# COMPARING THE PREDICTIVE POWER OF RISK ELICITATION INSTRUMENTS: EXPERIMENTAL EVIDENCE FROM GERMAN FARMERS

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## Abstract

Farmers face many risks in economic decision-making. Therefore, understanding farmers' risk attitudes is important to support decision-making and policy. Economic experiments have become popular to elicit farmers' risk preferences. However, previous research is inconclusive about the power of simple lotteries or survey questions to predict actual behavior of farmers. In this paper, we experimentally compare the predictive power of four different lottery tasks. In a 2 x 2 full factorial experimental design, we compare the effect of framing the task in an agricultural context vs. an abstract task, as well as the effect of incentivizing the lottery vs. not using monetary incentives. We also introduce three survey items that ask respondents to rank their risk attitude in different domains. We compare these measures against a benchmark of actual risk management instruments farmers are using. An incentivized lottery without contextual framing triggers most risk-seeking behavior among farmers. However, all four lotteries and three survey-based measures correlate only poorly with the use of actual risk management instruments such as hail insurance. Our findings cast doubt on the predictive power of commonly used risk elicitation instruments. Additional methods are necessary to establish greater external validity in the elicitation of farmers' risk attitudes.

## Keywords

Experimental economics, external validity, farmers, risk attitudes.

## 1 Introduction

Risk and uncertainty play an important role in farm management. Weather variation, fluctuations in input and output prices, plant pests, or changes in policy create an unstable environment for farmers. Understanding farmers' decision-making under risk and uncertainty has, thus, been a focus of agricultural economists for several decades. Since the seminal study of BINSWANGER (1980), experimental risk elicitation instruments have become particularly popular and are nowadays widely applied with farmers across the world (HILL and VICEISZA, 2012; REYNAUD and COUTURE, 2012; HELLERSTEIN et al., 2013; MAART-NOELCK and MUSSHOFF, 2014; MENAPACE et al., 2016).

There is an ongoing debate on how to adequately design economic experiments to inform decision-makers (COLEN et al., 2015; VICEISZA, in press). This debate is also concerned with the best way to ensure external validity of economic experiments in specific field contexts, because "it is not the case that abstract, context-free experiments provide more general findings if the context itself is relevant to the performance of subjects" (HARRISON and LIST, 2004: 1022). It has been argued that one way to increase the external validity of experimental studies is to frame experimental instructions in a context familiar to subjects and related to the phenomenon under investigation (VICEISZA, in press). In this line of reasoning, for instance, HILL and VICEISZA (2012) investigated Ethiopian farmers' risk preferences by framing the experimental task and survey questions in a context familiar to subjects. Participating farmers could decide to purchase fertilizer and the source of yield variation was framed as stochastic weather conditions.

In a recent study with 98 Italian farmers, MENAPACE et al. (2016) compared three hypothetical risk elicitation instruments, namely a simple survey-based measure, a commonly used lottery task, and a lottery task which was framed in an agricultural context. The authors showed that the three measures are only poorly correlated, but that the framed lottery task predicted fairly well the actual insurance purchase of farmers. However, in contrast to other studies (e.g., HELLERSTEIN et al., 2013), none of the tasks was incentivized.

HELLERSTEIN et al. (2013) correlated a framed version of a lottery task with farm management decisions of 68 US-American farmers. The authors did not find that actual decision-making such as the purchase of insurance could predict the number of riskier choices in the lottery. After transforming their main variable into a coarse binary measure of risk attitude, they found the counter-intuitive result that having purchased insurance is positively related to showing more risk-seeking behavior in the lottery.

It is, thus, an open question as to how far experimental risk elicitation instruments predict actual field behavior. Although earlier studies have investigated the use of contextual framing and monetary incentives, the combination and interaction of both factors has not been previously studied. As shown by DOHMEN et al. (2011), risk attitudes are domain-specific, and risk attitudes might correlate only weakly across domains. At the one hand, adding context to an experiment should increase the external validity of findings, i.e., participants are more likely to behave similar to the particular field context under investigation. At the other hand, paying participants well might over-emphasize general financial risk attitudes. In this case, the desirable effect of contextual framing would be crowded out.

It is the objective of this paper to investigate this interaction of contextual framing and monetary incentives in experimental risk elicitation. We extend and modify the studies of HELLERSTEIN et al. (2013) and MENAPACE et al. (2016) in several ways. Instead of the ECKEL and GROSSMAN (2008) task, here, we focus on the more commonly used HOLT and LAURY (2002) task. In contrast to previous studies, we introduce new treatments to explicitly separate the effect of incentives and the effect of framing in the lottery task. We implement domain-specific survey questions on risk attitudes (cf. DOHMEN et al., 2011) and ask farmers about risk management measures they implement on their farms. This approach allows us to compare specifically the predictive power of a large number of risk elicitation instruments on actual on-farm risk management instruments. For instance, we are able to test whether different lotteries yield different results and to assess the power of various risk elicitation instruments to predict field behavior such as the purchase of crop insurance.

