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Are Farmers as Risk-averse as They Think They Are?

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ABSTRACT

Studies on the acceptance of innovation often identify risk preference to be a decisive factor for the adoption of sustainable practices. While in finance and management research, lottery tasks are mostly used to measure risk aversion, behavioural studies usually use measures of risk tolerance and risk perception derived from explicit self-assessment questions. We empirically test the influence of three different risk measures on farmers' acceptance of a sustainability standard and the amount of investment made. The results of our analysis indicate that the results of lottery tasks are consistent with the risk-seeking behaviour of e.g. of investment decisions made, whereas the evaluation questions are more likely to capture other aspects like farmers' expectations of the innovation itself. The results suggest that we need to intensively investigate farmers' expectations of the single innovations in behavioural economic studies to distinguish more precisely between actual risk aversion or tolerance and a negative or positive opinion of the innovation.

Keywords

Farm standard adoption; Risk preference; Risk tolerance; Risk perception; Lottery-choice tasks

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1 Introduction

In the post-production era of farming, the sector is facing major challenges like climate change, sustainable food production, and rising societal requirements on land use practices. Against this background, academia and private enterprises continuously offer innovations for practitioners. These include innovative production technologies, improved finance models and sales practices, new agri-environmental schemes or new farming standards. To keep up with crucial developments, farmers must decide for all the possible innovations whether to adopt, or to reject. Since the 1980s the analysis of innovation adoption has been of interest to research (Rogers 1988; Davis 1989; Ghadim and Pannell 1999) but farmers' innovation behaviour is still hardly predictable. Therefore, surveys and behavioural experiments such as choice experiments are conducted continuously. Against the background of climate change and an increasing societal call in Europe for environmental protection, the uptake of sustainable practices is intensively examined (Dessart et al. 2019; Trujillo-Barrera et al. 2016; Läpple et al. 2015). Farmers' inherent risk tolerance and the individual risk perception of adopting an innovation are frequently amongst identified key drivers (Sauer and Zilberman 2012; Dörschner and Mußhoff 2014). Behavioural studies mostly use stated self-assessment questions or context related multiple questions to reflect latent constructs of risk tolerance and risk perception (Trujillo-Barrera et al. 2016; Läpple et al. 2015; Pavlis et al. 2016; Ghadim and Pannell 1999; Burton et al. 2008), while in finance research risk aversion is often measured with lottery-choice tasks (Holt and Laury 2002; Eckel and Grossman 2008; Teubner et al. 2015; Menapace et al. 2016). The study of Menapace et al. (2016) show for insurance purchase decisions that there are significant differences between measured risk-variables, depending on the elicitation method. Teubner et al. (2015) propose a reduced form of a lottery-task to simplify risk preference measurement, and Pennings and Smidts (2000) 'recommend elicitation methods based on the expected utility paradigm'. However, there is still no common approach to measure risk in behavioural studies, in particular, on the acceptance of sustainable practices.

We use survey data to evaluate the significance of risk measures from three different elicitation methods to explain adoption behaviour. Further, we test if stated risk tolerance corresponds to elicited risk aversion measures. Therefore, we include in the online survey (1) a self-assessment question on the importance of risk in an individual investment decision, (2) several questions on the 'risk tolerance' and the 'perceived risk' of the use of a sustainability standard plus controlling for stated own 'innovativeness', and (3) a 'Holt-and-Laury' lottery to estimate individual 'risk aversion'. By testing the statistical power of these measures to explain very risk-averse and very risk-seeking behaviour in the context of standard adoption and realized investments, we can derive recommendations for the selection of suitable parameters in comparable experiments.

2 Survey design

We conducted from mid-June to the end of July 2017 an anonymous online survey amongst farmers on the adoption of farm sustainability standards in cooperation with one of the biggest German farmer associations (the German Agricultural Society). The response rates in the online survey are expected to be lower for 'non-members' than for members (Shih and Fan 2008; Blumenberg and Barros 2018). Thus we invited participants by email in two different circulars, addressing one-third of association members and two-thirds of 'non-members' to get a balanced sample. The online questionnaire first contained questions on farm type and

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farming practices. These were followed by a short explanation of sustainability aspects and questions on knowledge and attitude towards the adoption of sustainable practices. Further, the questionnaire included a choice experiment on standard adoption and several questions on expected rewards, as well as on the perception of risk associated with using a sustainability standard. Additionally, we collected socioeconomic data for the farmer such as age, educational and family status, and gender. At the end of the survey, participants had the option to exit the survey, or to continue with a Holt-and-Laury lottery-choice task.

2.1 Self-assessment of risk preferences

We included in the questionnaire the single statement: *'For me, the associated risk is the most important decision criterion for investments.'* Farmers had to indicate whether they do '*not agree at all*' up to '*absolutely*' agree on a seven-point scale. The answer variable we use for the analysis as the risk measure 'Risk important'.

