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Risk attitudes of foresters, farmers and students: An experimental multimethod comparison

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Abstract

Many economic decision situations of foresters and farmers are characterized by risk. Thereby, the individual risk attitude is of particular interest for understanding decision behaviour and, thus, is fundamental for valuable policy recommendations. The literature provides various methods to measure risk attitude, however, their respective suitability has not been sufficiently tested. Furthermore, existing analyses focus mostly on students and the field of resource economics for farmers. However, there is a lack of knowledge regarding the risk attitude of foresters and how it compares to farmers and students' attitudes. Therefore, we investigate to what extent results are comparable across different methods and whether the risk attitude of foresters differs from that of farmers and forestry students. To analyse this issue, we conduct an incentivized online experiment using the Holt and Laury (HL) task, the Eckel and Grossman (EG) task and a self-assessment (SA) questionnaire. As a result, SA values do not correlate with the HL values, but the EG values correlate with the HL values across all groups, although, risk-aversion coefficients differ. According to the HL task and the EG task, we reveal higher risk aversion for foresters in comparison to farmers, while forestry students do not differ from foresters.

Keywords

Risk attitude, foresters, farmers, Holt and Laury task, Eckel and Grossman task, self-assessment of risk attitude

1 Introduction

Most economic decisions have to be taken in the presence of risk. Foresters and farmers especially are exposed to several types of risks since they have to deal with a specific type of production risk (e.g., plant diseases) including weather risks which are going beyond ordinary business risks such as price and demand variability (Hardaker 2004). These risks are reflected for instance in the decision of choosing the optimal tree species or crop to cultivate (Moschini and Hennessy 2001; Herberich and List 2012). Such wide-ranging decisions influenced by risk are significantly affected by the risk attitude of the respective decision-maker (Eckel and Grossman 2008). For example, risk-averse decision-makers may prefer a tree species or a crop with a lower yield variation rather than one with greater yield variation, which is associated with higher expected yields (Hardaker 2004). In contrast, risk-neutral decision-makers focus exclusively on the expected value and risk-seeking decision-makers strive for higher potential income. Therefore, the risk attitude of a decision maker essentially influences each decision with uncertain outcomes. Knowledge of farmers and foresters' risk attitudes is inevitably associated with understanding and forecasting their economic behaviour (Maart-Noelck and Musshoff 2014). Thus, measuring risk attitude is of particular- interest for understanding decision behaviour and, therefore, fundamental for valuable policy recommendations.

Experimental elicitation of risk attitudes has become very popular (Lönnqvist *et al.* 2011), which is primarily due to the advantages attributed to this approach in comparison to the econometric estimation alternatives that are based on field data. The main disadvantage of the field data based estimations is that field data are often only available on an aggregated level (Roe and Just 2009). Moreover with respect to field data, the framework conditions that influence the decision are very heterogeneous between individuals, specifically in consideration of financial constraints and the number of decision alternatives (Eswaran and Kotwal 1990). Additionally, it is often not possible to establish a connection between the risk attitude and the socio-demographic characteristics of the decision-makers due to an overall lack of information on the data (Yavaş and Sirmans 2005).

In recent years, the experimental Holt and Laury (HL) task (Holt and Laury 2002) has become one of the most applied elicitation methods for measuring risk attitude. The HL task has evolved into a so-

called “gold standard” (cf. Anderson and Mellor 2009) which has set a benchmark for newly developed tasks that are intended to measure risk attitude. Nevertheless, additional methods for measuring the risk attitude have been developed in an effort to enhance the shortcomings of the HL task, specifically with respect to comprehension difficulties. Alternative methods which have the advantage of being cognitively easier to understand have been introduced for instance by Eckel and Grossman (2008), as well as Dohmen *et al.* (2011). Generally, the measured risk attitude should be consistent across various methods because of the expectation that all of these methods result in the same risk attitude. Nevertheless, previous experimental investigations for eliciting the risk attitude exhibit a possible method-dependence (Lönnqvist *et al.* 2011; Reynaud and Couture 2012; Maart-Noelck and Musshoff 2014). Thus far, most of the research comparing the risk attitude when measured with different methods focuses on one specific group of participants. Convenience groups, such as students, often serve as experiment participants as it is a typical for experiments in the field of economics (Harrison and List 2008). Students have the advantage that they are easy to recruit, constitute a homogenous group and have higher incentive compatibility, all factors which make them an interesting group for experiments in general. However, conclusions drawn from experiments with students and transferred on a specific group of entrepreneurs are sometimes viewed critically (Khera and Benson 1970; Harrison and List 2008); each method must therefore be individually tested for each group of entrepreneurs. Furthermore, the validity of results based on the decisions of one industry-specific group, lead to restricted transferability of conclusions to another branch-specific group (Egan *et al.* 1997; Brush *et al.* 2000). For professional branch-specific group, such as foresters, little research has been done regarding the experimental analysis of their risk attitude. Only a few studies have elicited the risk attitude of foresters, Musshoff and Maart-Noelck (2014) for instance carry out an HL task with foresters and use the elicited risk attitude to explain inconsistencies of experimentally observed harvesting decisions with investment theories. However, the risk attitude of foresters is not analysed and the risk attitude is not obtained through the use of different lottery-based methods in order to compare the results.

In consideration of this, the present study pursues the objective of eliciting the risk attitude of foresters, farmers and forestry students by using three different methods. In particular, we carry out an

online experiment that is comprised of the HL task (Holt and Laury 2002), the Eckel and Grossman (EG) task (Eckel and Grossman 2002) and the self-assessment (SA) questionnaire on the risk attitude according to Dohmen *et al.* (2011); foresters, farmers and forestry students then serve as the participants for the experiment. Based on the experimental data, we compare the EG task and the SA with the HL task to evaluate whether the results of these methods are comparable. We examine the EG task and the SA specifically since they are associated with having different advantages than the HL task when used for eliciting risk attitude (Dave *et al.* 2010; Dohmen *et al.* 2011) Additionally, we compare the separate groups of foresters, farmers and forestry students with regard to their risk attitude.