The remainder of the paper is structured as follows. In the next section we introduce the experimental design and data. In the third section, we present our results. In a final section, we discuss the results and conclude.

## 2 Experimental Design and Data

### 2.1 Experimental Design and Treatments

Our experiment was based on the commonly known HOLT and LAURY (2002) lottery. Participants were randomly assigned to one of four possible combinations of multiple price lists. We manipulated two factors in two levels of a full factorial design which were implemented partly between and within subjects. First, we manipulated the use of monetary incentives in the risk elicitation task between subjects. One half of the sample was told that their choices would be purely theoretical; for the other half there was a ten percent probability to receive an actual payment of up to 385 Euros.

Secondly, we manipulated the use of contextual framing within subjects. To avoid order effects, one half of the sample started with an abstract version of a multiple price list and then was confronted with a contextually framed version. For the other half this treatment was

reversed, i.e., all participants had to respond to two different framings. In the abstract version we implemented the commonly used lottery from the original study (HOLT and LAURY, 2002). In the framed version the risky decision was framed as a decision between two wheat varieties that differed in the variation of their marginal returns contingent on stochastic weather events. Each multiple price list consisted of ten rows. Excerpts of an English translation of the two differently framed multiple price lists are displayed in the following tables.

**Table 1: The abstract Holt and Laury task**

| Scenario | Lottery A | | Lottery B |
|---|---|---|---|
| 1 | with 10% a gain of 200 €<br>with 90% a gain of 160 € | A ○ ○ B | with 10% a gain of 385 €<br>with 90% a gain of 10 € |
| 2 | with 20% a gain of 200 €<br>with 80% a gain of 160 € | A ○ ○ B | with 20% a gain of 385 €<br>with 80% a gain of 10 € |
| … | … | … | … |
| 10 | with 100% a gain of 200 €<br>with 0% a gain of 160 € | A ○ ○ B | with 100% a gain of 385 €<br>with 0% a gain of 10 € |

**Table 2: The framed Holt and Laury task**

| Scenario | Wheat Variety A | | Wheat Variety B |
|---|---|---|---|
| 1 | with 10% good weather and a marginal return of 200 €<br>with 90% bad weather and a marginal return of 160 € | A ○ ○ B | with 10% good weather and a marginal return of 385 €<br>with 90% bad weather and a marginal return of 10 € |
| 2 | with 20% good weather and a marginal return of 200 €<br>with 80% bad weather and a marginal return of 160 € | A ○ ○ B | with 20% good weather and a marginal return of 385 €<br>with 80% bad weather and a marginal return of 10 € |
| … | … | … | … |
| 10 | with 100% good weather and a marginal return of 200 €<br>with 0% bad weather and a marginal return of 160 € | A ○ ○ B | with 100% good weather and a marginal return of 385 €<br>with 0% bad weather and a marginal return of 10 € |

## 2.2 The Post-experimental Questionnaire

After completion of the lotteries, a survey asked participants to provide some details on their socio-economic background and their farms. We also included a number of items (cf. DOHMEN et al., 2011) that asked farmers to self-assess their risk attitudes on an eleven-point scale, ranging from zero (= not willing to take risks at all) to ten (= very much willing to take risks), focusing on different domains (health, business and investment, farm management, etc.). The first question asked was:

How would you assess yourself? Are you generally willing to take risks or do you try to avoid risks? Please use the scale to indicate the value that best describes your willingness to take risks where zero means "not willing to take risks at all" and ten means "very much willing to take risks." You can use the values in between to grade your response.

Additional items asked for different domains:

One can behave differently in different domains. How would you assess your willingness to take risks with respect to the following domains? How willing are you to take risks…

- …when driving?
- …when making investments?
- …in your leisure time and in sports?
- …in your career?
- …in your health?

- …when trusting other people?
- …when deciding as a farm manager?

A number of questions were concerned with eliciting farmers' actual use of risk management instruments such as the use of crop insurance or futures contracts. To elicit farmers' numeracy skills, a small test (MURRAY et al., 2005) was introduced.

