European Review of Agricultural Economics Vol **43 (1)** (2016) pp. 113–135
doi:10.1093/erae/jbv013
Advance Access Publication 8 June 2015

A comparison of hypothetical risk attitude elicitation instruments for explaining farmer crop insurance purchases

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Received September 2013; final version accepted February 2015

Review coordinated by Giannis Karagiannis

Abstract

This article presents evidence on the stability and behavioural validity of alternative survey mechanisms for eliciting farmers' attitudes towards risk. Three hypothetical instruments are considered that differ in terms of the simplicity, context and payoff scale of the decision presented to respondents. Responses are assessed in terms of their relative ability to explain actual farmer crop insurance purchases. Results indicate that measures of risk attitudes are poorly correlated across alternative mechanisms. The strongest positive evidence of behavioural validity is found for the gamble task explicitly defined in the context and scale of farmers' economic activities pertaining to their insurance purchase decision.

Keywords: risk preferences, lottery-choice tasks, crop insurance

JEL classification: D81, Q12

1. Introduction

Risk and uncertainty are fundamental elements of modern microeconomic theory and are ubiquitous in economic decisions. In agricultural production farmers are confronted with a wide-range of potential risks to their farming income due to crop diseases, pests, price fluctuations and weather events. Not only do these risks ultimately affect farmers' bottom-lines, but attitudes towards risk have been shown to influence how farmers manage their operation including crop-selection and crop-rotation schemes (El-Nazer and McCarl, 1986), adopt new technologies (Purvis *et al.*, 1995) and affect the environment and compliance with environmental policies (Ozanne, Hogan and Colman, 2001; Brick, Visser and Burns, 2012). Given the pervasive presence of risk in

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agricultural production and its importance to understanding and predicting economic behaviour, market outcomes and policy assessment (Harrison, 2011) as well as serving as a control variable in econometric analysis of individual decision making, it is critical to develop instruments that consistently and meaningfully measure individual risk attitudes. Measures of individual risk attitudes are commonly included in a wide range of econometric models of individual behaviour across the spectrum of applied economic fields including agriculture (Lusk and Coble, 2005), development (Giné and Yang, 2009; Liu, 2013), energy (Qiu, Colson and Grebitus, 2014), health (Anderson and Mellor, 2008) and resource economics (Eggert and Martinsson, 2004). Several elicitation approaches have been developed in the literature with the two most common procedures either based upon hypothetical or non-hypothetical lottery-choice tasks (e.g. Binswanger, 1980; Holt and Laury, 2002; Harrison, Lau and Rutström, 2007; Eckel and Grossman, 2008; von Gaudecker, van Soest and Wengström, 2011; Bocquého, Jacquet and Reynaud, 2014), simple survey questions (e.g. Barsky *et al.*, 1997; Dohmen *et al.*, 2011) or a combination of methods (Pennings and Garcia, 2001; Franken, Pennings and Garcia, 2012).

Despite the popularity of lottery-choice tasks and survey questions, there are a number of concerns surrounding these risk attitude elicitation methods whose resolution is critical for developing best practices for future studies and building confidence that they are indeed fruitful for explaining real-world agent behaviour. In this study, we present new evidence on the stability and behavioural validity of alternative hypothetical mechanisms for the elicitation of farmers' attitudes towards risk. This focus contributes to a growing literature contrasting different mechanisms to elicit risk attitudes (Berg, Dickhaut and McCabe, 2005; Anderson and Mellor, 2009; Dave *et al.*, 2010; Reynaud and Couture, 2012; Maart-Noelck and Musshoff, 2013) and assessing the behavioural validity of experimental and survey methods to measure risk preferences (Barsky *et al.*, 1997; Harrison, Lau and Towe, 2007; Hellerstein, Higgins and Horowitz, 2013). We consider three relatively simple, quickly implemented hypothetical elicitation instruments and test their power in explaining actual farmer decisions in crop insurance markets. The first two instruments have previously been employed in the literature while the third is a new adaptation of previous methods. The first method is the quick, straightforward survey question recently considered by Dohmen *et al.* (2011) that asks individuals to self-assess their willingness to take risks without defining any context or payoff scale. The second method is similar to the approach introduced by Eckel and Grossman (2008) that confronts participants with a series of small-stakes 50–50 gambles including a sure payoff and several risky choices with linearly increasing expected payoffs. The third method is our proposed modification of the gamble-choice task by Eckel and Grossman (2008) that aims to increase the similarity and relevance of the task with the actual economic decision of interest. This is achieved by recasting the Eckel and Grossman (2008) approach in a context and scale that directly pertains to the risk setting of the actual behaviour that we attempt to explain. In contrast to the second method in which no context for the gambles is provided, in the proposed approach the gambles are in terms of

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the respondent's annual income from his economic activity. We contrast the measures of farmer-specific risk attitudes elicited across these three mechanisms and assess their behavioural validity by testing how well each measure correlates with farmer insurance purchase decisions. Other things equal, across the three instruments we expect to elicit lower levels of risk aversion for farmers who did not purchase insurance than for farmers who bought insurance.

Our focus on quick, easily implemented, hypothetical mechanisms to measure individual-specific risk attitudes is driven by two practical factors faced by researchers, particularly when conducting research with farmers in high-income countries. Previous research using real-money lottery-based tasks and television game show data have found that individuals exhibit different degrees of risk aversion depending upon the size of the risky payoff (Holt and Laury, 2002; Bombardini and Trebbi, 2012). This raises the question of whether the small-stakes gambles commonly considered in the literature (e.g. Andersen *et al.*, 2010) are capturing the appropriate attitude towards risk of individuals in real-world settings involving more substantial stakes (see Rabin, 2000 for a discussion of the theoretical foundations for this result).[1] For researchers attempting to measure farmer risk attitudes in high-income countries, this poses a serious dilemma. Farming decisions such as crop selection, number of pesticide applications or crop insurance participation involves a gamble over substantial sums of money. For example, the apple and grape farmers in the region considered in this study must decide every year whether to put their annual farm gross income at risk (about EUR 70,000 on average) or purchase hail insurance at a cost that varies between 2.2 and 9.6 per cent of crop value. While the economics literature is generally in agreement that financially incentive compatible methods are preferred when feasible due to evidence of potential hypothetical bias (e.g. List and Gallet, 2001; Murphy *et al.*, 2005; Harrison and Rutström, 2008), most researchers do not have sufficient funds to conduct lottery-choice tasks over monetary domains on the order of farm income in developed countries and could benefit from an accurate hypothetical measure to rely upon.[2] Furthermore, due to the opportunity cost of farmer time when conducting research studies, there is a trade-off between fast methods such as the approach considered by Dohmen *et al.* (2011) and more time-consuming lottery-based tasks that involve instructions, cheap-talk scripts and multiple decisions. If both yield similar measures of risk attitudes and behavioural validity, the parsimony of a single straightforward survey question would be desirable.