This study is an extension of the existing literature regarding four aspects: First, to the best of our knowledge, this is the first study that investigates whether the EG task and the SA are suitable substitutes for the HL task when measuring the risk attitude of foresters, farmers and forestry students. Thus, we extend the methodological comparisons of previous research studies with a comparison of multilevel methods. Second, we are the first who experimentally measure and analyse the risk attitudes of foresters. Third, by comparing the stated risk attitudes between foresters and farmers, we are the first that provide insight into potential differences between these two groups; potential differences are especially necessary for appropriate policy implications. Fourth, we compare the risk attitude of foresters and forestry students to investigate whether students can adequately be used as substitutes for foresters in experiments within the field of forestry economics research. Since experiments are an upcoming method in forestry economics, we can contribute to the development of this methodical approach by testing the suitability of students as subjects for risk-related forestry economics experiments.

The hypotheses are derived from the existing literature in Section 2, while the experimental design is presented in Section 3. Subsequently, Section 4 presents the descriptive statistics and the validity of the hypotheses is tested. The article ends with conclusions and future research perspectives, as provided in Section 5.

2 Literature review and hypotheses

Since risk attitude is a key issue in economic decision-making, it is often evaluated in behavioural-economic studies (cf. in the field of agricultural economics: Reynaud and Couture 2012; Maart-Noelck and Musshoff 2014; Musshoff and Maart-Noelck 2014). These studies typically employ experiments, especially lotteries and self-assessments via questionnaires, in order to obtain results. In comparison to self-assessments, lottery-based experiments hold the advantage of reflecting the participants' inherent choice, rather than reflecting their self-perception. The participant's choice is further supported by financial incentives in a lottery-based experiment. When using lotteries, risk attitude can be quantified in terms of the constant relative risk aversion (CRRA) coefficient. The HL task has been established as a standard in achieving the CRRA (Anderson and Mellor 2009) because it comprises several decision situations (typically ten or twenty), each of which constitute the choice between two lotteries, one being a safe option and one a risky option. Thereby, the lottery values are held constant throughout all decision situations, while probabilities for winning the higher, and the respective lower, value are systematically varied. This approach allows for the risk measurement to take place within one table and has the advantageous possibility of transferring the taken decisions into a risk utility function (Abdellaoui *et al.* 2011). However, thereby obtained CRRA coefficients might be biased, for which reason the HL task is also criticized. One point of criticism regarding the HL task is its structure, which only allows for the specification of a certain range of CRRA coefficients (Abdellaoui *et al.* 2011). Furthermore, the HL task may suffer from framing effects, since participants might change from the rather safe to the riskier lottery in the central row of decisions (Lévy-Garboua *et al.* 2012). Due to the varying probabilities in the HL task, the results may suffer from probability weighting (Abdellaoui *et al.* 2011). According to Tversky and Kahneman (1992), this leads to more risk-averse behaviour for high probabilities and more risk-seeking behaviour for low probabilities. (4) The HL task demands that participants have high cognitive math abilities in order to reveal meaningful results (Eckel and Grossman 2002; Dave *et al.* 2010).

Alternatively, the EG task is also based on lottery selection and, thus, allows for depicting CRRA values. In contrast to the HL task, the EG task comprises constant probabilities, while changing lottery

values throughout the process. Thus, probability weighting is fixed and equal for all lotteries; changing values, however, might introduce stake effects. The EG task allows for a less cognitively demanding choice on behalf of participants in comparison to the structure of the HL task (Dave *et al.* 2010).

Although there are some differences between the HL and the EG tasks, both methods are based on the selection of lotteries, which is why their incentive systems can be comparably designed. From doing so, one might expect equal results. Indeed, Harrison and Rutström (2008) conducted the HL task as well as the lottery of Binswanger (1980), which is comparable to the EG task, with students and concluded that both methods reveal roughly the same results in terms of CRRA coefficients. Dave *et al.* (2010) worked with Canadian residents and found comparable results with the HL and EG tasks, but only for participants with high cognitive math abilities; respective results differ for participants with lower abilities. Loomes and Pogrebna (2014) conducted their experiments with student participants, where they found highly significant rank correlations between the HL and the EG tasks; they found, however, that the transferability of precise estimates of the CRRA coefficient between these two lotteries is limited. Reynaud and Couture (2012) applied the EG and HL tasks on French farmers and came to the conclusion that the results of both methods are correlated, though the HL task results in lower risk aversion than the EG task. Generally, the regarded studies found correlating results, while actual CRRA coefficients mostly differ in their magnitude. However, none of these studies have focused on foresters and none compare the risk attitude measured across groups for testing the stability of results and group differences, specifically not in the field of resource economics. Future usage of elicitation methods in the context of resource economics raises the question of to which extent the results from the EG task can be compared with those from the HL task, especially with respect to foresters, farmers and forestry students. Condensing the findings from the literature, we reached the following hypothesis H1a that is to be investigated:

H1a: The EG task and the HL task result in diverging CRRA values, however, their elicited risk attitudes correlate at all groups: foresters, farmers and forestry students.