In addition, farmers were asked four questions on the risk perception (RP) associated with the use of a farm sustainability standard and four questions regarding their individual risk tolerance (RT) in company decisions. With these multiple questions, we intended to get a more reliable measure of the risk preferences by modeling a latent construct from the answer variables. Further, we asked three questions on the perceived own innovativeness of the farmer in order to control for self-perception in the context of the survey.

2.2 Lottery-choice task

We applied a Lottery-choice task very close to the originally reported experiment of Holt and Laury (2002). In the choice-task participants have to indicate for every choice which option they would take in a real-world lottery. The share of 'save' choices indicates the risk aversion of the individual. In order to address the anchoring problems of the lottery, we displayed the single decisions in a randomized form to the participating farmers (Iyer et al. 2020). Table 1 shows the two options in each of the lottery decisions and the difference in expected payoffs.

Table 1. Holt-and-Laury lottery task

Lottery task	Option A	Option B	Expected payoff difference
1	0/10 of €20.00, 10/10 of €16.00	0/10 of €38.50, 10/10 of €1.00	15,00
2	1/10 of €20.00, 9/10 of €16.00	1/10 of €38.50, 9/10 of €1.00	11,65
3	2/10 of €20.00, 8/10 of €16.00	2/10 of €38.50, 8/10 of €1.00	8,30
4	3/10 of €20.00, 7/10 of €16.00	3/10 of €38.50, 7/10 of €1.00	4,95
5	4/10 of €20.00, 6/10 of €16.00	4/10 of €38.50, 6/10 of €1.00	1,60
6	5/10 of €20.00, 5/10 of €16.00	5/10 of €38.50, 5/10 of €1.00	-1,75
7	6/10 of €20.00, 4/10 of €16.00	6/10 of €38.50, 4/10 of €1.00	-5,10
8	7/10 of €20.00, 3/10 of €16.00	7/10 of €38.50, 3/10 of €1.00	-8,45
9	8/10 of €20.00, 2/10 of €16.00	8/10 of €38.50, 2/10 of €1.00	-11,80
10	9/10 of €20.00, 1/10 of €16.00	9/10 of €38.50, 1/10 of €1.00	-15,15

2.3 Hypotheses development

The study of Trujillo-Barrera et al. (2016) with hog farmers in the Netherlands identifies risk perception and risk tolerance to impact the adoption of sustainable stables. Further, they demonstrate that risk tolerance

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moderates positively the economic reward-adoption relation; higher risk perception, on the other hand, was associated with lower levels of adoption in this study. A high impact of risk perception on innovation adoption is further described by Dörschner and Mußhoff (2014), Pennings and Smidts (2000), and Dessart et al. (2019). The latter analyses a wide range of studies on the adoption of sustainable practices and distinguishes between '*risk tolerance*' being a disposal factor and the cognitive factor *'risk perception'*. We assume that measured risk tolerance (RT) captures a risk-seeking behaviour while a lottery task reflects the disposal factor '*risk aversion'*. Both having an impact on standard acceptance and investment decisions but in different directions. Higher '*risk perception'* is expected to reduce standard acceptance and to have no effect on investments. The importance of risk in the context of investment decisions is expected to impact only investment decisions and to have no significant impact on standard adoption. Against this background, we pose the following four hypotheses (Table 2).

Table 2. Hypotheses statements and expected effects

Hypotheses		**Expected effect on**	
		standard adoption	high investments
H1	high importance of risk in investment decisions (sg. statem.: Risk perception Investment)	0	-
H2	high risk perception of standard use (construct: Risk perception Standard)	-	0
H3	high risk tolerance in company decisions (construct: RT)	+	+
H4	high risk aversion shown in the lottery-choice task (Risk aversion)	-	-

We use as one dependent variable the probability of standard adoption. This we measure with the statement: *'I can imagine using a sustainability standard on my farm.'* The agreement was captured on a seven-point scale, which we grouped from '*not at all'* to *'neutral'* (refuse adoption), '*likely'* (as baseline), and '*very likely*' to *'absolutely'* (adopt standard). To control the variables' effect on management decisions in general, we use the amount of investment of the last five years. These we grouped as follows: ranges up to 100,000€ (low), 100,000€ to 500,000€ (as baseline) and higher than 500,000€ (high).

4 Measures of farmers' risk attitudes

We first apply a principal component analysis (PCA) and then a confirmatory factor analysis (CFA) to develop latent components from the eight evaluation questions using each a seven-point Likert-scale. Table 3 describes the variables, the latent constructs, and indicators following the procedure applied by Trujillo-Barrera et al. (2016).

