:

HYPOTHESIS 2B. *Risk aversion will be positively correlated with choice of less risky marketing channels.*

Selling output all at once on the spot market is very risky. In contrast, spreading sales by trading *frequently* will yield an average price. The latter strategy is attractive for risk-averse managers, since it allows them to reduce their price risk substantively, particularly when they perceive high risks. We hypothesize that:

HYPOTHESIS 2C. *Risk aversion will be positively correlated with trading frequency. The effect of risk aversion on the frequency of trading will be larger the more risk managers perceive.*

3. Research Method

3.1. Decision Context

Several times a year, Dutch hog farmers have to decide either to sell their hogs forward, thereby eliminating price risk, or sell their hogs in the spot market, and hence face price risk. Price changes in the spot market are hard to predict (i.e., prices can go up or down with equal probability), in line with the finance literature showing that commodity prices follow a random walk (Cargill and Rausser 1975). Moreover, Dutch hog farmers are price takers: They are not able to influence the probabilities. They recognize very clearly that their business involves a large price risk. These characteristics make this decision context very suitable for testing the construct validity of risk attitude measures.

The Dutch hog industry is among the largest exporters of slaughter hogs in the European Union and accounts for an important part of the country's export. Because the market for slaughter hogs in the European Union is not subject to government regulation, slaughter hog prices show large fluctuations.[1] Hog farming typically accounts for 85% or more of the manager's total income. The production process is rather simple: The manager buys piglets, and raises them to slaughter hogs in three months. At any moment in time, a number of "rounds" are present, each representing a group of hogs of the same age. Each "round" constitutes a new risk when buying piglets and feed, since the price level of slaughter hogs three months after the time of purchase is largely unknown. Price risk management instruments including options, futures, and cash forward contracts can be used to hedge against these risks.

3.2. Data Collection

A questionnaire was developed using 40 test interviews to ensure that the questions would be interpreted correctly. The survey consisted of computer-guided interviews using a user-friendly interface. From a random sample of 577 enterprises, a net total of 346 managers were interviewed. The interviews lasted for about 35 minutes and were held at the manager's enterprise during the second half of 1996. All the interviewers had prior experience and received extensive training.

3.3. Measurement Procedures

3.3.1. Assessment of Utility Function: The Lottery Technique. Utility functions were assessed for the price for slaughter hogs denoted in Dutch guilders per kilogram live weight, over a range of 2.34 to 4.29 Dutch guilder.[2] These boundaries reflect the minimum and maximum price of hogs based on historical price data. The certainty equivalence method was applied: The respondent compared a certain outcome to a 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 certain outcome was varied until the respondent revealed indifference. This certain outcome is denoted CE(p) (for further details, see Keeney and Raiffa 1976). This study implemented a bisection framework, only using probability 0.5 in which each question involves a bisection of a particular interval. The respondents were asked to imagine themselves selling their hogs. They were given a choice between three alternatives: Alternative A was a 50/50 chance of receiving a relatively high price or a relatively low price, Alternative B was a fixed price, and Alternative C indicated indifference. Respondents saw the three alternatives depicted in rectangles on the computer screen. Upon choice, the computer generated a new fixed price B and the respondent had to choose again. The choice between A and B was repeated until the respondent chose C, after which a new lottery would start.

The lottery procedure took about 20 minutes. Nine points 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). Exponential functions were fit to each subject's

[1] The coefficient of variation (CV) is 0.19, based on daily observations over the period 1990–1997. This is relatively high even when compared to U.S. soybeans (CV is 0.14), which is generally known as a risky food raw material.

[2] Test interviews showed that hog farmers use the hog price per kilogram instead of revenue when deciding on whether or not to enter a forward contract, and they appeared to relate hog prices directly to their profit margins.

outcomes (see Appendix A).[3] Based on the assessed utility curve, the Pratt-Arrow coefficient of absolute risk aversion was derived as a measure of risk attitude.

3.3.2. Assessment of Strength of Preference Functions: The Rating Technique. The strength of preference function $v(x)$ was assessed by means of a rating technique. The respondent had to express the strength of preference towards a price level by assigning a value on a scale from 1 to 10, with fractional increments of 0.25 (e.g., 1.00, 1.25, 1.50, and so on). This scale was easy to implement because it resembles the grading system used in Dutch schools. Before beginning the rating task, respondents were shown the range of price levels, which was the same as in the lottery assessment. Price levels were presented in random order. Respondents rated nine price levels in less than five minutes.