1 The same concern regarding the lack of realism of experimental studies involving small stakes gambles and the limited generality of the risk preference estimates obtained from such experiments is not new and was raised by Kahneman and Tversky (1979: 265). However, the evidence on the presence of a stake size effect in economic experiments is mixed (see, for example, Slonim and Roth, 1998; Camerer and Hogarth, 1999; Johansson-Stenman, Mahmud and Martinsson, 2005; Kocher, Martinsson and Visser, 2008).

2 A study of farmer time preferences by Duquette, Higgins and Horowitz (2011) involved non-hypothetical choices over payments on the order of US$ 400. To our knowledge, this is among the largest payment sums in a preference experiment conducted with farmers.

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In addition to the financial constraint dilemma researchers face when choosing a mechanism to elicit farmer risk attitudes, there are potential concerns regarding the context in which the study is framed. In the pioneering lottery-choice task studies proposed by Holt and Laury (2002) and Eckel and Grossman (2008), individuals were asked to choose among a menu of alternative gambles with differing degrees of risk and monetary returns. In these studies, the monetary payoffs of the alternative gambles presented to individuals were not framed in terms of a specific context (e.g. a gamble over family income, returns on a stock investment or health care expenditures). While theoretically the utility an individual gains from a unit of money is independent of the circumstance of the gamble, previous research has indicated that individuals display different behaviour towards risk in different contexts such as financial, recreational, ethical or health-related decisions (MacCrimmin and Wehrung, 1986, 1990; Weber, Blais and Betz, 2002; Reynaud and Couture, 2012). Even within a common family of risk choices such as household auto and home insurance decisions (Barseghyan, Prince and Teitelbaum, 2011) and financial decisions (Einav *et al.*, 2012), there is strong evidence of risk context dependence. Under the presumption that risk attitudes are context and scale dependent, we constructed a new gamble task that is tailored with regard to these two features and test whether responses in the task exhibit greater behavioural validity (i.e. if responses elicited with this instrument better correlate with the actual insurance decision).

In the remainder of this article we first describe the survey design and farmer sample. Then, we present a comparison of risk attitudes across the three hypothetical risk elicitation mechanisms and an unconditional analysis relating the different measures to farmer crop insurance purchases. In the next section we use regression analysis to assess the behavioural validity of the three mechanisms to analyse the relationship between risk attitude measures and actual crop insurance purchase decisions controlling for an array of farmer-specific factors. Finally, we conclude.

2. Survey design

To evaluate the relative performance of three alternative hypothetical risk attitude elicitation mechanisms, in 2011 we conducted a survey of 98 farmers in the Province of Trento, Northern Italy. Farmers, as opposed to students, university populations or the general public, were selected for the purposes of this study for three primary reasons. First, as discussed in the 'Introduction' section, obtaining reliable measures of farmer risk attitudes is critical for understanding and analysing farm-level behaviour. Due to the magnitude of the financial risks farmers face and their high opportunity cost of time, easily implemented consistent and meaningful hypothetical risk measurement instruments are a much needed tool for empirical agricultural research. Second, in order to assess the potential impact of framing risk preference elicitation tasks in the appropriate context and payoff domains related to economic decisions, it was critical to have a sample of individuals engaged in a common risky economic activity. Third,

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farmers are prominent in the literature as a popular population subsample for conducting risk experiments due to the nature of their profession entailing regular decisions under risk and uncertainty arising from the inherent weather and price risks in agricultural production (e.g. Lybbert and Just, 2007; Just and Lybbert, 2009; Herberich and List, 2012; Menapace, Colson and Raffaelli, 2013). They are a natural sub-population for contrasting alternative elicitation instruments and testing the performance of experimental and survey outcomes on real-world choices. Farmers were recruited via the local agricultural extension service as to provide a representative sample of professional farmers in the area.

Data were collected via a touch-screen computer-assisted face-to-face interview. To engage participants in the risk preference tasks and mitigate potential biases due to the hypothetical nature of the study we proceeded as follows. We used a short cheap-talk script with each participant, gave farmers a gift for participation (a hacksaw or a pruning shear valued at approximately EUR 30) and promised individual feedback regarding the outcome of the study as a non-monetary incentive as in Reynaud and Couture (2012).

2.1. Self-assessment of risk preferences

The first measure of risk preferences elicited from the sample of farmers was a straightforward self-assessment of their willingness to take risk: 'On a scale from 1 to 10, where 1 means "not at all willing to take risks" and 10 means "very willing to take risks", how would you assess your personal inclination to take risks?' This very simple and fast instrument to measure risk attitudes has been investigated by Dohmen *et al.* (2011) in a representative sample of the German population and by Reynaud and Couture (2012) in a sample of French farmers. The appeal of this approach for eliciting risk attitudes rests in its simplicity, giving its wide potential for collecting risk preference measurements at a very low marginal cost. However, because the question is devoid of any context for the underlying risk and its scale lacks a quantitative interpretation in terms of a risk aversion coefficient, there is potential concern as to whether such a measure captures actual risk preferences and agent choices in risky settings.

2.2. Lottery-choice tasks

Following the simple self-assessment of risk preferences, farmers engaged in two different hypothetical lottery-choice tasks.[3] Among the variety of lottery-based instruments that have been proposed in the literature, the procedure of Eckel and Grossman (2008) distinguishes itself for its simplicity; an important

3 The three risk preference tasks were delivered from simplest to most complex in order to avoid potential bias from fixating farmers on income prior to the self-assessment and small stakes gamble. This leaves open the possibility of framing and ordering effects on the elicited risk measures. A comprehensive analysis of such effects is left for future research.

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feature that potentially minimises choice errors by participants.[4] In the Eckel and Grossman task (hereafter EG), subjects are confronted with a set of 50–50 gambles including a sure outcome and several risky outcomes with linearly increasing expected payoffs and risk (measured as the standard deviation of expected payoffs).