## 2.3 Data and Subject Pool

The experiment was conducted as an online survey in July 2015. Participants were recruited from an email list of approximately 500 German farmers. Participants were offered a 15 Euro Amazon voucher for participation. From the participants who provided their email addresses (136 out of 146 participants did so), 131 indicated interest in receiving the Amazon voucher which was sent to them by email a couple of days after the study. Seven participants in the incentivized treatments were randomly selected to receive additional cash payments. After being contacted by email, all seven farmers provided their bank account details, and we transferred the respective payments to them. Table 3 displays summary statistics for selected characteristics of participants.

**Table 3: Description and summary statistics of participant characteristics**

| | Description | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| NUMERACY | Index of numerical skills based on MURRAY et al. (2005)[a] | 83.95 | 19.57 | 25.95 | 100.00 |
| UNIVDEGREE | = 1 if respondent has university degree | 0.54 | 0.50 | 0.00 | 1.00 |
| AGE | Age in years | 38.95 | 13.26 | 19.00 | 79.00 |
| FEMALE | = 1 if female | 0.08 | 0.26 | 0.00 | 1.00 |
| INCOME1 | = 1 if net income below 1,500 Euro/month | 0.14 | 0.35 | 0.00 | 1.00 |
| INCOME2 | = 1 if net income 1,500 to 3,000 Euro/month | 0.32 | 0.47 | 0.00 | 1.00 |
| INCOME3 | = 1 if net income 3,000 to 4,500 Euro/month | 0.20 | 0.40 | 0.00 | 1.00 |
| INCOME4 | = 1 if net income above 4,500 Euro/month | 0.18 | 0.39 | 0.00 | 1.00 |
| INCOME5 | = 1 if net income not specified | 0.16 | 0.37 | 0.00 | 1.00 |
| TOTALLAND | Farmland in hectares | 294.29 | 690.21 | 0.00[b] | 6300.00 |

Source: own calculations; a) re-scaled to ensure a minimum possible value of zero and a maximum of 100; b) One respondent indicated not to own or lease any land.

It can be seen that participating farmers are well educated, with more than half of the sample holding a university degree. The average age is approximately 39 years, and only a few farmers in the sample are female. The modal farmer stated a net monthly income of 1,500 to 3,000 Euros. The average farm size is approximately 300 hectares with the median farm being around 100 hectares large. Compared to the German average, farmers in our sample are more educated and manage larger farms. Our results have to be interpreted against this background.

## 2.4 Farmers' Actual Use of Risk Management Instruments and Survey Questions

Table 4 shows the use of risk management instruments of the participating farmers. Our survey asked for the use of hail, crop, and indexed-based weather insurance, as well as the use of futures contracts for hedging price risks. The variable COUNT_INSTRUMENTS is the simple sum of the number of instruments used, and PCA_INSURANCE is an index based on the first component of a principal component analysis of the four risk management instruments as proposed by FILMER and PRITCHETT (2001). Similar to a factor analysis, the

procedure is used to extract a maximum of variation in components in order to reduce the dimensions from a larger set of variables. Indices constructed from principal component analysis are commonly used to extract a maximum of information for instance on household wealth (cf. FILMER and PRITCHETT, 2001).

**Table 4: Summary statistics of actual risk management instruments used**

| Variable Name | Description | Relative Frequency/Mean (SD) |
|---|---|---|
| HAIL | = 1 if respondent purchased hail insurance | 76.71 percent |
| CROP | = 1 if respondent purchased crop insurance | 8.22 percent |
| INDEX | = 1 if respondent uses index-based weather insurance | 2.05 percent |
| FUTURES | = 1 if respondent uses futures contracts for hedging purposes | 47.26 percent |
| COUNT_INSTRUMENTS | = HAIL + CROP + INDEX + FUTURES | 1.34 (0.77) |
| PCA_INSURANCE | = Index based on first component of a principal component analysis of HAIL, CROP, INDEX, FUTURES | 0[a] (1.10) |

Source: own calculations; a) By construction of the index, all components have a mean of zero.

It can be seen that farmers used risk management instruments widely. The majority of farmers used hail insurance, and almost half of the respondents used futures contracts for hedging price risks. As explained above, respondents were also asked to self-assess their risk attitude on an eleven-point scale for different domains (with zero = not willing to take risks at all to ten = very much willing to take risks). Here we specifically focus on the general willingness to take risks (RISK_GENERAL; Mean = 4.93; SD = 1.81), the willingness to take risks when investing (RISK_INVEST; Mean = 3.87; SD = 2.19), and the willingness to take risks in managing the farm (RISK_FARM; Mean = 4.82; SD = 2.11).