Table 3. Factor analysis results

Constructs and indicators		Loading	SE
Risk perception (RP) (Cronbach's α = 0.775)			
(1)	very risky (rp1)	0.820***	(0.031)
(2)	safe (rp2 rc[1])	0.498***	(0.047)
(3)	questionable (rp3)	0.534***	(0.046)
(4)	involving a lot of risk (rp4)	0.845***	(0.030)

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Risk tolerance (RT) (Cronbach's α = 0.871)			
(1)	I prefer certainty over uncertainty when I invest in my firm. (rt1)	0.825***	(0.023)
(2)	I avoid risks when deciding for my business. (rt2)	0.753***	(0.029)
(3)	I like to take financial risks. (rt3 rc)	0.701***	(0.033)
(4)	I like to 'play it safe' when I invest in my firm. (rt4)	0.894***	(0.019)

[1]rc = reverse coded; Significance level: ***99.9%

We use the following standards to assess the CFA models goodness of fit (Bagozzi and Yi 2012; Hu and Bentler 1999): root means square error of approximation (RMSEA) < 0.06, comparative fit index (CFI) > 0.95 and standardised root mean square residual (SRMR) < 0.08. The CFA goodness of fit indicators for our estimation is as follows: RMSEA 0.059, CFI 0.98 (Tucker-Lewis index of 0.97), and SRMR 0.042. Reliability is high for all constructs demonstrated by the loadings and the Cronbach alphas reported in Table 3.

5 Results

We realized a sample of 338 farmers (50.3 % association members) to finalize the questionnaire up to the relevant questions and 93 to participate additionally in the Holt-and-Laury lottery. Table 4 displays the farm and farmer characteristics of the participants' sample.

Table 4. Farm and farmer characteristics

Variable Name	**Farm and Farmer Characteristics**	Observations	Mean	SD	Min.	Max.
Farm Size	Utilised Agricultural Area (UAA) in hectare	333	202.95	306.62	1	1.815
Full-time farmer°	1 if a full time farmer	338	0.828	0.378		
Organic farm[1]	1 if an organic farm	338	0.109	0.313		
Participation in AES	1 if farm participates in AES	338	0.544	0.499		
Crop farm	1 if main income derives from crop production	338	0.352	0.478		
Investment stable	1 if inv. of last 5 y. mainly in stable building	338	0.370	0.483		
Investment energy	1 if inv. of last 5 y. mainly in renewn. energy production	338	0.316	0.466		
Age	Farmer age in years	318	47.23	11.82	18	72
Gender	1 if male	335	0.901	0.298		
Status	1 if living without partner	333	0.138	0.346		
Education	1 if education is college or university or higher	338	0.358	0.480		

° Farm-holders working full-time on the farm, legal entities and other legal forms; [1]organic and farms in conversion

We find a farmers' sample managing bigger farms than the German average in 2016 with 60.49 ha (Destatis 2016). Most of the farms are operated on a full-time basis. The sample consists of mainly male farmers with an average age of 47 years and living with a partner.

We use a multinomial logistic regression model to investigate the impact of the risk measures and some latent variables on the adoption of a farm sustainability standard and the investments made. Table 5 shows, regression coefficients of the dependent standard adoption variable on the levels: '*refuse adoption*' and '*adopt*

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standard' compared to the neutral base level. Besides, the regression coefficients of the dependent investment variable levels '*low'* and '*high'* are displayed compared to the baseline outcome. Estimations were calculated separately for both cases, and each for the complete sample and the reduced sample that had answered also the Holt-and-Laury experiment. We find different results for the risk-averse and the risk-seeking decision alternatives. Standard refusers are more likely to be elder and crop farmers. They and perceive the risk associated with the use of a standard being high and are less risk-tolerant. Standard adoption is more likely for a farmer with lower risk perception and lower risk aversion.