Following the approach by Eckel and Grossman (2008), participants were presented two sets of 11 gambles (one sure outcome and 10 risky outcomes). Gambles were numbered from #1 to #11 in order of ascending risk, with gamble #1 being the sure item. For each set of gambles, farmers were asked to select the most preferred among the 11 possible gambles. In the first set of gambles shown to participants, which we refer to as the *Few Euro Gambles*, the gamble payoffs were constructed in terms of modest Euro quantities. Specifically, the sure outcome consisted of a payoff of EUR 10 and the payoffs in risky outcomes were payoff pairs ranging from EUR 9 and EUR 12 (the least risky pair) to EUR 0 and EUR 30 (the most risky pair). For this choice task, participants were asked to select their most preferred gamble. No other information or reference to any specific context beyond the monetary payoffs and probabilities was given for this task.

The second set of gambles presented to participants, which we refer to as the *Farm Income Gambles*, was constructed analogously to the *Few Euro Gambles*, but the hypothetical payoffs consisted of sizable shares of the respondent's annual farm ordinary gross income and the gambles specifically concerned farming income. The motivation for this task was to engage farmers in the relevant domain of the actual risk they face from farm crop losses which is farmer specific due to differences in farm income. In contrast to the no context setting of the *Few Euro Gambles*, this gamble task required more instructions about the decision scenario and hence more time for farmers to complete the task. Before farmers were shown this task, they were asked to quantify in Euros their own ordinary gross annual farm income which, as used in the context of agricultural appraisal, refers to the income that a farmer would receive in a normal year. The concept of ordinary income is intuitive to farmers and was explained prior to the task. Once a farmer stated his ordinary gross annual farm income he was asked to consider himself in a situation in which he was given the option to determine, by selecting one from a set of possible gambles, the percent of his ordinary gross annual farm income that he would receive as farm income in that year. Specifically, farmers could select one among different gambles that included a sure outcome consisting of a payoff of 100 per cent of his annual farm ordinary gross income and 10 risky outcomes that consisted of income-percent pairs from 90 to 120 per cent and 0 to 300 per cent of annual farm ordinary income. See Figure 1 for a screenshot of the *Farm Income Gambles* decision made by farmers.

4 Another potential advantage of the Eckel and Grossman task over the widely popular Holt and Laury (2002) task is that it may not be subject to the problem of confounding risk preferences with individual non-linear weighting of probability (Drichoutis and Lusk, 2012).

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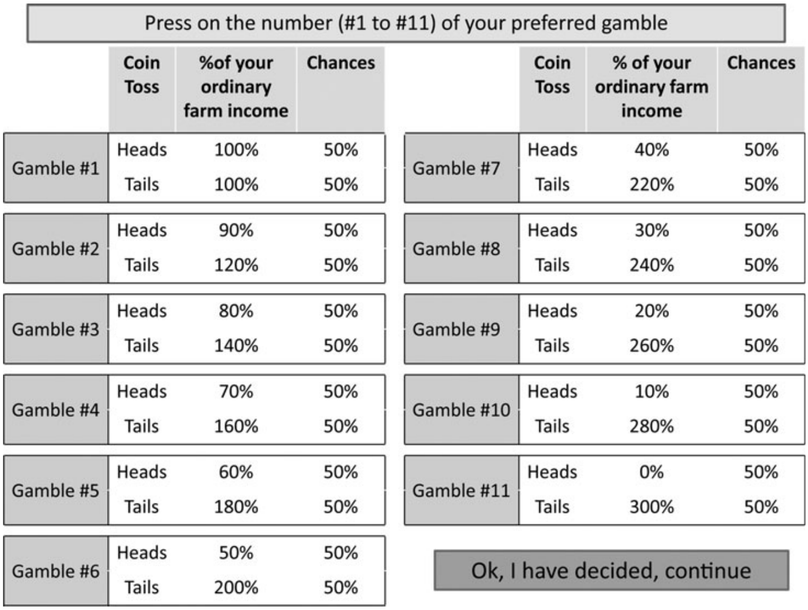

Press on the number (#1 to #11) of your preferred gamble							
	Coin Toss	%of your ordinary farm income	Chances		Coin Toss	% of your ordinary farm income	Chances
Gamble #1	Heads	100%	50%	Gamble #7	Heads	40%	50%
	Tails	100%	50%		Tails	220%	50%
Gamble #2	Heads	90%	50%	Gamble #8	Heads	30%	50%
	Tails	120%	50%		Tails	240%	50%
Gamble #3	Heads	80%	50%	Gamble #9	Heads	20%	50%
	Tails	140%	50%		Tails	260%	50%
Gamble #4	Heads	70%	50%	Gamble #10	Heads	10%	50%
	Tails	160%	50%		Tails	280%	50%
Gamble #5	Heads	60%	50%	Gamble #11	Heads	0%	50%
	Tails	180%	50%		Tails	300%	50%
Gamble #6	Heads	50%	50%	Ok, I have decided, continue			
	Tails	200%	50%				

Fig. 1. Farm income gamble (English Translation from Italian).

The two different lottery-choice tasks are summarised in Table 1. The first three columns contain information displayed on the computer screen for each participant in both of the lottery-choice tasks: the gamble number (from #1 to #11), the choice events (Heads or Tails for a fair coin toss) and the probability of each event (50 per cent and 50 per cent). The final piece of information displayed for participants, the payoffs corresponding to each gamble number, differed between the two tasks. In Table 1, the column marked *Few Euro Gambles* describes the Euro payoffs used in one task and the column marked *Farm Income Gambles* describes the farm income percentages used as payoffs in the other task. The final three columns of Table 1 are calculations (not presented to participants) describing the expected payoff, standard deviation of the expected payoff and a range of values of the relative risk aversion coefficient, r. Specifically, the range of values of r corresponds to the possible values of the relative risk aversion coefficient of an individual choosing that particular gamble under the assumption of the constant relative risk aversion (CRRA) utility function, $U(w) = w^{1-r}/(1 - r)$, the most popular functional form used to characterise risk attitudes (Harrison *et al.*, 2007).