Questionnaires are commonly used to measure risk attitudes, especially in household surveys. Conducting a Self Assessment questionnaire (SA) is less time consuming and costly because financial incentives are not necessary. Furthermore, the SA tends to be less complex in comparison to most experimental tasks (Lönnqvist *et al.* 2011). SA results feature a higher test-retest stability, although, SA results can hardly be standardized since the central decision for risk-neutrality is the only point of reference (Lönnqvist *et al.* 2011). Hence, an SA choice of one cannot be associated with a standardized risk-aversion value and, thus, it is interpreted subjectively. A recent important study in this field is that of Dohmen *et al.* (2011), whose household survey involved a question regarding the participants' self-perception of their general risk attitude, using an eleven-point Likert-type-scale (0: absolutely risk averse to 10: absolutely risk seeking). Maart-Noelck and Musshoff (2014) compared the results of the HL task with the SA of Dohmen *et al.* (2011), using German students and farmers, as well as Kazakhstani farmers as participants. They reveal correlations, however, only for their subgroups of German farmers and German students. In comparison, Lönnqvist *et al.* (2011) did not find any correlation between the HL task and the SA (according to Dohmen *et al.* (2011). Concerning the SA, they found correlation between personality traits and the outcome of a trust game; such correlations could not be confirmed for the HL task. Reynaud and Couture (2012) compared the HL task with the SA of Blais and Weber (2006) and is comparable to the questionnaire of Dohmen *et al.* (2011); they found correlating results of the SA with the HL task, however, only when using high payoffs in the HL task.[1] Overall, results on the comparison of the SA and the HL task do not lead to equal conclusions, while no direct comparison has yet been made between the HL task and the SA across the regarded occupational groups. Therefore, we condense the findings from the literature to form hypothesis H1b and examine its relevance:

H1b: The SA does not serve as an adequate surrogate for the HL task regarding the classification of the risk attitude for all groups: foresters, farmers and forestry students.

[1] For detailed information on hypothetical payoffs, we refer to Reynaud and Couture (2012).

To our knowledge, we are the first that compare the risk attitude of foresters with farmers and forestry students. All other relevant studies that were found measure the risk attitude of either foresters or farmers in relatively comparable circumstances.

In terms of the HL task, we lean our comparison on the studies of Musshoff and Maart-Noelck (2014) and Maart-Noelck and Musshoff (2014). Musshoff and Maart-Noelck (2014) carried out an experiment with German foresters and determined an average HL value[2] of 5.9 from ten decision situations, which exhibits a risk-averse risk attitude. Maart-Noelck and Musshoff (2014) examined the risk attitude of German farmers and revealed an HL value of 4.4 on average, indicating that they are slightly risk-averse. Brunette *et al.* (2014) analysed the risk attitude of French foresters by means of the EG task, where they obtained an average CRRA value of 1.15, without the use of financial incentives. Applying the EG task on French farmers in a non-incentivized experiment, Reynaud and Couture (2012) revealed an average CRRA value of 0.62 when using low hypothetical payoffs and 1.02 when using high hypothetical payoffs.

Regarding the comparison of students and an occupational group, Masclet *et al.* (2009) compared the risk attitude of students, salaried workers and self-employed workers. They found that self-employed participants exhibit an average HL value of 5.5 and, thus, are less risk-averse than students and salaried workers, who exhibit a very similar average HL value of 6.7 and 6.6, respectively. Maart-Noelck and Musshoff (2014) found significant differences between farmers and students by revealing an average HL value of 4.4 for German farmers and 5.8 for German students.

Due to widely varying experimental circumstances, a detailed comparison of the risk attitude among groups is not suitable. The conducted experiments differ in the selection of participants and the incentive system, among other divergences, which might influence the respective results. Still, regarding the comparison of the aforementioned studies, obvious differences between the risk attitude

[2] We use the term HL value for the number of safe choices (lottery A) in the HL task (cf. Holt and Laury 2002).

of famers and foresters are not expected. For the comparison of forestry students with foresters and farmers, differences are expected. Hence, hypothesis H2 is as follows:

H2: Measured risk aversion coefficients do not differ significantly between foresters and farmers; however, they do differ between forestry students and foresters, as along with farmers.

3 Experimental design

In the following section, we describe the three experimental tasks for measuring the risk attitude. First, the HL task is described, then the conducted EG task is shown and finally, the SA is illustrated. The fully detailed experimental design is depicted in the appendix.

3.1 Structure of the HL task

To determine the risk attitude according to Holt and Laury (2002), the participants were asked to choose between two lotteries (A and B) in 20 decision situations. The task conducted in the present analysis is an extension of the original HL task (Holt and Laury 2002); this extension was proposed originally by Laury *et al.* (2012). In lottery A, €180.00 or €144.00 could be gained, while in lottery B, participants could receive €346.50 or €9.00. The probabilities for winning one of these monetary amounts were systematically varied over the 20 decision situations. The higher amount (€180.00 or €346.50) for both lotteries was received with a probability of 5 per cent in the first decision situation while gradually being increased in each subsequent decision situation by an additional five per cent until it reaches 100 per cent in decision-making situation 20. The probability of winning the lower amount (€144.00 or €9.00) therefore corresponds to 95 per cent in decision situation one and then gradually being decreased in each subsequent decision situation by five per cent until 0 per cent is reached in decision situation 20. Lottery B was the riskier option since a greater range of possible outcomes (€346.50 or €9.00) compared to the possible outcomes in lottery A (€180 or €144) exists. Table 1 depicts the decision situations and the associated lotteries with their respective probabilities.

Table 1: HL task according to Laury *et al.* (2012)