3.3.3. Psychometric Risk Attitude Scale. We used a Likert scaling procedure adhering to the iterative procedure recommended by Churchill (1979). First a large pool of items was generated from previous studies (Childers 1986, Jaworski and Kohli 1993, MacCrimmon and Wehrung 1986, 1990, Miller et al. 1982, Shapira 1995). Next, items were tested for clarity and appropriateness in pretests with 40 managers. Based on feedback from the respondents, some items were eliminated, others were modified, and additional items were developed. In the final questionnaire, seven items were included.

3.3.4. Attitude and Intention Variables. Innovativeness was measured using a shortened version of the Open Processing Scale (OPS), first developed by Leavitt and Walton (1975). The abridged scale consisted of four items identified in Appendix B. Confirmatory factor analysis shows that the measure is unidimensional and sufficiently reliable (see Appendix B for statistics).

Market orientation was measured using four items from the scale developed by Narver and Slater (1990). The scale is unidimensional and sufficiently reliable (see Appendix B).

The extent to which managers intend to reduce fluctuations in their profit margin was measured by indicating their agreement with the statement "I intend to reduce profit margin fluctuations" on a nine-point scale. The extent to which managers intend to reduce net income fluctuations was operationalized similarly.

3.3.5. Market Behavior Variables. Managers were asked whether they had used futures as a hedging tool in the last three years. They were also asked to indicate their current marketing channel: (1) selling to a trader, (2) selling to a slaughterhouse, or (3) selling to a cooperative. When selling to the first two channels, the manager receives the spot price and is exposed to cash market risk. When selling to a cooperative, they receive an average price and consequently reduce cash price risk. Also, credit risk is lower for cooperatives, making this a relatively safe marketing channel.

The frequency of trading was measured by recording the annual number of market transactions, between a maximum of once a week and a minimum of four times per year. This minimum is imposed by the nature of the production process, since raising piglets into hogs takes three months.

Managers used a nine-point scale to express the extent to which they perceived the market for hogs as risky. Secondly, managers used a nine-point scale to indicate their ability to predict the market price in three months. These two ratings correlated positively and significantly ($r=0.65$, $p<0.001$).

4. Results

4.1. Risk Perception and Trading Behavior

An average score of 7.5 on a nine-point scale (with a standard deviation of 2.1) suggests that managers perceive the market in which they operate as risky. Managers also indicated that prices are hard to predict (an average score of 7.5 with a standard deviation of 2.5). This perception of market risk, however, is not associated with frequent use of price risk

[3] Both power and exponential functions were fit to the data. The exponential function fit the data consistently better.

management instruments. A mere 13% of the managers interviewed used futures contracts, and 3% used cash forward contracts to cover their price risk. These results suggest that managers were willing to tolerate price risk in the sale of slaughter hogs. As one manager put it during an interview: "We value markets with high price volatility because they provide opportunities for gain." A total of 64% of respondents sold to traders or directly to slaughterhouses, where they are exposed to price risk; only 23% sold exclusively to a cooperative, thus spreading their risk. The remaining 13% sold their slaughter hogs through a combination of marketing channels (trader, slaughterhouse, and cooperative).

4.2. Lottery Measurement

Table 1 reports descriptive statistics of the parameter estimates for the lottery assessments. A negative parameter indicates risk-seeking preferences and a positive parameter indicates risk-averse preferences.

Two sets of repeated measurements were obtained to test the internal consistency of the utility assessments. The repeated assessments were not significantly different ($p>0.99$ (pairwise tests)). The correlations between the repeated measurements were quite high ($r=0.88$, $p<0.001$ and $r=0.86$, $p<0.001$, respectively), further supporting internal consistency.

Examining the second column of Table 1, the median mean squared error (MSE) for $u(x)$ is 0.019, the median mean absolute error (MAE) is 0.102, and the median R^2 is 0.92, indicating that the exponential function provided a good fit to the managers' lottery responses. On average, managers were risk-prone (mean $a=-0.497$). About 60% were risk-seeking, whereas 40% were either risk-neutral or risk-averse.

4.3. Strength of Preference Measurement

All farmers rated the randomly presented prices in a consistent manner, that is, higher prices were rated as more preferred. Results show that, on average, the managers show decreasing marginal preferences (i.e., the strength of preference function $v(x)$ is concave) (see Table 1, Column 3). The fit of the exponential function to the data is good (median MSE for $v(x)$ is 0.008, median MAE is 0.064, and median R^2 is 0.94).