As in EG, in both gamble tasks the gamble numbers are linearly related to the properties of the gambles (expected return and standard deviation) so that the gamble number can be used as a parametric summary index of risk preferences. Furthermore, the gambles were designed to satisfy some important properties. First, payoffs feature only prominent numbers conferring simplicity to the task, reducing subjects' cognitive efforts and limiting rounding and decision-making errors. Second, for comparison among the two gamble tasks, gamble

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Table 1. Summary of lottery-based tasks

			Payoff				
Gamble	Coin toss	Chances (%)	Few Euro gambles (EUR)	Farm income gambles (per cent of income)	Expected payoff[a]	Risk[a,b]	CRRA ranges[c]
#1	Heads	50	10	100	$1.00 \times X$	$0.00 \times X$	$r > 4.92$
	Tails	50	10	100			
#2	Heads	50	9	90	$1.05 \times X$	$0.15 \times X$	$1.64 < r < 4.92$
	Tails	50	12	120			
#3	Heads	50	8	80	$1.10 \times X$	$0.30 \times X$	$1.00 < r < 1.64$
	Tails	50	14	140			
#4	Heads	50	7	70	$1.15 \times X$	$0.45 \times X$	$0.72 < r < 1.00$
	Tails	50	16	160			
#5	Heads	50	6	60	$1.20 \times X$	$0.60 \times X$	$0.56 < r < 0.72$
	Tails	50	18	180			
#6	Heads	50	5	50	$1.25 \times X$	$0.75 \times X$	$0.45 < r < 0.56$
	Tails	50	20	200			
#7	Heads	50	4	40	$1.30 \times X$	$0.90 \times X$	$0.38 < r < 0.45$
	Tails	50	22	220			
#8	Heads	50	3	30	$1.35 \times X$	$1.05 \times X$	$0.30 < r < 0.38$
	Tails	50	24	240			
#9	Heads	50	2	20	$1.40 \times X$	$1.20 \times X$	$0.24 < r < 0.30$
	Tails	50	26	260			
#10	Heads	50	1	10	$1.45 \times X$	$1.35 \times X$	$0.16 < r < 0.24$
	Tails	50	28	280			
#11	Heads	50	0	0	$1.50 \times X$	$1.50 \times X$	$r < 0.16$
	Tails	50	30	300			

[a] $X = 10$ in the *Few Euro Gambles* and $X = 100$ per cent of ordinary income in the *Farm Income Gambles*.
[b] Measured as standard deviation of expected payoff.
[c] Calculated as the range of values of r in the CRRA function $U(w) = w^{1-r}/(1-r)$ for which a subject would chose a given gamble.

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payoffs were constructed in such a way that, under the assumption that preferences are represented by the CRRA utility function, the range of values of the relative risk aversion coefficient for which a subject prefers a given gamble is the same across both the *Few Euro Gambles* and the *Farm Income Gambles* tasks. Finally, compared with EG who used only five gambles, we have a finer grid with 11 gambles to increase the precision of risk preference measurements.

3. Measures of farmer risk attitudes

Table 2 presents a breakdown of responses by participants across the three risk preference elicitation tasks. Under the assumption of CRRA, the responses in the *Few Euro Gambles* and the *Farm Income Gambles* are directly comparable in terms of their implied risk aversion. Such direct comparison is not possible in the case of the self-assessment survey question, whose scale cannot be converted to values of the risk aversion coefficient.

Comparing the two gamble tasks, farmers chose, on average, smaller gamble numbers in the *Farm Income Gambles* task than in the *Few Euro Gambles* task. The mean gamble selected by respondents is 3.20 in the *Few Euro Gambles* with a standard deviation of 2.76 and the mean gamble in the *Farm Income Gambles* is 2.01 with a standard deviation of 1.30. A paired *t*-test for the equality of the means of the selected gamble across the two tasks is rejected at the 1 per cent significance level. As well, comparing the distribution of selected gambles using a Kornbrot test, the null hypothesis that the distribution of responses is equal is rejected at the 1 per cent significance level (Kornbrot, 1990). Converting the gamble choices into relative risk aversion coefficients for preferences characterised by CRRA, the average values of the CRRA coefficients implied by the *Few Euro Gambles* and the *Farm Income Gambles* are 2.80 and 3.71, respectively (for the first and last gambles, 5.5 and 0.08 are, respectively, used as the class midpoints).

Table 2. Summary of respondents' preferred choices (%)

Gamble #	Self-assessment	Few Euro gambles	Farm income gambles
1	3.1	35.7	45.9
2	4.1	17.4	26.5
3	12.2	18.4	18.4
4	9.2	3.1	3.1
5	26.5	6.1	1.0
6	9.2	10.2	5.1
7	9.2	2.4	0.0
8	17.4	0.0	0.0
9	3.1	0.0	0.0
10	6.1	0.0	0.0
11	–	7.1	0.0

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A closer look at farmer-level responses reveals a clear picture of the difference in behaviour under the two tasks and the impact on estimates of CRRA coefficients. Nearly half of the participants (45.9 per cent) chose equivalent gamble numbers in both the *Few Euro Gambles* and the *Farm Income Gambles*. For this subset of participants, the average CRRA coefficient is equal across the two tasks with a value of 3.70. For the remaining 54.1 per cent of respondents who chose different gamble numbers in the two tasks, 39.8 per cent chose a less risky alternative in the *Farm Income Gambles* than in the *Few Euro Gambles* while only 14.3 per cent chose a more risky alternative. Considering this subset of respondents who changed their gamble choices across the two tasks, the implied CRRA coefficient characterising their attitude towards risk is substantially different across tasks. The average CRRA coefficient for individuals who switched to a different gamble between the *Few Euro Gambles* and the *Farm Income Gambles* is 1.71 in the former and 3.09 in the latter task. Hence, individuals who responded differently in the two tasks displayed substantially more risk aversion in the income-based task, but still not to the degree of the average participant who selected the same gamble number across both tasks. Overall, the degree of risk aversion that we find is higher than that found in most studies of alternative populations (e.g. general population, farmers in developing countries, students), which using small-stake gamble tasks uncovered CRRA coefficients at or below unity (e.g. Liu (2013) finds an average CRRA coefficient for Chinese farmers of 0.71 and Andersen *et al.* (2010) finds an average CRRA coefficient for a sample of the Danish population between 0.63 and 0.79 depending upon the treatment). Nevertheless, the degree of risk aversion that we find is similar to the findings of Reynaud and Couture (2012) for French farmers using the Eckel and Grossman (2008) approach where the risk free gamble was chosen by a sizable share of farmers and the riskier gambles had low or no attendance.