Row	Lottery A			Lottery B		Difference between the expected values[†) ‡)]	Range of constant relative risk aversion if switching in this row[†) §)]
	Chance of gaining €180.00	Chance of gaining €144.00	Please choose one Lottery in each row	Chance of gaining €346.50	Chance of gaining €9.00		
1	5%	95%	A ○ ○ B	5%	95%	€119.93	$r \leq -2.48$
2	10%	90%	A ○ ○ B	10%	90%	€104.85	$-2.48 \leq r \leq -1.71$
3	15%	85%	A ○ ○ B	15%	85%	€89.78	$-1.71 \leq r \leq -1.27$
4	20%	80%	A ○ ○ B	20%	80%	€74.70	$-1.27 \leq r \leq -0.95$
5	25%	75%	A ○ ○ B	25%	75%	€59.63	$-0.95 \leq r \leq -0.70$
6	30%	70%	A ○ ○ B	30%	70%	€44.55	$-0.70 \leq r \leq -0.49$
7	35%	65%	A ○ ○ B	35%	65%	€29.48	$-0.49 \leq r \leq -0.31$
8	40%	60%	A ○ ○ B	40%	60%	€14.40	$-0.31 \leq r \leq -0.14$
9	45%	55%	A ○ ○ B	45%	55%	€-0.68	$-0.14 \leq r \leq 0.01$
10	50%	50%	A ○ ○ B	50%	50%	€-15.75	$0.01 \leq r \leq 0.15$
11	55%	45%	A ○ ○ B	55%	45%	€-30.83	$0.15 \leq r \leq 0.28$
12	60%	40%	A ○ ○ B	60%	40%	€-45.90	$0.28 \leq r \leq 0.41$
13	65%	35%	A ○ ○ B	65%	35%	€-60.98	$0.41 \leq r \leq 0.54$
14	70%	30%	A ○ ○ B	70%	30%	€-76.05	$0.54 \leq r \leq 0.68$
15	75%	25%	A ○ ○ B	75%	25%	€-91.13	$0.68 \leq r \leq 0.82$
16	80%	20%	A ○ ○ B	80%	20%	€-106.20	$0.82 \leq r \leq 0.97$
17	85%	15%	A ○ ○ B	85%	15%	€-121.28	$0.97 \leq r \leq 1.15$
18	90%	10%	A ○ ○ B	90%	10%	€-136.35	$1.15 \leq r \leq 1.37$
19	95%	5%	A ○ ○ B	95%	5%	€-151.43	$1.37 \leq r \leq 1.68$
20	100%	0%	A ○ ○ B	100%	0%	€-166.50	$1.68 \leq r \leq 2.25$

[†)] Column is not shown to participants.
[‡)] Expected value is the expected value of lottery A minus the expected value of lottery B.
[§)] A power utility function in the form $u(x) = \frac{x^{(1-r)}}{(1-r)}$ is assumed.

By determining the decision situation in which a participant switched from the safer lottery A to the riskier lottery B, the risk attitude of the participants could be determined. A risk neutral participant switches from choosing lottery A to choosing lottery B in decision situation 9, since the expected value of lottery B exceeds the expected value of lottery A for the first time in this decision situation. Therefore, a risk-averse participant chose the 'safe' option, A, eight times and consequently had, according to Laury *et al.* (2012), an HL value of eight. However, if a participant chose lottery A less than eight times, this preference indicated a risk-seeking behaviour. Switching after more than eight 'safe' choices therefore indicated a risk-averse participant. The CRRA value of a participant is located within the range given for the row wherein he/she chose lottery B for first time. For instance, a

participant with an HL value of 10 chose lottery B for the first time in row 11; therefore, the CRRA value is located in the range between the CRRA values of 0.15 and 0.28, as can be seen in Table 1.

3.2 Structure of the EG task

In the EG task, the participants were asked to choose one of nine lotteries in which they were most likely to participate. The lotteries in which they could participate in are shown in Table 2. Each lottery had a 50 per cent probability of winning payoff A and a 50 per cent probability of winning payoff B. Starting with a safe payment in lottery one, the span between the payoffs in A and B became greater with each additional lottery. These varying payoffs affected the overall expected value and the lotteries gradually became more risky. Lotteries one through five indicated a risk-averse participant, while lotteries seven through nine signify risk-seeking behaviour. Lottery six suggested a risk-neutral attitude since the expected value was maximized when choosing lottery six.

Table 2: EG task according to Reynaud and Couture (2012)

Lottery	Payoff A probability 50%	Payoff B probability 50%	Please choose your preferred Lottery	Difference between the expected values[†) ‡)]	Range of constant relative risk aversion[†) §)]
1	€170.00	€170.00	☐	€-41.45	r > 1.37
2	€136.00	€216.75	☐	€-35.07	0.97 < r ≤ 1.37
3	€102.00	€272.00	☐	€-24.45	0.68 < r ≤ 0.97
4	€68.00	€332.50	☐	€-11.20	0.41 < r ≤ 0.68
5	€51.00	€365.50	☐	€-3.20	0.15 < r ≤ 0.41
6	€34.00	€388.90	☐	€0.00	-0.15 < r ≤ 0.15
7	€25.50	€394.85	☐	€-1.27	-0.49 < r ≤ -0.15
8	€17.00	€396.95	☐	€-4.47	-0.95 < r ≤ -0.49
9	€4.25	€397.40	☐	€-10.62	r ≤ -0.95

[†)] Column is not shown to participants.
[‡)] The difference is calculated by the expected value of lottery six (greatest expected value) minus the expected value of the respective lottery.
[§)] A power utility function in the form $u(x) = \frac{x^{(1-r)}}{(1-r)}$ is assumed.

3.3 Structure of the SA according to Dohmen *et al.* (2011)

In an extensive household survey in Germany, Dohmen *et al.* (2011) implemented a measurement method for the individual risk attitude. Instead of choices between different lotteries with various

potential expected payoffs, they utilized a statement directed towards the individual risk attitude of participants. The participants then decided within a given 11-point scale how they see themselves concerning their risk attitude. A similar approach was taken for the present analysis, with the given question being shown in Table 3. The potential responses of the participants range from 'very risk averse' to 'very risk seeking'. Therefore, the decision to choose five on the scale reflected a risk-neutral decision-maker.

Table 3: Self-assessment (SA) of the risk attitude according to Dohmen *et al.* (2011)

How do you see yourself: Are you generally a risk-seeking person or do you try to avoid risks?	☐ 0 (not at all willing to take risks) ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 (risk is not relevant for my decisions) ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 (very willing to take risks)

3.4 Conducting the experiment

The experiment was carried out online from January to April 2014. Through various agricultural and forestry associations and organizations in Germany, practicing foresters and farmers were invited to participate in the experiment. Students were acquired by using an e-mail list of the forestry students at the university. The time to complete the experimental tasks and the socio-demographic questionnaire was around 9.7 minutes on average. In order to increase participants' motivation to think about and really apply themselves during the experiment, and thus to achieve more realistic decision situations, all sub-experiments are linked to monetary incentives. Two out of every 70 participants gained a cash premium, with one receiving the cash premium based on their respective decisions in the HL task and one receiving the cash premium based on their respective decisions in the EG task. For each selected winner of the cash premium in the HL task, a random decision situation (1-20) was drawn. The lottery

chosen by the participant in the drawn decision situation was actually performed for this participant. Therefore, the participant could win between €9.00 and €346.50. For the winner in the EG task, the individual cash premium was the result of the lottery that the participant chose in the EG task, with the potential cash premium varying between €4.25 and €397.40. The incentive structure is identical for each group (foresters, farmers and students).