Table 1 Results of Estimating the Risk Attitude, Strength of Preference and Intrinsic Risk Measures for the Exponential Function ($N=346$)

	Lottery	Rating	Intrinsic risk measure
Parameter[a]	*a*	*b*	*c*
Mean	−0.497	0.334	−0.884
Median	−0.266	0.368	−0.642
St.dev.	1.569	0.491	1.877
Fit indices[b]			
Mean MSE	0.026	0.012	0.012
Median MSE	0.019	0.008	0.007
Mean MAE	0.106	0.069	0.065
Median MAE	0.102	0.064	0.055
Mean R^2	0.891	0.908	0.909
Median R^2	0.922	0.939	0.945
Percentiles parameter			
20th	−1.322	−0.083	−1.683
40th	−0.492	0.245	−0.914
60th	−0.049	0.460	−0.381
80th	0.595	0.700	0.229
Classification of respondents on the basis of the *t*-value[c]			
Concave function	35%	84%	26%
Linear function	4%	4%	1%
Convex function	61%	12%	73%

[a] For the function specifications, see Table A1 in Appendix A. Parameters reflect the Pratt-Arrow coefficient of absolute risk aversion. In order to compare the parameter estimates of the lottery with those of the intrinsic risk measure, the latter estimates were divided by 1.95 (which is the range of the price levels, that is $x_H - x_L$). If $a>0$ the respondent is said to be risk-averse and if $a<0$ risk-prone. If $b>0$ the respondent shows decreasing marginal strength of preference and if $b<0$ increasing marginal strength of preference. If $c>0$ the respondent is said to be intrinsically risk-averse and if $c<0$ intrinsically risk-prone.

[b] MSE = Mean Squared Error; MAE = Mean Absolute Error; R^2 is calculated by squaring the Pearson correlation between actual values and the values predicted from the model.

[c] A respondent is classified as risk-neutral when the parameter is not significantly different from zero at the $p=0.05$ level (two-tailed). We assume that the residuals are independent and that the non-linear-squares estimator is distributed approximately normal.

4.4. Intrinsic Risk Measure

Table 1 (fourth column) shows the results for the intrinsic risk measure. The median MSE for the exponential function is 0.007, median MAE is 0.055, and

median R^2 is 0.95, again indicating a good fit. The mean intrinsic risk measure parameter implies that the average respondent was intrinsically risk-prone, which corresponds to the findings of Smidts (1997). A total of 73% of managers were classified as intrinsically risk-prone. Krzysztofowicz (1983a, 1983b), Keller (1985), and Weber and Milliman (1997) also found high percentages of intrinsically risk-seeking respondents. The tendency to intrinsically risk-prone behavior is indeed significantly different from intrinsic risk-neutrality ($t = -7.74$, $p < 0.001$). The mean absolute deviation between the utility and strength of preference function, evaluated at $u(x) = v(x) = 0.5$, is 0.39 Dutch guilders per kilogram (standard deviation 0.15). As in previous studies, our results confirm the proposition that $u(x)$ and $v(x)$ are different constructs.

4.5. Psychometric Risk Attitude Scale

We used item-total correlation and exploratory factor analysis for purification of the initial scale of seven items. Selecting only high-loading items further reduced the number of items, following the procedure described in Steenkamp and van Trijp (1991). The composite scale averaging three items appeared to be unidimensional, all factor loadings were significant (minimum t-value was 4.60, $p < 0.001$) and exceeded 0.4, with a composite reliability of 0.72. Appendix B shows the items in the final scale and their psychometric properties.

4.6. Convergent and Discriminant Validity

Table 2 shows the correlation matrix for all three measures of risk attitude and the strength of preference measure. All measures are scaled so that higher values correspond to risk aversion and lower values correspond to risk taking. Measures of risk attitude show a significant, albeit low, positive convergent correlation. Also, some support for discriminant validity can be derived. The correlation between the lottery and the rating technique is not significant at the 5% level and is lower than that found by Smidts (1997). We may expect to find some relationship between the lottery and the rating technique because $v(x)$ is embedded in $u(x)$, i.e., $u(x) = f(v(x))$. The weak relationship may be explained by heterogeneity in intrinsic risk attitude.