Although not directly comparable to either of the gamble tasks, the self-assessment of willingness to take risks displays substantially more heterogeneity, in the sense that the self-assessment scores span the entire scale from ‘not at all willing to take risks’ to ‘very willing to take risks’, a feature that does not appear to correspond well with responses to the *Farm Income Gambles* in particular. The modal response of the self-assessment question is 5 with a mean of 5.64 and standard deviation of 2.26. Overall, responses to the self-assessment question match well with the findings of Dohmen *et al.*, (2011) who found in their representative sample of the German population a modal response of 5 on a 11-point scale and a standard deviation of 2.4 (or 2.18 if rescaled to a 10-point scale). The weak relationship between the self-assessment scores and the selected gambles in the gamble tasks is further confirmed by comparing the Pearson correlation coefficients between all three risk preference elicitation mechanisms. There is a moderate positive correlation between the *Few Euro Gambles* and the *Farm Income Gambles* of 37 per cent (in terms of the selected gamble number). However, the correlation between the *Farm Income Gambles* and the self-assessment question is nearly zero

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(2 per cent). Further, the correlation between the *Few Euro Gambles* and the self-assessment is even negative (−10 per cent). Again, the correlation across all three measures is weak at best, further indicating that they are not delivering similar assessments of farmer risk attitudes.

4. Relationship between risk measures and crop insurance purchases

While it is clear from the previous section that there are substantial differences between risk preference measures obtained via the very simple and quickly implemented self-assessment, the slightly more involved hypothetical small Euro stakes lottery-based task and the more complex lottery-based task framed in the context and scale of risk actually faced by participants in their economic activities, the critical question remains if these measures are fruitful in explaining actual farmer behaviour. For the farmers considered in this study, a relevant risk to annual income is uncontrollable losses due to hail. From time series data (1990–2011) provided by Consorzio Difesa Produttori Agricoli (Co.Di.Pr.A.), the body responsible for crop insurance for the entire agricultural sector, we have estimated that hail causes an average loss of 12 per cent of the aggregate crop value in the region under consideration, implying sizable percentage losses for individual farmers' income.[5] In the extremes, crop losses from hail can approach 100 per cent of individual annual farm income.

The primary instrument available to farmers in the region to mitigate the income losses attributable to hail precipitations is an insurance policy that pays an indemnity in the event of crop losses.[6] This insurance policy can be bought at identical conditions (e.g. premiums, deductibles, etc.) from Co.Di.Pr.A. or any insurance company. The insurance contract conditions are the result of collective bargaining actions lead by Co.Di.Pr.A. as the representative of the agricultural sector. In our sample, about 80 per cent of farmers have purchased hail insurance. This share matches well with the fact that about 80 per cent of the crop value is insured against hail in the Province of Trento (Trentino Corriere delle Alpi, 2013).

Based upon the standard theory of risk, it would be expected that, *ceteris paribus*, farmers who are more risk averse are more likely to purchase insurance against crop losses due to hail events. In this section we test whether the measures of risk preferences obtained via the three considered instruments have power in explaining whether farmers decide to purchase hail insurance.

5 A 12 per cent damage has been calculated by averaging the county-wide ratios of indemnities paid to insured value over 57 'comuni' (counties) and 22 years (1990–2011). This is likely to be an underestimate of the actual damage since it does not take into consideration crop damage above the indemnities cap (90 per cent of insured value for a given farm) and below the threshold (crop damage must be above 30 per cent of crop value insured for a given farm).

6 For readers more familiar with traditional yield or revenue crop insurance policies in the USA, the hail policy available in the Province of Trento, Italy, is slightly different and simpler. Farmers essentially face a binary decision whether to purchase hail insurance for a given crop on their entire farm or no hail insurance. Farmers are not able to choose their desired coverage level (e.g. 65 per cent vs. 85 per cent revenue guarantee), nor can they insure only a subset of the farm plots.

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Given that the insurance decision against hail resembles a large-scale gamble concerning farm income, *a priori* it is hypothesised that the risk preferences measured via the *Farm Income Gambles* will better capture the relevant attitude towards risk that corresponds with the actual insurance decision process.

In order to appropriately assess the relationship between risk preference measures and insurance purchases, the farmer survey included a number of questions designed to elicit individual-specific factors that could be hypothesised to be related to farmers decision to protect against farm income losses due to hail. In addition to standard socio-demographic and farm characteristics, a number of questions were included to collect data on farmers' past experiences with crop losses, future expectation of hail precipitations and exposure to information about insurance policies and crop risks. Table 3 provides a summary of the survey questions presented to the participants.

Farmers in the sample have an average age of 43.7 with 22.8 years of farming experience. As is typical in the region, farms are small with an average size of 5.2 hectare and the average monthly net income is EUR 2,380. The sample of farmers matches well with statistics from the annual survey of the Farm Accounting Data Network (FADN) for the region which found in 2010 the average farm size of perennial crop farmers is 4.8 hectare and the average net income is EUR 2,780 per month. Two questions regarding *Own Farm Recent Crop Damage* and *Other Farms Crop Damage* capture farmers' experience with hail damage in the region using a five-point qualitative scale ranging from 'no damage' to 'very heavy damage', and a dichotomous (yes/no) question, respectively. Based upon responses to these questions, the average farmer in the previous five years has experienced between light and moderate crop damage from hail and 89 per cent has personally seen very heavy crop damage on other farms in the region. To measure future expectations of hail risks, farmers were asked their perceptions of the *Expected Weather Conditions* on a five-point scale indicating their expectations that climatic conditions will lead to changes in hail precipitation intensity in the coming years. Responses show that farmers expect a moderate increase of hail precipitations. In addition, we have information about the 2011 hail insurance premiums paid by farmers (net of subsidies), which vary by county and range from 2.2 to 9.6 per cent of crop value.[7] Premiums are determined annually by Co.Di.Pr.A. for each county and are based on a deterministic formula that accounts for historical damages.[8] To account for the impact of information exposure on insurance decisions, three questions were included concerning farmer membership in a cooperative and their attendance at farmer information events. The majority of farmers (94 per cent) are members of a local cooperative. Slightly more than half of the farmers reported that they had attended the

7 Premiums are publically subsidised. Subsidies are calculated as a percentage (equal across all farmers) of the gross premium faced by farmers. Note that the premiums reported above represent actual costs to the farmers (i.e. net of subsidies). For any given crop, farmers in a given county face the same premium.

8 The formula is a weighted average of past damage for a given county, with decreasing weights for more distant years. The actual formula was not revealed to us by Co.Di.Pr.A.