# 3 Results

## 3.1 Method Comparison Lotteries

It was our first question to separate the effects of monetary and contextual framing. We asked whether differences in these factors would yield different results in terms of risk attitude. A commonly used outcome measure to do so is the number of riskier choices (the number of times a participant selected Option B in Tables 1 and 2 above, cf. HELLERSTEIN et al., 2013). We include only the first multiple price list of each participant here, i.e., we limit our analysis to the between subjects comparison to avoid demand effects.

Table 5 displays absolute frequencies of riskier choices per participant by treatments. The column BASELINE denotes the treatment which uses incentives and no contextual framing (cf. Table 1); INC_FRA uses incentives and framing (cf. Table 2); NOINC_NOFRA uses neither incentives nor framing; NOINC_FRA does not use incentives and uses framing.

**Table 5: Absolute frequencies of riskier choices per participant by treatments**

| Number of Riskier Choices | Range of Constant Relative Risk Aversion Coefficient[a] | BASELINE | INC_FRA | NOINC_ NOFRA | NOINC_ FRA | Full Sample |
|---|---|---|---|---|---|---|
| 0-1 | 1.37 < r | 0 | 4 | 1 | 4 | 9 |
| 2 | 0.97 < r < 1.37 | 0 | 5 | 5 | 6 | 16 |
| 3 | 0.68 < r < 0.97 | 5 | 6 | 8 | 6 | 25 |
| 4 | 0.41 < r < 0.68 | 7 | 7 | 6 | 6 | 26 |
| 5 | 0.15 < r < 0.41 | 4 | 8 | 6 | 10 | 28 |
| 6 | -0.15 < r < 0.15 | 13 | 3 | 4 | 3 | 23 |
| 7 | -0.49 < r < -0.15 | 6 | 2 | 7 | 2 | 17 |
| 8 | -0.95 < r < -0.49 | 1 | 1 | 0 | 0 | 2 |
| 9-10 | r < -0.95 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | 36 | 36 | 37 | 37 | 146 |
| Mean (SD) | | 5.31 (1.41) | 3.83 (1.92) | 4.35 (1.86) | 3.70 (1.85) | 4.29 (1.86) |
| Median | | 6 | 4 | 4 | 4 | 4 |

Source: own calculations; a) based on HOLT and LAURY (2002)

It can be seen in the last column that – across treatments – the modal participant is slightly risk averse, choosing the riskier option five times. One can also see that there are differences in modal values and medians between treatments. Formal testing reveals that differences in medians are statistically significant at the one percent level (Kruskal-Wallis-Test; d.f. = 3; $\chi^2$ = 15.839; p = 0.0012).

Pair-wise testing reveals that the median number of riskier choices is significantly different from each of the other treatments at the five percent level (Wilcoxon Rank Sum Tests; z = -3.364, p = 0.0008 for a comparison of BASELINE with INC_FRA; z = -2.210, p = 0.0271 for a comparison of BASELINE with NOINC_NOFRA; z = -3.677, p = 0.0002 for a comparison of BASELINE with NOINC_FRA). To sum up, the BASELINE version of our lottery yields higher relative risk aversion than the other versions; whereas there is no significant difference between the other three treatments with respect to the absolute level of risk-taking. Note that differences between treatments are not driven by observed heterogeneity in socio-economic characteristics as shown in Table 6. A Kruskal-Wallis test does not reject the null hypothesis of equal medians for several tested socio-economic variables across treatments.

**Table 6: Medians of socio-economic covariates by treatments**

| | BASELINE | INC_FRA | NOINC_NOFRA | NOINC_FRA | $\chi^2$-statistic (d. f. = 3) Kruskal-Wallis equality-of-populations rank test | p-Value |
|---|---|---|---|---|---|---|
| NUMERACY | 100 | 100 | 100 | 77.01575 | 4.288 | 0.2320 |
| UNIVDEGREE | 1 | 1 | 1 | 0 | 3.155 | 0.3683 |
| AGE | 32 | 35.5 | 38 | 33 | 1.543 | 0.6724 |
| FEMALE | 0 | 0 | 0 | 0 | 0.555 | 0.9067 |
| INCOME1 | 0 | 0 | 0 | 0 | 1.972 | 0.5782 |
| INCOME2 | 0 | 0 | 0 | 0 | 3.445 | 0.3279 |
| INCOME3 | 0 | 0 | 0 | 0 | 2.497 | 0.4758 |
| INCOME4 | 0 | 0 | 0 | 0 | 1.150 | 0.7650 |
| INCOME5 | 0 | 0 | 0 | 0 | 0.563 | 0.9048 |
| TOTALLAND | 98 | 138 | 105 | 90 | 0.681 | 0.8776 |

Source: own calculations

## 3.2 The Predictive Power of Lotteries and Survey Questions

We calculated Pearson correlation coefficients of choices in the four lotteries and the three survey-based measures of risk attitude with the use of actual risk management instruments. We use only the first lottery of each participant (between-subjects design). The correlation coefficients are displayed in Table 7.