4 Results

4.1 Descriptive statistics

A total of 116 foresters, 150 farmers and 100 forestry students participated in the experiment. Table 4 summarizes the descriptive statistics of participants, including information on their socio-demographic and risk-attitude-related variables.

Table 4: Descriptive statistics for participating foresters, farmers and forestry students

Parameters	**Average value (standard deviation)**		
	Foresters N=116	**Farmers N=150**	**Students N=100**
Gender (male: 0, female: 1)	0.13	0.11	0.31
Age (years)	43.97 (13.15)	36.71 (12.80)	23.09 (2.51)
University degree (no: 0; yes: 1)	0.88	0.41	0.15
Self-employed (no: 0, yes: 1)	0.12	0.87	-
Participation in previous experiments (no: 0; yes: 1)	0.39	0.55	0.53
Holt and Laury value (0 to 20)[†]	11.84 (4.57)	10.70 (4.28)	13.08 (3.84)
Eckel and Grossman value (1 to 9)[‡]	3.66 (2.76)	3.83 (2.75)	2.94 (2.01)
Self-assessment value (0 to 10)[§]	4.26 (1.90)	4.65 (1.79)	4.58 (1.93)

[†] 0 – 7: risk-seeking, 8: risk-neutral, 9 – 20: risk-averse
[‡] 0 – 5: risk-averse, 6: risk-neutral, 7-9: risk-seeking
[§] 0 – 4: risk-averse, 5: risk-neutral, 6-10: risk-seeking

The majority of participants were male, though the low percentage of female participants is representative, especially in agriculture and forestry enterprises (Pöschl 2004; FAO 2006). The share of participants with a university degree is very low for forestry students, indicating that most are undergraduates. Higher education and lower self-employment rates in forestry are associated with the fact that the majority of foresters are employed by public forestry agencies or large private forestry

companies, where academic education is often required. Farmers on the other hand typically manage their own farm, which is frequently inherited.

Table 4 depicts the descriptive statistics of the participants, as well as their risk attitude. When measuring the risk attitudes with the HL task, inconsistent lottery choices can occur. For example, a participant that initially chooses option A then switches to option B and switches back to option A in later decision situations. In our analysis, 21 per cent of participants revealed similar inconsistent lottery choices. Following Holt and Laury (2002), participants with inconsistent lottery choices can still be included in the analysis by counting only their safe choices (option A). In total, the average HL values point towards a slightly risk-averse attitude for farmers and foresters, and a risk-averse attitude for forestry students. The EG values exhibit risk-averse attitudes and have a comparable high standard deviation. The results from the average SA values indicate slightly risk-averse to almost risk-neutral attitudes for all groups. Collectively, our results suggest risk aversion, at least to some degree, for all participating groups across all methods.

A comparison of all groups and risk measurement methods has been developed in an effort to provide a graphical depiction (Figure 1) of risk attitudes. Since, the EG task reveals the smallest scale of all regarded methods, HL values were transformed into EG values by using the CRRA value, as stated in the HL task; each value was then assigned to its corresponding EG value. For the purpose of illustration, the SA values are also displayed, although lower and upper values are not standardized. This means that, e.g., a high SA value represents a risk-seeking attitude, which again indicates a negative, but not a distinct CRRA or a distinct EG value respectively.[3]

[3] SA values were transformed by calculation, with an SA value of 0 corresponding to an EG value of 1 (risk-averse), an SA value of 5 corresponding to an EG value of 6 (risk-neutral) and an SA value of 10 corresponding to an EG value of 9 (risk-seeking).

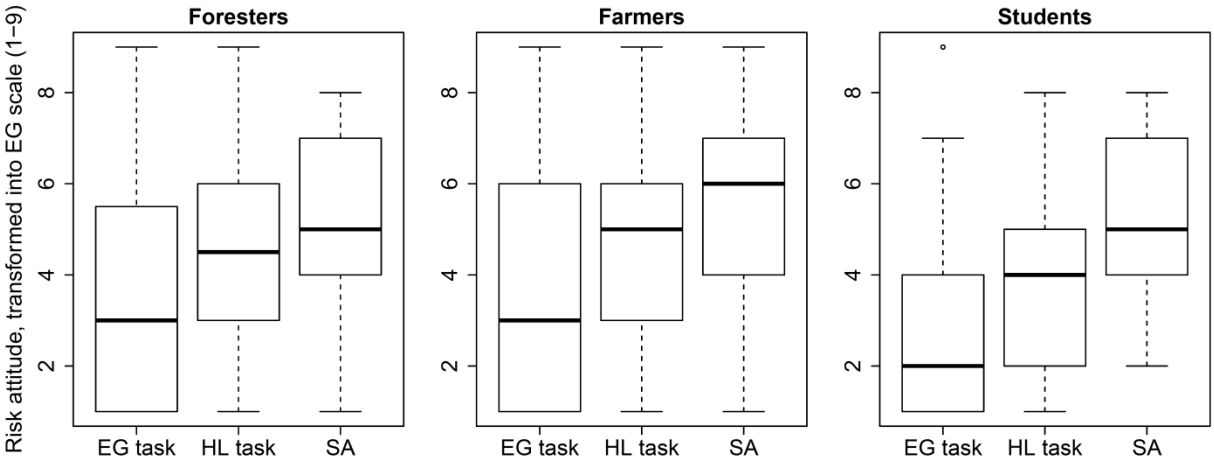

Figure 1: Risk attitude of foresters, farmers and forestry students measured with the Eckel and Grossman (EG) task, the Holt and Laury (HL) task and the self-assessment (SA). All obtained values are transformed into the EG scale (risk-averse: 1 to 5, risk-neutral: 6 and risk seeking: 7 to 9).