Table 2 Pearson Correlations Between the Measurements

	Psychometric scale	Lottery	Intrinsic risk measure	Rating
Psychometric scale	1.000			
Lottery	0.157*	1.000		
	$p = 0.00$			
Intrinsic risk measure	0.134*	0.760*	1.000	
	$p = 0.01$	$p = 0.00$		
Rating	0.054	0.093	0.133*	1.000
	$p = 0.30$	$p = 0.07$	$p = 0.01$	

Note. An asterisk indicates that the correlation is significant at $p < 0.05$ (two-tailed).

Also, while the psychometric scale correlates significantly with the risk attitude obtained from the lotteries ($r = 0.157$, $p = 0.003$) and the intrinsic risk measure ($r = 0.134$, $p = 0.012$), it not significantly correlated with the strength of preference measure ($r = 0.054$, $p = 0.299$). Moreover, the correlation between the lottery and the rating technique is lower than between the lottery and the psychometric scale. The main conclusion from Table 2, however, is that the measures are quite diverse, and thus may differ in their ability to predict intentions and market behavior.

4.7. Nomological Validity

Structural equation modeling (SEM) was used to test the hypotheses formulated earlier (Jöreskog and Sörbom 1993). Each of the attitude and intention variables is treated as a latent construct that is measured by a set of observable indicators (items). Observable variables are assumed to be measured with error. The coefficients in the structural equation model represent theoretical cause-and-effect relationships among the latent variables that underlie the observed variables.[4] The relationships between risk attitude (measured by the lottery, intrinsic risk measure, and

[4] PRELIS (Jöreskog and Sörbom 1996) was used to test the underlying assumptions of SEM. The coefficient of relative multivariate kurtosis was 1.09, indicating multivariate normality (Steenkamp and van Trijp 1991). We used LISREL 8 (Jöreskog and Sörbom 1993) to find maximum likelihood estimates for the structural equation models, with the covariance matrix as input.

Table 3 **Relationship Between Risk Attitude Measures and Attitudes and Intentions (Structural Equation Models using LISREL 8, $N = 346$)**

Construct	Psychometric scale	Lottery	Intrinsic risk measure	H(+/-)
Innovativeness				
$\beta =$	−0.445	−0.064	−0.037	H(-)
$t =$	(−5.593)*	(−1.043)	(−0.597)	
Market orientation				
$\beta =$	−0.178	−0.099	0.053	H(-)
$t =$	(−2.429)*	(−1.612)	(0.863)	
Intention to reduce profit margin fluctuations				
$\beta =$	0.255	0.164	0.096	H(+)
$t =$	(3.925)*	(3.085)*	(1.782)	
Intention to reduce net-income fluctuations				
$\beta =$	0.184	0.090	0.065	H(+)
$t =$	(2.872)*	(1.676)	(1.213)	

Note. H(+/-) indicates the expected sign of β; Beta is the standardized regression coefficient (= correlation) which shows the relationship between the risk attitude measures and the latent constructs. An asterisk indicates that the t-value is significant at the 5% level (two-tailed test).

Table 4 **Results of Logistic Regression in Which Risk Attitude Predicts Behavior**

	Psychometric scale	Lottery	Intrinsic risk measure
Uses futures markets to cover risk: Yes (=1) or No (=0)			
B	0.062	0.567	0.320
Wald Statistic	1.813	7.105	6.870
Significance	0.178	0.007*	0.009*
R	0.000	0.190	0.186
χ^2-improvement	1.902	8.022	8.115
Significance	0.168	0.005*	0.004*
Marketing channel choice: Selling to a trader or directly to a slaughterhouse (=1) versus selling to a cooperative (=0)			
B	0.023	0.192	0.080
Wald Statistic	1.388	6.116	3.927
Significance	0.238	0.013*	0.047*
R	0.000	0.093	0.064
χ^2-improvement	1.392	6.667	4.822
Significance	0.238	0.010*	0.028*

Note. An asterisk indicates that each model significantly improves the fit when compared to the null model, which includes only an intercept, at the 5% level.

the psychometric scale, respectively) and the (four) attitude and intention variables were tested one by one, resulting in twelve models.

Table 3 summarizes the results. We report only beta coefficients (which represent the unbiased correlations) and corresponding t-values. The fit of all models was good when evaluated using the recommended goodness of fit indices (RMSEA, GFI, AGFI, TLI; see Jöreskog and Sörbom 1993).[5] Table 3 shows that the psychometric scale is significantly related to all four attitude and intention variables in the predicted direction, hence, confirming hypotheses H1A to H1C. More risk-averse subjects are indeed less innovative, less market oriented, and express stronger intentions to reduce the fluctuations in profit margins and net income. In contrast, risk attitude measured by lotteries showed a significant relationship only with the intention to reduce fluctuations in profit margins. Finally, the intrinsic risk attitude measure showed no significant relationship with any of the attitude and intention variables. Based on these results, we conclude that the psychometric scale outperforms both measures derived from the expected utility framework in predicting attitude and intention measures.