**Table 7: Correlation of lotteries and actual risk management instruments**

| | BASELINE | INC_FRA | NOINC_ NOFRA | NOINC_ FRA | RISK_ GENERAL | RISK_ INVEST | RISK_ FARM |
|---|---|---|---|---|---|---|---|
| HAIL | 0.2254 | -0.2235 | 0.0399 | -0.0785 | 0.0508 | 0.0488 | 0.1670* |
| CROP | 0.1211 | 0.0214 | 0.0194 | 0.2319 | 0.1630* | 0.0521 | 0.1328 |
| INDEX | 0.0844 | 0.0149 | . | 0.2094 | 0.0322 | -0.0135 | -0.0560 |
| FUTURES | -0.1965 | 0.0245 | 0.2670 | -0.0400 | 0.0662 | 0.0438 | -0.0211 |
| COUNT_INSTRUMENTS | 0.0702 | -0.0832 | 0.2140 | 0.0907 | 0.1363 | 0.0720 | 0.1162 |
| PCA_INSURANCE | 0.2408 | -0.0742 | 0.0477 | 0.2382 | 0.1347 | 0.0467 | 0.1251 |
| Number of observations | 36 | 36 | 37 | 37 | 146 | 146 | 146 |

Source: own calculations; * $p < 0.05$

Overall, lotteries and survey questions correlate only poorly with farmers' actual use of risk management instruments. Only two of the reported Pearson correlation coefficients are statistically significantly different from zero at the five percent level – although not in the expected direction. Notable differences exist in the size and direction of associations. Intuitively one would expect a negative correlation between risk attitudes elicited from the experiments and survey (higher values indicate risk-seeking behavior) and the actual use of risk management instruments (higher values indicate risk-avoiding behavior) which is not the case for most correlation coefficients. As a robustness test we have also calculated Spearman rank correlation coefficients. The results are qualitatively not different and the calculations are available from the authors on request.

## 4 Discussion and Conclusion

In this paper we have compared four experimental and three survey-based measures of risk attitude. We found that an abstract and incentivized lottery encouraged farmers to engage in risk-seeking behavior. Similar to a previous study (HELLERSTEIN et al., 2013), we found that

the tested measures correlate only poorly with actual risk management on farms. However, some correlation coefficients pointed towards interesting hypotheses. For instance, the framed and incentivized lottery correlates negatively with the actual use of hail insurance (r = -0.1965 in Table 7); the abstract incentivized lottery correlates negatively with the use of futures contracts (r = -0.2235 in Table 7). Owed to the small sample size, both correlations were statistically not significantly different from zero. Despite this fact, these correlations may point towards a domain-specificity within agriculture that deserves further investigation in future research. Risk-taking in the financial domain could be predicted relatively well by abstract lotteries, whereas risk-taking in cropping decisions could be predicted by contextually framed lotteries. Consequently, an even finer distinction of risk domains (cf. DOHMEN et al., 2011) might be a way forward to predict risk-taking in rather specific domains. Conversely, it is still desirable to find adequate instruments to elicit farmers' risk attitudes more generally.

Unlike MENAPACE et al. (2016), we did not find that hypothetical risk elicitation instruments are able to predict actual on-farm risk management. This difference might be explained by differences in the study design. In their contextual task MENAPACE et al. (2016) worked with multiple price lists based on farmers' actual gross margins. In other words, larger farmers also faced greater – albeit hypothetical – absolute risks. Even with monetary incentives we were not able to replicate the result. Therefore, we conclude that risk preferences measured by standardized lottery tasks cannot predict the actual application of risk management instruments. In accordance with MENAPACE et al. (2016), adjusting lottery tasks to the individual contexts of respondents might be a step forward to achieve greater external validity of experimental risk elicitation instruments.

In accordance with a previous study (HELLERSTEIN et al., 2013), we found an unexpectedly large number of *positive* correlations between actual risk-avoiding behavior in the field and risk-seeking in the experiment and survey. An explanation for this might be found in the behavioral economics literature. For instance, BABCOCK (2015) shows that cumulative prospect theory (TVERSKY and KAHNEMAN, 1992) can adequately explain violations of expected utility theory in farmers' purchase of insurance. Introducing gains vs. losses relative to reference points and focusing on small probabilities in lotteries might be a way forward to enhance the predictive power of lotteries.

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