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Table 3. Farm and farmer characteristics

Variable name	Variable definition	All farmers ($n = 98$) Mean	All farmers ($n = 98$) Std. dev.	Insurance buyers ($n = 79$) Mean	Insurance buyers ($n = 79$) Std. dev.	Non insurance buyers ($n = 19$) Mean	Non insurance buyers ($n = 19$) Std. dev.
Farm and farmer characteristics							
Age		43.66	11.99	44.06	12.28	42.00	10.84
Education	Number of years of schooling	10.86	2.63	10.66	2.59	11.68	2.69
Farming experience	Number of years operating as a farmer	22.76	11.87	23.28	11.67	20.58	12.76
Full time	1 if a full time farmer	0.89	0.32	0.91	0.29	0.84	0.37
Farm size	Number of hectare	5.19	2.61	5.17	2.54	5.29	2.93
Apple	Per cent of farm land with apple orchards	84.98	27.68	89.33	23.38	66.89	36.48
Cultivated/owned	Per cent of cultivated land that is owned	74.10	29.00	72.52	30.04	80.68	23.80
Net income	Household monthly net income (1,000 Euro/month)	2.38	1.31	2.43	1.39	2.14	0.91
Liquidity unconstrained	1 if able to pay 20,000 Euro within 5 days to cover an unforeseen expense	0.69	0.46	0.68	0.47	0.74	0.45
General level of concern	Average stated concern (10 point scale) over 10 risk factors	6.12	1.58	6.19	1.49	5.82	1.93
Probability test score	Number of probability questions correctly answered	3.47	1.24	3.52	1.19	3.26	1.45
Past damage and crop risk information							
Own farm hail damage	0 – none; 1 – light; 2 – moderate; 3 – heavy, 4 – very heavy	1.76	1.12	1.78	1.15	1.63	0.97
Other farms hail damage	1 if seen very heavy crop damage in other farms	0.89	0.54	0.94	0.54	0.70	0.53
Insurance premium	Hail insurance premium (per cent of crop value)	3.87	1.50	3.80	1.42	4.16	1.80
Expected weather	Expect weather conditions for hail to become more frequent (0–4 scale)	2.33	0.82	2.43	0.86	1.89	0.46
Coop member	1 if a member of a farmer cooperative	0.94	0.24	0.95	0.22	0.89	0.32
Co.Di.Pr.A. meeting	1 if attended an information session by Co.Di.Pr.A in 2011	0.56	0.50	0.62	0.49	0.32	0.48
Information sessions	Number of recently attended information sessions or related booklets read	4.99	2.39	5.26	2.34	3.89	2.32

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2010 information session by Co.Di.Pr.A.[9] With regard to the information sessions organised by the extension services during the previous year, 4.99 is the average number of information sessions attended or booklets summarising the information session read (booklets summarising the content of information sessions are regularly prepared by the extension service).

Finally, based upon previous literature on risk attitudes and economic decisions under uncertainty (Mansour *et al.*, 2008; Dohmen *et al.*, 2009, 2010), three additional sets of questions were asked of participants. A set of seven probability tasks, adapted from Fischbein and Schnarch (1997), was used to assess participants' ability to process probabilistic information. On average, the sample of farmers correctly answered 3.47 questions out of seven. To control for potential liquidity constraints influencing farmers' ability to purchase crop insurance, a binary question labelled *Liquidity Unconstrained* was included. Nearly 70 per cent of farmers indicated that they would be able to pay EUR 20,000 within 5 days to cover an unforeseen expense. Finally, to capture farmers' general level of concern/optimism, 10 different risk factors on a 10-point scale were used to construct a composite score of farmers' *General Level of Concern*.

4.1. Unconditional comparison of risk measures and crop insurance purchases

Before turning to regression analysis to control for potentially confounding farmer-specific factors, in this section we present a simple unconditional analysis of the relationship between the three risk attitude measures and farmer crop insurance decisions. Tables 4–6 present a breakdown of the gamble number choices made by farmers in each of the three mechanisms. Responses are categorised for crop insurance purchasers and non-purchasers. Table 4 shows the average gamble number selected by farmers. As can be seen, for the self-assessment question and the *Farm Income Gambles* the average decision by farmers is nearly identical between those who purchase crop insurance and those who do not. For the case of the *Few Euro Gambles*, the average selection by crop insurance purchasers is larger than for those who did not purchase crop insurance. Although the difference is not statistically significant (paired *t*-test), the result is counter to expectations in that those farmers who purchase crop insurance tend to make selections that are more risky in the *Few Euro Gambles*.

To further contrast responses between the *Few Euro Gambles* and the *Farm Income Gambles*, Table 5 presents average farmer selections for the subset of farmers that selected the same gamble number in both tasks. Table 6 presents the average selections for the subset of farmers who selected different gamble numbers in the two tasks. First, looking at Table 5, the average selection is

9 During the annual meeting (which is repeated in several locations across the region to facilitate farmers attendance), Co.Di.Pr.A. provides extensive statistical information to farmers including an overview of historical crop damage data in the area and simulations of financial performance under different risk scenarios with and without insurance.

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Table 4. Average selected gamble number by farmers ($N = 98$)

Buy crop insurance?	Self-assessment	Few Euro gambles	Farm income gambles
Yes ($N = 79$)	5.6 (2.2)	3.4 (3.0)	2.0 (1.3)
No ($N = 19$)	5.7 (2.5)	2.4 (1.3)	2.1 (2.3)

Note: Standard deviation in parentheses.

Table 5. Average selected gamble number by farmers who choose the same gamble number in each lottery task ($N = 45$)

Buy crop insurance?	Few Euro gambles	Farm income gambles
Yes ($N = 33$)	1.9 (1.5)	1.9 (1.5)
No ($N = 12$)	2.2 (1.5)	2.2 (1.5)

Note: Standard deviation in parentheses.