As shown in Figure 1, there is an indication of method dependency since the order of methods regarding the obtained values is similar for all groups. The usage of the EG task results in a lower median in comparison to the HL task, as well as in a higher standard deviation in the forester and farmer groups. The median value from the SA measurements is relatively close to risk neutrality for all groups.

4.2 Results regarding hypotheses 1 (a and b) -comparison of risk elicitation methods

For comparing the correlation of elicited risk attitudes across the regarded methods, we use the Spearman rank correlation coefficient (cf. Loomes and Pogrebna 2014). This nonparametric method is appropriate for our paired samples data. For simplification of interpretation, the reverse order of HL values was used. With respect to EG and SA values, the reverse HL values indicate increasingly risk-seeking behaviour with higher values.

Table 5: Spearman rank correlation coefficients for the correlation between the risk elicitation methods: the Holt and Laury (HL) task (results in reverse order) and the Eckel and Grossman (EG) task, as well as the self-assessment (SA)

	Foresters	**Farmers**	**Students**
HL task / EG task	0.203*	0.179*	0.284**
HL task / SA	0.115	0.072	0.171

Level of significance: *** p<0.001, ** p<0.01, * p<0.05

Regarding the correlation of the EG task and the HL task (Table 5), significant coefficients (at the 0.05 level) can be obtained for all groups, meaning that the HL value and the EG value are consistently correlated. This finding supports the results of Harrison and Rutström (2008) and Reynaud and Couture (2012), as well as Loomes and Pogrebna (2014).

Correlation results from the HL task and the SA reveal insignificant Spearman rank correlation coefficients. Thus, the SA is not an adequate surrogate for the HL task. This underlines the findings of Lönnqvist *et al.* (2011), as well as some of the subgroups from Maart-Noelck and Musshoff (2014). However, this finding contradicts the results of Dohmen *et al.* (2011) and Reynaud and Couture (2012), who reveal that the SA can predict lottery choices. The discrepancies between Reynaud and Couture (2012) and our results might be explained by the lack of financial incentives in their HL task.

As indicated in the descriptive statistics, the experimental methods exhibit differences in the obtained average CRRA values. To analyse these differences statistically, we conducted the Wilcoxon signed rank test, which is comparable to the Kornbrot test, and is used by Reynaud and Couture (2012). As a requirement of this test, we transformed results of both methods into the same scale; the scale from the EG task was chosen since it has the smallest range. HL values were transformed accordingly to their corresponding CRRA value into the corresponding EG value. For comparing the actual mean value of the HL task and the SA, the results of both methods were transformed into a common scale. Since the lowest value and the highest value of the SA are not standardized, the only common scale is a condensed risk classification of the three categories: risk-averse, risk-neutral and risk-seeking.

Table 6: P-values from the Wilcoxon signed rank tests on the comparison of the risk attitude according to the Holt and Laury (HL) task with the Eckel and Grossman (EG) task and with the self-assessment (SA)

	Foresters	**Farmers**	**Students**
HL task / EG task	0.006	0.000	0.001
HL task (†) / EG task (†)	0.740	0.237	0.875
HL task (†) / SA (†)	0.007	0.006	0.000

† Condensed risk classification with the categories risk-averse, risk-neutral and risk-seeking

As shown in Table 6, p-values obtained by the Wilcoxon signed rank test for the comparison of the HL with the EG values give clear evidence for the deviating average values at the 0.05 significance level for all groups. Additionally, by doing a one-sided Wilcoxon signed rank test we can confirm the findings of Loomes and Pogrebna (2014), as well as Reynaud and Couture (2012) that the EG task led to significantly lower CRRA values than the HL task[4].

When using the condensed risk classification (risk-averse, risk-neutral and risk-seeking) results for the HL and EG tasks, we have evidence of a common level of risk aversion. However, one has to keep in mind that the condensed risk attitude is a very rough estimate; even when applying this classification to the comparison of the HL task and the SA, test results exhibit clear evidence for differences. This means that the SA cannot serve as an adequate surrogate for the HL task simply by looking at the comparison of mean values.

As both of the regarded experimental methods, the HL task and the EG task, lead to significantly correlated results, hypothesis 1a can be confirmed. Moreover, this indicates that when analysing the influence of the risk attitude in the regression analysis, the EG task can be applied as an alternative for the HL task. This finding is valid for all regarded subgroups. However, the actual height of the risk attitudes elicited by the HL and EG tasks differ. The HL task reveals significantly higher CRRA values, implying that for the determination of actual CRRA values (e.g., for calculating the risk-adjusted interest rate), the EG task is not equivalent to the HL task.

[4]Even when taking into account only participants with consistent HL choices, we still find significant differences between CRRA values based on the EG task and the HL task at the 0.05 significance level for the farmer and forestry student groups, as well as at the 0.1significance level for foresters.

Since there are no significant correlations between the results of the HL task and the SA for any of the observed groups, hypothesis 1b can also be confirmed. Moreover, we have clear evidence for the differences between these two methods. This suggests that the SA cannot serve as an adequate surrogate for the HL task, neither for the regression analysis nor for the unambiguous comparison of results across studies.

4.3 Results on hypothesis 2 (comparison of risk attitudes across groups)

We conduct interval regressions to analyse the differences between foresters and farmers, as well as forestry students with respect to their risk attitude. This implies that foresters form the reference group of the analysis. By means of an interval regression, we rationalize the interval structure of the CRRA values that result from the HL and EG tasks and serve as dependent variables. Furthermore, we can control the influence of additional parameters on the risk attitude (cf. Harrison and Rutström 2008).