Table 5. Multinomial logistic regression results

	full sample[1]		lottery sample[2]		full sample		lottery sample	
Variable name	Coeff.	S.E.[3]	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
	Reject standard				**Low investments**			
Farm size	-0.000	(0.000404)	0.00152	(0.00101)	-0.00532**	(0.00198)	-0.0206***	(0.00589)
Investment stable	0.662°	(0.356)	1.856*	(0.809)	-0.769*	(0.373)	-0.202	(1.070)
Investment energy	0.167	(0.321)	-0.230	(0.655)	-0.638°	(0.373)	-1.887*	(0.824)
Crop farm	0.906*	(0.353)	1.235°	(0.683)	0.496	(0.368)	3.630***	(1.035)
Risk perception (RPS)	0.781***	(0.159)	1.138***	(0.277)	0.0292	(0.151)	0.0567	(0.395)
Risk tolerance (RT)	0.362*	(0.177)	0.714°	(0.419)	-0.140	(0.181)	-0.142	(0.409)
Innovativeness	-0.121	(0.303)	0.754	(0.656)	-1.256***	(0.313)	-0.0998	(0.901)
Risk perception (RPI)	-0.292**	(0.105)	0.215	(0.292)	-0.0354	(0.113)	0.598	(0.410)
Risk averse (lottery)			-2.426	(1.582)			-2.753	(1.938)
Age	0.0178°	(0.00994)	-0.00207	(0.0256)	0.00968	(0.0103)	-0.00242	(0.0391)
Status	0.212	(0.441)	-0.665	(0.821)	0.970*	(0.453)	-0.270	(0.990)
Education	0.161	(0.310)	0.529	(0.707)	0.246	(0.328)	1.049	(0.914)
	Adopt standard				**High investments**			
Farm size	-0.00120*	(0.000599)	-0.00149	(0.00172)	0.00169***	(0.000468)	0.00214*	(0.00105)
Investment stable	0.557	(0.372)	2.369*	(0.967)	1.102**	(0.373)	2.146**	(0.756)
Investment energy	0.195	(0.335)	-0.846	(0.803)	0.769*	(0.331)	0.695	(0.696)
Crop farm	0.307	(0.395)	0.563	(0.885)	-0.0441	(0.418)	0.704	(0.807)
Risk perception (RP)	-0.305°	(0.185)	0.526	(0.387)	0.213	(0.168)	0.851*	(0.331)
Risk tolerance (RT)	-0.0167	(0.204)	0.307	(0.434)	0.0272	(0.201)	-0.645°	(0.351)
Innovativeness	0.306	(0.335)	1.536°	(0.827)	1.060**	(0.397)	3.691***	(0.773)
Risk important	-0.163	(0.111)	0.185	(0.274)	-0.173	(0.112)	-0.251	(0.233)
Risk averse (lottery)			-3.017*	(1.533)			-4.102*	(1.658)
Age	0.00646	(0.00999)	-0.0206	(0.0266)	-0.0194	(0.0103)	-0.0283	(0.0282)
Status	0.110	(0.505)	-0.678	(1.057)	-0.480°	(0.533)	-0.441	(0.821)
Education	-0.0972	(0.336)	0.0955	(0.728)	0.117	(0.327)	1.433*	(0.689)
Sample size	310		93		310		93	
AIC	635.1		203.3		578.3		167.3	
BIC	717.3		264.1		660.5		228.1	

[1]Sample size n=93; [2]Sample size n=310; Significance level: ***99.9%; **97.5%; *95.0%; °90.0%

6 Discussion and conclusion

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None of the measures reflects the revealed adoption or investment decisions completely. Similar approaches of Menapace et al. (2016), Teubner et al. (2015), and Pennings and Smidts (2000) find risk measurement also to be challenging for behavioural economists. The particular impact of risk aversion or risk tolerance measures seems to differ depending on the viewing angle. Table 6 summarizes the results of our logit estimations on the hypotheses. It is indicated, if any significant result was found (✓), and in brackets how many of the estimations the variable was significant.

The single statement delivers a significant result only in one case. Reported risk perception is significant in most cases in the context of standard adaptation. Results from our analysis suggest that farmers' answers on risk perception capture their expectations on the innovation itself, while the results from lottery tasks seem to correspond to a disposal risk preference factor. In contrast, risk tolerance seems to capture a different underlying disposal factor than the risk aversion measure from the lottery task. This implies that risk-averse behaviour must be distinguished from risk-seeking decisions in general.

Table 6. Summary of results

Hypotheses		**Expected effect on**			
		standard adoption		high investments	
H1	high importance of risk in investment decisions (sg. statem.: Risk perception - Investment)	none	✓ (1/4)	-	n.s.
H2	high risk perception of standard use (construct: Risk perception - Standard)	-	✓ (3/4)	none	✓ (1/4)
H3	high risk tolerance in company decisions (construct: Risk tolerance)	+	✓ (2/4)	+	✓ (1/4)
H4	high risk aversion shown in the lottery-choice task (Risk aversion)	-	✓ (1/2)	-	✓ (1/2)
PLUS	high perceived own innovativeness of the farmer (factor: Innovativeness)	+	✓ (1/4)	+	✓ (3/4)

+ increase; - reduce; ✓ significant result; n.s. not significant result

On this preliminary basis, we propose that researchers must focus again on expected effects on farm economy and management of innovations self to better understand perceived risk and to investigate adoption behaviour. Further, they should use lottery gambles if they are interested in the disposal structures of the decision-maker. Self-stated risk perception of decision-makers does not reflect their risk attitudes completely. Further research on the adoption of sustainable practices is needed concerning the risk measures: risk tolerance and risk perception to analyse their interrelations and to identify sources of risk perception.

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