Next, we test the nomological validity of risk attitude measures for actual market behavior. We predicted that more risk-averse managers would be more likely to use futures contracts (Hypothesis 2A). We used logistic regression (Hosmer and Lemeshow 1989) to model the probability of the choice to use futures contracts. The results, displayed in Table 4, show that greater risk aversion, reflected by both lottery and intrinsic risk measures, is significantly ($p < 0.005$) related to the use of futures contracts. In contrast, the psychometric scale is not significantly related to the use of futures contracts ($p > 0.2$). Therefore, Hypothesis 2A is confirmed for the lottery and intrinsic risk attitude measures, but is rejected for the psychometric scale.

In Hypothesis 2B, we predicted that risk-aversion would be associated with selling to a "safe" rather than a "risky" marketing channel. Logistic regression results displayed in Table 4 show that both the lottery and the intrinsic risk measure are significantly related to the choice of marketing channel ($p < 0.03$), thereby confirming Hypothesis 2B. The poor fit of the model

[5] These statistics are available from the authors on request.

Table 5 Results of Multiple Regression in Which Risk Attitude Predicts Behavior

Frequency of trading in the risky market	β	Standard error	*t*-value	*p*-value
Size of enterprise	0.144	0.000	2.75	0.006
Risk perception (RP)	0.159	0.026	3.01	0.002
Intrinsic risk measure (IRM)	0.067	0.153	1.22	0.220
Interaction† (IRM*RP)	0.018	0.009	1.91	0.057

$R^2 = 0.07$
Adjusted $R^2 = 0.06$
$F(4,341) = 6.15$ ($p = 0.00$)

†The variables risk perception and intrinsic risk measure were centered prior to forming the multiplicative term (Jaccard, Turrisi and Wan 1990).

containing the psychometric scale shows that Hypothesis 2B is rejected for this measure.

In Hypothesis 2C, we predicted that a risk-averse manager would tend to trade more frequently, that is, enter the market more often. To investigate the relationship between the frequency of trading in the risky market and risk attitude, a model was developed which includes an interaction between risk perception and risk attitude. Apart from "risk attitude" and "risk perception," the model includes "size of enterprise," because technical and logistic aspects of the production process force larger companies to keep more rounds at the same time.

Table 5 shows the regression results for the intrinsic risk measure. As expected, the variable "size of enterprise" shows a positive, significant relationship with the frequency of trading in the market. Also, the interaction between risk perception and intrinsic risk measure is significant. This indicates that risk-averse managers will trade in the risky market relatively more often than a risk-prone subject. However, this behavior occurs when risk is perceived to be large. With little perceived risk, that behavior will not be so prominent. Similarly, for a risk-prone manager, high risk perception will lead to an even lower frequency of trades in the market, thereby increasing risk exposure.

We also estimated this model for the psychometric scale and the lottery measure. In both cases, there was no significant association between risk attitude, the interaction between risk attitude, risk perception, and trading frequency.

5. Discussion

In this paper, we use a real business setting to evaluate risk attitude measures derived from two distinct theoretical approaches. The three risk attitude measures show significant, yet low, positive correlation, indicating very limited convergent validity. They also show discriminant validity. While the psychometric measure correlates significantly with the risk attitude measure based on lotteries and the intrinsic risk attitude measure, it does not correlate with the strength of preference function, apparently because the strength of preference function does not measure risk attitude.

The tests of nomological validity produce a striking pattern of results. The risk attitude measure derived from the psychometric framework shows a relationship with the attitude and intention variables. Managers who describe themselves as more risk averse appear to be less innovative, less market orientated, and more intent on reducing fluctuations in net income and profit margin. However, no relationship was found between the psychometric scale and actual behavior. For risk attitude measures derived from the expected utility framework, the reverse pattern emerges. The intrinsic risk measure showed no relationship to the attitude and intention variables, while the lottery was associated only with the manager's intention to reduce profit fluctuations. In contrast, both the lottery and intrinsic risk measures were significant predictors of the manager's choice of market channel, the incidence of using futures contracts, and the number of trades.