Table 7: Interval regressions on the CRRA value obtained from the conducted Holt and Laury (HL) task and the Eckel and Grossman (EG) task

	HL CRRA value	**EG CRRA value**
Constant	0.664**	0.998***
Gender (male: 0; female: 1)	-0.155	0.125
Age (years)	-0.005	-0.007
University degree (no: 0; yes: 1)	0.079	-0.122
Self-employed (no: 0, yes: 1)	0.202**.**	0.446*
Participation in previous experiments (no: 0; yes: 1)	-0.051	0.059
Farmer (no: 0; yes: 1)[†]	-0.35*	-0.497*
Student (no: 0; yes: 1)[†]	0.214	0.049
sigma	0.759	0.944

Level of significance: *** p<0.001, ** p<0.01, * p<0.05, **.** p<0.1
[†] Foresters serve as reference group, when both, "Farmer" and "Student" are equal to zero

Focusing on the influencing variables on the CRRA coefficients (Table 7), we observe a generally comparable structure for both methods in terms of characterizing the risk attitude of participants. The only significant variable at the 0.05 significance level is the dummy variable "Farmer"; additionally for the EG task, the dummy variable "Self-employed" is utilized. At the 0.1 significance level, the variable "Self-employed" is also significant for the CRRA coefficient from the HL task. If, for example, inconsistent choices were taken out of consideration in the HL task, the variable "self-employed" would also be significant at the 0.05 significance level, which underlines the comparability

of both risk measurements for the regression analysis.[5] The sigma value represents the estimated standard error of the interval regressions. Only small differences exist between the two risk measurements, where the HL task reveals a lower standard error and, thus, is more precise.

The significance of the variable "Farmer" reflects distinct differences in the risk attitudes of farmers and foresters. Ceteris paribus, famers exhibit lower CRRA coefficients than foresters in accordance with both methods; this implies that farmers are less risk-averse than foresters. Simultaneously, the EG and HL tasks reveal that self-employed participants are more risk-averse than employed (salaried) participants. When applying this insight to the employment structure in Germany, the main groups, self-employed farmers and employed foresters, reveal only small differences in their risk attitude. A separate interval regression which excludes self-employed foresters and employed farmers, reveal very small differences between the remaining foresters and farmers; these differences were not significant at the 0.1 significance level, neither for the HL task nor for the EG task. The impact of self-employment on the risk attitude in our analysis has the opposite effect as that observed by Masclet *et al.* (2009). However, their results are supported by the insignificant variable "Student", which states that forestry students have the same level of risk aversion as foresters. This implies that we can use forestry students as auxiliary group for foresters in the context of risk attitude.

Contrary to our expectations, the risk attitude differs for farmers and foresters; thus, we reject hypothesis 2. Furthermore, no differences between forestry students and foresters were established, which implies, however, that there are differences between forestry students and farmers. Famers are less risk-averse than foresters and forestry students. This effect is almost invalidated when taking into consideration that no significant differences are present with regards to the risk attitude of the main groups, employed foresters and self-employed farmers. However, in light of political implications,

[5] Not taking inconsistent lottery choices into consideration, however, is a matter under discussion. For instance, Andersen *et al.* (2006) stated that inconsistent lottery choices may reflect indifference between alternatives and, thus, should still be included in the analysis.

self-employed farmers and self-employed foresters mainly influence decision-making in their enterprises and these two groups exhibit distinct differences in their risk attitude.

5 Conclusions

Decisions made in the presence of risk are crucial affected by the risk attitude of the respective decision-maker. Hence, knowledge regarding the risk attitude of decision-makers in the agricultural and forestry sector is of special interest for understanding decision behaviour, as well as for contributing valuable policy recommendations. The present study examines the risk attitude of foresters, farmers and forestry students with three different elicitation methods. A within subject method comparison was carried out to investigate whether the risk attitudes measured by a lottery based and incentive compatible Eckel and Grossman (EG) task and the self-assessment (SA) are comparable to the lottery based and incentive compatible Holt and Laury (HL) task. The HL task is regarded as being the benchmark for such methods and is often referred to as the "gold standard". Moreover, we compare the risk attitude of foresters, farmers and forestry students in a between subjects comparison and investigate whether there are differences between the three groups.

Our results reveal that the risk attitudes elicited with lottery based tasks, namely the HL task and the EG task, are significantly correlated for foresters, farmers and forestry students. However, the HL task and the EG task do not depict the same average value for the constant relative risk aversion. On average, foresters, farmers and forestry students displayed a more risk-averse attitude in the EG task than in the HL task. The SA measured risk attitude, however, is not at all correlated with the HL task across all occupational groups. Additionally, we found significant differences in the degree of risk aversion for self-employed farmers and foresters, with foresters being more risk averse than farmers. Furthermore, forestry students reveal a degree of risk aversion that is comparable to salaried foresters and are therefore suitable experimentation surrogates for this specific group.

The difference in the risk attitude between farmers and foresters is especially relevant for political measures, specifically with respect to promoting risk management in the agricultural and forestry sector. It is necessary to take into account that self-employed foresters have higher amounts of risk

premia than self-employed farmers in order to design efficient policy measures. Based on our results, we can also conclude that the choice in methodology possibly affects the direction of a regression estimation coefficient for risk attitude because the results of the SA are not correlated with the results of the HL task. Additionally, detected differences in risk aversion could be solely based on different elicitation methods and should therefore be validated through the utilization of the same method. Furthermore, our results complement the findings of Loomes and Pogrebna (2014) in that the result of imprecise preferences across the different elicitation methods reveal a core structure which is stable over three occupational groups. It is necessary to mention here that each group was determined to have a lower degree of risk aversion the HL task than in the EG task. Psychological factors in the structure of the elicitation methods or in the illustration of the methods may be responsible for the differences between the three methods, something that should be addressed in future research. Furthermore, the risk attitude elicitation methods need to be tested with real forestry and farm data in order to further investigate which method best measures risk attitude. Moreover, such risk elicitation measurements should be conducted at various points in time with the same group of participants to test whether the findings are consistent over time. The risk attitude of other occupational groups from different sectors could additionally be examined to determine potential differences between occupational groups.