Table 6. Average selected gamble number by farmers who choose a different gamble number in each lottery task ($N = 53$)

Buy crop insurance?	Few Euro gambles	Farm income gambles
Yes ($N = 46$)	4.6 (3.3)	2.1 (1.1)
No ($N = 7$)	2.7 (1.1)	1.8 (0.9)

Note: Standard deviation in parentheses.

slightly lower among farmers who purchase crop insurance (1.9) compared with those who did not purchase (2.2). While this conforms to expectations, the difference is not statistically significant. In Table 6, a more marked difference is revealed. For farmers who chose different gamble numbers in the two tasks, a contradictory result is found for the *Few Euro Gambles* but not the *Farm Income Gambles*. Among this subset of farmers, the average gamble selection in the *Few Euro Gambles* is greater (i.e. less risk averse) among those farmers who purchased crop insurance than for those who did not purchase crop insurance. As a whole, the unconditional analysis shows little or no correspondence between the selections in the elicitation tasks and insurance purchase decisions. In what follows, regression analysis controlling for other farmer-specific factors is performed to assess the relationship between decisions in the three risk elicitation tasks and crop insurance behaviour.

4.2. Regression analysis of risk measures and crop insurance purchases

To complement the unconditional results in the previous section, further analysis of the relationship between the three risk elicitation mechanisms and crop insurance decisions is presented controlling for farmer- and farm-specific

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characteristics. Tables 7 and 8 present coefficient estimates and average marginal effects (AMEs) from five standard probit models, each with the same dependent variable taking a value of 1 if the farmer purchased a crop insurance policy for the current year (2011) and 0 otherwise. The independent variables, which are described in Table 3, are equivalent across the five models except for the specification of the *Risk Aversion* variable, which varies in each model. For the three regressions in Table 7, the *Risk Aversion* variable is represented, respectively, by the gamble number selected by the farmer in the *Farm Income Gambles* and in the *Few Euro Gambles*, and the score on the 10-point scale in the *Self-Assessment* question. Additionally, exploiting the mapping between the gamble choices and the risk aversion coefficient under the assumption that preferences are represented by CRRA, two additional regressions are presented in Table 8. In these two regressions for the *Farm Income Gambles* and the *Few Euro Gambles*, the measure of risk aversion is the midpoint of each CRRA class corresponding to the selected gamble.

The estimated relationships between the different measures of risk preferences and insurance purchases presented in Tables 7 and 8 tend to be in line with our expectations of the superiority of the lottery task framed in the context of shares of annual farm income. The estimated effect of both the gamble number and the CRRA coefficient calculated using the *Farm Income Gambles* on the hail insurance purchase decision are statistically significant at the 10 per cent level (0.083 and 0.053 *p*-values, respectively) and present the expected sign (negative for the gamble number and positive for the CRRA coefficient). This indicates, as theory would dictate, that farmers who displayed greater levels of risk aversion in the *Farm Income Gambles* are more likely to purchase crop insurance. Specifically, on average the probability of purchasing crop insurance increases by about 3 per cent for a one point increase in the value of the CRRA coefficient obtained from the *Farm Income Gambles*. Similarly when using the gamble numbers as a measure of risk attitudes, the AME is −3.9 per cent.

At standard levels, no statistically significant relationship between risk preferences elicited in the *Few Euro Gambles* task and insurance purchases is found using either the gamble number (0.69, *p*-value) or the associated CRRA coefficient (0.16, *p*-value). This indicates, as hypothesised, that there is not as strong a correspondence between decisions in a hypothetical small-stakes Euro gamble and actual behaviour in the context of substantial stakes involving actual economic activities. When considering the self-assessment of risk attitudes a similar result is found. The relationship is not statistically significant (0.18, *p*-value).

Considering other variables included in the model to control for additional factors other than risk preferences on insurance decisions, results fall largely in line with expectations. Given the relatively homogenous sample of individuals in the study, none of the socio-demographic variables except education and income have a statistically significant effect on the likelihood of insurance purchases. As intuition suggests, farmers who perceive future hail risk to become more pronounced are more likely to purchase insurance (AME ranging

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Table 7. Probit estimates and AMEs of farmer insurance participation using selected gamble numbers and self-assessment scores

	Farm income gamble task		Few Euro gamble task		Self-assessment question	
Variable name	Coef.	AME	Coef.	AME	Coef.	AME
Risk aversion	0.188*	0.031*	0.108	0.019	0.113	0.019
	(0.097)	(0.016)	(0.077)	(0.014)	(0.084)	(0.015)
Age	0.007	0.001	0.006	0.001	0.004	0.001
	(0.019)	(0.003)	(0.019)	(0.003)	(0.020)	(0.003)
Education	−0.144	−0.024	−0.193*	−0.033*	−0.212**	−0.036**
	(0.109)	(0.017)	(0.114)	(0.018)	(0.104)	(0.017)
Farming experience	0.006	0.001	−0.001	0.000	0.002	0.000
	(0.022)	(0.004)	(0.023)	(0.004)	(0.022)	(0.004)
Full time	0.470	0.079	0.458	0.079	0.613	0.105
	(0.609)	(0.102)	(0.576)	(0.098)	(0.607)	(0.104)
Farm size	0.010	0.002	0.024	0.004	0.013	0.002
	(0.071)	(0.012)	(0.067)	(0.012)	(0.070)	(0.012)
Apple	0.017**	0.003***	0.017**	0.003***	0.017**	0.003***
	(0.007)	(0.001)	(0.007)	(0.001)	(0.007)	(0.001)
Cultivated/owned	−0.007	−0.001	−0.006	−0.001	−0.009	−0.002
	(0.007)	(0.001)	(0.007)	(0.001)	(0.007)	(0.001)
Net income	0.314	0.052**	0.364*	0.063**	0.374**	0.064**
	(0.203)	(0.030)	(0.204)	(0.032)	(0.186)	(0.030)
Liquidity unconstrained	−0.621*	−0.104	−0.713	−0.124	−0.721	−0.124
	(0.487)	(0.077)	(0.476)	(0.080)	(0.461)	(0.077)
General level of concern	0.189	0.032	0.194	0.034	0.133	0.023
	(0.109)	(0.018)	(0.122)	(0.021)	(0.114)	(0.019)
Probability test score	0.090	0.015	0.098	0.017	0.120	0.021
	(0.201)	(0.033)	(0.199)	(0.034)	(0.196)	(0.033)
Own farm hail damage	0.072	0.012	0.081	0.014	0.032	0.005
	(0.180)	(0.030)	(0.173)	(0.030)	(0.180)	(0.031)
Other farms hail damage	0.407	0.068	0.308	0.053	0.353	0.061
	(0.448)	(0.073)	(0.482)	(0.082)	(0.479)	(0.081)
Insurance premium	−0.112	−0.019	−0.132	−0.023	−0.159	−0.027
	(0.126)	(0.021)	(0.134)	(0.024)	(0.130)	(0.023)
Expected weather	0.546**	0.091**	0.508**	0.088**	0.503**	0.086**
	(0.239)	(0.040)	(0.223)	(0.039)	(0.228)	(0.038)
Coop member	0.458	0.077	0.346	0.060	0.212	0.036
	(0.767)	(0.128)	(0.778)	(0.134)	(0.725)	(0.124)
Co.Di.Pr.A. meeting	0.894*	0.149*	0.899*	0.156*	0.916*	0.157**
	(0.535)	(0.082)	(0.519)	(0.083)	(0.478)	(0.078)
Information sessions	0.124	0.021	0.128	0.022	0.113	0.019
	(0.081)	(0.014)	(0.083)	(0.015)	(0.082)	(0.014)
Constant	−4.206**		−3.035		−2.323	
	(2.027)		(2.162)		(2.170)	
Wald Chi^2	35.47**		26.26		31.01**	
R^2	0.391		0.373		0.374	
Log-likelihood	−29.34		−30.23		−30.18	