One possible explanation for these findings is that responding to lotteries may elicit a mental set that resembles daily decision-making behavior. The choice between a 50% chance of receiving either a relatively high or a relatively low price and receiving a fixed price is quite similar to the choices these managers make, i.e., selling in the cash market and hence being exposed to price risks (a "lottery") or selling forward in the futures market and hence fixing the price.

The psychometric scale, on the other hand, performs better with respect to the self-report scales. This may be explained by the fact that both attitudes and intentions and the psychometric scale are on an

"opinion" level (See Sherman 1980, Lance et al. 1994). Although managers may truly consider themselves to be risk-takers, their actual behavior (as compared to that of others) may reveal patterns inconsistent with this self-assessment.

An important goal in marketing and management research is to understand and predict actual market behavior. Our findings imply that when investigating decision-making behavior under risk, it may be advisable to use measurement methods based on the expected utility model (lotteries) to reveal preferences.

Unfortunately, the lottery assessment task is relatively time consuming, and is best performed through relatively expensive face-to-face interviews. In contrast, psychometric scales can be implemented relatively quickly and easily, though they may not be as predictive of actual behavior.

Also note that in this study, the intrinsic risk measure appeared to perform slightly better than the measures derived from lotteries. This confirms the results of Weber and Milliman (1997). Therefore, if one decides to use lotteries, it seems wise to include strength of preference measurement as well.[6]

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Appendix A

Table A1 Function Specifications

Lottery	Rating	Intrinsic risk measure
Function		
$u(x) = \frac{1 - e^{-a(x-x_L)}}{1 - e^{-a(x_H-x_L)}}$	$v(x) = \frac{1 - e^{-b(x-x_L)}}{1 - e^{-b(x_H-x_L)}}$	$u(x) = \frac{1 - e^{-cv(x)}}{1 - e^{-c}}$
Estimation function		
$x_l = \frac{\ln(0.5(e^{-ax_l} + e^{-ax_h}))}{-a}$	$v(x_l) = \frac{1 - e^{-b(x_l-x_L)}}{1 - e^{-b(x_H-x_L)}}$	$u(x_l) = \frac{1 - e^{-cv(x_l)}}{1 - e^{-c}}$
$+ e_l$	$+ e_l$	$+ e_l$

x_H and x_L denote the upper and lower bound respectively of the outcome range. In the estimation function for the lottery technique, x_l and x_h represent the low and high outcomes of the lottery, and x_l represents the assessed certainty equivalent. For the rating technique, x_l is the price level that the respondent valued on a 10-point scale (indicated by $v(x_l)$), and x_H and x_L denote the highest and lowest price level presented. All parameters estimated using least squares estimates obtained by Fletcher's Quasi-Newton Method (see Smidts 1997).

Appendix B Confirmatory Factor Analysis Results of the Measures

To examine the measurement quality of the constructs (Steenkamp and van Trijp 1991), confirmatory factor analysis has been performed using LISREL 8 (Jöreskog and Sörbom 1993). The input for the analysis consisted of covariance matrices. In what follows, RMSEA is the root mean square error of approximation, GFI the goodness-of-fit index, TLI the Tucker–Lewis index, and the CFI the comparative fit index (Jöreskog and Sörbom 1993).

Managers were asked to indicate their agreement with each item on a nine-point scale ranging from "strongly disagree" to "strongly agree" for the following constructs:

Innovativeness

1) I buy new products before my colleagues (competitors) buy them
2) I like to experiment with new ways of doing things
3) I take chances more than others do
4) I generally like trying out new ideas in my enterprise

Construct reliability = 0.76; Fit-indices: $\chi^2 = 8.37$ (df = 2, $p = 0.01$); RMSEA = 0.09; GFI = 0.99; TLI = 0.95; CFI = 0.98

Market orientation

1) I think it is important to understand the wishes of my customers
2) I think it is important to know how my customers evaluate my product
3) I adapt to changes in the market
4) I think it is important to know a lot of the end-users

Construct reliability = 0.72; Fit-indices: $\chi^2 = 4.54$ (df = 2, $p = 0.08$); RMSEA = 0.06; GFI = 0.99; TLI = 0.96; CFI = 0.99

Psychometric scale

1) I am willing to take high financial risks in order to realize higher average yields
2) I like taking big financial risks
3) I am willing to take high financial risks when selling my hogs, in order to realize higher average yields

Construct reliability = 0.72; model is saturated.

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