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Appendix

Experiment description, translation from German

Instruction

To investigate the influence of risk on your decision making behaviours, we offer different lottery opportunities. **There is no right or wrong answer!**

The experiment consists of two parts: First, you decide between different payouts, afterwards, you will be asked a few questions regarding your farm and yourself.

What can you gain?

Each participant has a 10 per cent chance of being drawn for winning a cash premium. More precisely, 5 of every 50 participants will receive a cash premium and, for each of these winners, one of the following five lotteries and choice decisions will be randomly selected for determining a cash premium. The maximum cash premium per participant can be up to €388.45. **Through your decisions, you determine the amount of your potential cash premium!**

For a detailed explanation of the chances of winning, please click the 'stack of coins' button on the respective page. […]

We will then inform you via e-mail if you have won a cash premium. The disbursement of the cash premium occurs either immediately after drawing a winner or at the time specified in the respective sub-experiment.

The completion of the experiment will take approximately **20 minutes**. Your information will be kept confidentially and anonymously. For further questions, please do not hesitate to contact us. […]

Part 1: Lotteries

[The order of the following two lotteries was randomized.]

Please choose between lottery A and B in each row!

You can decide between lotteries A and B. With certain probabilities, you receive **€180.00 or €144.00 in lottery A** and **€346.50 or €9.00 in lottery B**.

[…]**Please choose either lottery A or B for <u>each row</u>.**

	Lottery A		Lottery B
1	With 5% gain of €180.00 With 95% gain of €144.00	A ○ ○ B	With 5% gain of €346.50 With 95% gain of €9.00
2	With 10% gain of €180.00 With 90% gain of €144.00	A ○ ○ B	With 10% gain of €346.50 With 90% gain of €9.00
3	With 15% gain of €180.00 With 85% gain of €144.00	A ○ ○ B	With 15% gain of €346.50 With 85% gain of €9.00
4	With 20% gain of €180.00 With 80% gain of €144.00	A ○ ○ B	With 20% gain of €346.50 With 80% gain of €9.00
5	With 25% gain of €180.00 With 75% gain of €144.00	A ○ ○ B	With 25% gain of €346.50 With 75% gain of €9.00
6	With 30% gain of €180.00 With 70% gain of €144.00	A ○ ○ B	With 30% gain of €346.50 With 70% gain of €9.00
7	With 35% gain of €180.00 With 65% gain of €144.00	A ○ ○ B	With 35% gain of €346.50 With 65% gain of €9.00
8	With 40% gain of €180.00 With 60% gain of €144.00	A ○ ○ B	With 40% gain of €346.50 With 60% gain of €9.00
9	With 45% gain of €180.00 With 55% gain of €144.00	A ○ ○ B	With 45% gain of €346.50 With 55% gain of €9.00
10	With 50% gain of €180.00 With 50% gain of €144.00	A ○ ○ B	With 50% gain of €346.50 With 50% gain of €9.00
11	With 55% gain of €180.00 With 45% gain of €144.00	A ○ ○ B	With 55% gain of €346.50 With 45% gain of €9.00
12	With 60% gain of €180.00 With 40% gain of €144.00	A ○ ○ B	With 60% gain of €346.50 With 40% gain of €9.00
13	With 65% gain of €180.00 With 35% gain of €144.00	A ○ ○ B	With 65% gain of €346.50 With 35% gain of €9.00
14	With 70% gain of €180.00 With 30% gain of €144.00	A ○ ○ B	With 70% gain of €346.50 With 30% gain of €9.00
15	With 75% gain of €180.00 With 25% gain of €144.00	A ○ ○ B	With 75% gain of €346.50 With 25% gain of €9.00
16	With 80% gain of €180.00 With 20% gain of €144.00	A ○ ○ B	With 80% gain of €346.50 With 20% gain of €9.00
17	With 85% gain of €180.00 With 15% gain of €144.00	A ○ ○ B	With 85% gain of €346.50 With 15% gain of €9.00
18	With 90% gain of €180.00 With 10% gain of €144.00	A ○ ○ B	With 90% gain of €346.50 With 10% gain of €9.00
19	With 95% gain of €180.00 With 5% gain of €144.00	A ○ ○ B	With 95% gain of €346.50 With 5% gain of €9.00
20	With 100% gain of €180.00 With 0% gain of €144.00	A ○ ○ B	With 100% gain of €346.50 With 0% gain of €9.00

Please choose your preferred lottery out of the nine offered lotteries!

You can decide between the following nine lotteries. Different values are obtainable in each lottery with a 50 per cent probability.

[…]

Please choose your preferred lottery.

Lottery	With a probability of 50%	With a probability of 50%	Preferred lottery
1	€170.00	€170.00	○
2	€136.00	€216.75	○
3	€102.00	€272.00	○
4	€68.00	€332.50	○
5	€51.00	€365.50	○
6	€34.00	€388.90	○
7	€25.50	€394.85	○
8	€17.00	€396.95	○
9	€4.25	€397.40	○

Part 2: Information about the agricultural operation and your person

Now, we would like to ask you a few questions about your farm. Additionally, we want to explicitly point out that all survey results will be handled completely anonymously.

[…]

Finally, we would like to ask you a few questions about yourself. As mentioned above, all survey results will be handled completely anonymously.

[…]

How do you see yourself: Are you generally a risk-seeking person or do you try to avoid risks?

(Please tick the box on the scale which best fits your willingness to take risk.)

○ 0	- not at all willing to take risk
○ 1	
○ 2	
○ 3	
○ 4	
○ 5	- risk is not relevant for my decisions
○ 6	
○ 7	
○ 8	
○ 9	
○ 10	- very willing to take risk

[…]

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Diskussionspapiere

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Department für Agrarökonomie und Rurale Entwicklung

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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