Note: Standard deviation in parentheses.
*,**,*** denote 10, 5 and 1 per cent significance levels, respectively.

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Table 8. Probit estimates and AMEs of farmer insurance participation using CRRA coefficients

	Farm income gamble task		Few Euro gamble task	
Variable name	Coef.	AME	Coef.	AME
Risk aversion	−0.226*	−0.039*	0.021	0.004
	(0.130)	(0.022)	(0.053)	(0.009)
Age	0.005	0.001	0.001	0.000
	(0.019)	(0.003)	(0.019)	(0.003)
Education	−0.155	−0.027	−0.181	−0.032*
	(0.111)	(0.017)	(0.113)	(0.018)
Farming experience	0.006	0.001	0.002	0.000
	(0.023)	(0.004)	(0.023)	(0.004)
Full time	0.334	0.057	0.473	0.083
	(0.606)	(0.103)	(0.584)	(0.102)
Farm size	0.010	0.002	0.014	0.002
	(0.067)	(0.011)	(0.067)	(0.012)
Apple	0.016**	0.003***	0.016**	0.003***
	(0.007)	(0.001)	(0.007)	(0.001)
Cultivated/owned	−0.008	−0.001	−0.005	−0.001
	(0.007)	(0.001)	(0.007)	(0.001)
Net income	0.319	0.055*	0.293	0.052
	(0.201)	(0.031)	(0.198)	(0.032)
Liquidity unconstrained	−0.631	−0.108	−0.620	−0.109
	(0.485)	(0.079)	(0.480)	(0.081)
General level of Concern	0.191*	0.033*	0.152	0.027
	(0.112)	(0.019)	(0.119)	(0.021)
Probability test score	0.096	0.016	0.072	0.013
	(0.199)	(0.034)	(0.199)	(0.035)
Own farm hail damage	0.039	0.007	0.014	0.002
	(0.178)	(0.030)	(0.177)	(0.031)
Other farms hail damage	0.370	0.063	0.324	0.057
	(0.464)	(0.077)	(0.485)	(0.084)
Insurance premium	−0.095	−0.016	−0.149	−0.026
	(0.128)	(0.022)	(0.135)	(0.024)
Expected weather	0.490**	0.084**	0.478**	0.084**
	(0.231)	(0.040)	(0.222)	(0.039)
Coop member	0.372	0.064	0.248	0.044
	(0.773)	(0.132)	(0.733)	(0.129)
Co.Di.Pr.A. meeting	0.928*	0.159*	0.821	0.145*
	(0.542)	(0.085)	(0.525)	(0.087)
Information sessions	0.129	0.022	0.127	0.022
	(0.079)	(0.014)	(0.081)	(0.015)
Constant	−2.558		−1.945	
	(1.981)		(2.012)	
Wald Chi^2	29.16*		21.92	
R^2	0.381		0.362	
Log-likelihood	−29.85		−30.75	

Note: Standard deviation in parentheses.
*,**,*** denote 10, 5 and 1 per cent significance levels, respectively.

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approximately between 8 and 9 per cent over all models). As well, operators with a higher percentage of acreage dedicated to apples are more likely to purchase insurance reflecting the higher susceptibility of apples to hail (for each additional percentage of land used for growing apples farmers on average have a 0.3 per cent higher probability of purchasing crop insurance). Information effects are found as farmers who had attended the 2010 annual member meeting organised by the local farmer association responsible for crop insurance are about 15 per cent more likely to purchase insurance.

5. Conclusion

Despite having a long history in economic analysis, risk preferences remain a difficult individual-specific attribute to quantify in empirical settings. While recent advances in survey and experimental methods offer tremendous promise for the potential to elicit risk preferences, the consistency of measurements across different experimental methods and the issue of behavioural validity remain an open question. In this article, we have contrasted three alternative hypothetical methods for assessing risk preferences that vary in terms of their simplicity and contextual framing and payoff scale. The evidence strongly suggests that risk preference measurements differ substantially across (i) a simple quickly implemented self-assessment devoid of any contextual or monetary farming, (ii) a small-stakes gamble task with no contextual framing and (iii) a more time-consuming large stakes gamble with a specific framing in terms of income related to actual economic activities. Additional analysis relating the three mechanisms to actual market behaviour finds the strongest support for the latter approach in explaining farmers' hail insurance purchase decision. However, it is important to note that the observed variation in crop insurance purchases is far from being perfectly correlated with our measurements of risk preferences, implying that economic researchers attempting to control for risk posture in behavioural regressions should be prepared to observe measurement error and perhaps some ambiguity about what is being measured. This is a potential consequence of using an elicitation method in lieu of observed field data. Further, the evidence that three similar hypothetical risk preference elicitation methods deliver different assessments of risk attitudes suggests that further research is needed to further explore the impact of design elements (e.g. potential framing effects) on measures. Overall, the results of this study indicate that it is advisable to design risk preference elicitation instruments that engage participants in the appropriate domain of analysis and despite the opportunity cost of using a gamble task approach to elicit risk preferences in lieu of a simple single survey question, there may be a return for researchers from the investment due to the greater behavioural validity of the measure.

Acknowledgements

This research was funded by the Autonomous Province of Trento, Big Projects 2006, ENVIROCHANGE and Reintegration Post-Doc 2010, EBC-Risk. We

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thank the extension service personnel of the Edmund Mach Foundation and Co.Di.Pr.A. for help in the recruitment of the sample and data.

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