Eliciting Risk Preferences: A Field Experiment on a Sample of French Farmers[1]

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Abstract: We designed a field experiment involving real payments to elicit farmers' risk preferences. Farmers are a very interesting sample to study since risk has always played an important role in agricultural producers' decisions. Besides, European farmers may face more risky situations in the future. In this context, it is very important for any economic analysis focusing on agriculture to correctly assess farmers' behaviour in the face of different sources of risk. We test for two descriptions of farmers' behaviour: expected utility and cumulative prospect theory. We use two elicitation methods based on the procedures of Holt and Laury (2002) and Tanaka et al. (2010) on a sample of 30 French farmers. The experiment consists in asking subjects to make series of choices between two lotteries with varying probabilities and outcomes. We estimate parameters describing farmers' risk preferences derived from structural models. We find farmers are slightly risk averse in the expected utility framework. In the cumulative prospect theory frame, we find farmers display either loss aversion or probability weighting, tending to overweight small probabilities and to underweight high probabilities. In our study, expected utility is not a good description of farmers' behaviour towards risk.

Keywords: Risk Attitudes, Field Experiment, Farming.

JEL Classification: C93 (Field Experiments), D81 (Criteria for Decision-Making under Risk and Uncertainty), Q10 (Agriculture)

1. Background and motivation

Risk has always played an important role in agricultural producers' decisions. Besides, European farmers may face more risky situations in the future for different reasons. In particular farm production risks may increase due for example to tighter environmental regulations and to the effects of climatic change. The variability of European farm price is also likely to be greater in the future due to the reforms of the Common Agricultural Policy. In this context, it is very important for any economic analysis focusing on agriculture to correctly assess farmers' behaviour in the face of these different sources of risk.
Recent contributions in the field of experimental economics may help to better assess this farmer behaviour. This approach enables to elicit risk attitudes both in the standard framework of expected utility and in the framework of alternative theories (Holt and Laury, 2002; Harrison and Rutström, 2008, 2009; Andersen et al., 2010; Tanaka et al., 2010).

We designed a field experiment to test for two descriptions of farmers' behaviour: expected utility and cumulative prospect theory. We also test for the impact of context (output price risk and yield risk) on risk aversion parameters. We use two elicitation methods based on the procedures of Holt and Laury (2002) and Tanaka et al. (2010) on a sample of 30 French farmers. The experiment consists in asking subjects to make series of choices between two lotteries with varying probabilities and outcomes. We estimate parameters describing farmers' risk preferences derived from structural models. We find farmers are slightly risk averse in the expected utility framework and display loss aversion and probability weighting (overweighting of small probabilities and underweighting of high probabilities). In our study, expected utility is not a good description of farmers' behaviour towards risk.

Our paper is organized as follows. In the next section (section 2), we describe the empirical models derived from structural models. In section 3, we describe the field experiment. In section 4, results are presented and discussed. Section 5 concludes.

2. Empirical models

Following Harrison and Rutström (2008) and Andersen et al. (2010), we use structural modelling to estimate risk aversion parameters for the farmers in our sample.

2.1. Estimation of a structural model assuming expected utility theory

In the context of expected utility theory, we elicit a parameter (r) describing risk attitude using the following CRRA utility function specification (x is wealth) for individual *i*:

$$u_i\left(x\right)=\frac{x^{1-r}}{1-r}$$

The coefficient of constant relative risk aversion is the parameter $r = x.\left(-u_{xx}/u_x\right)$. This leads to the following values for r according to risk attitudes: r>0 if individual is risk averse, r=0 if individual is risk neutral and r<0 if individual is risk loving.

In the experiment, farmers faced series of lottery choices *j* where a choice was made between two lotteries A and B: $\left\{\left(p_j, y_H^A, y_L^A\right);\left(p_j, y_H^B, y_L^B\right)\right\}$. Lottery A (resp. B) offers a high outcome

y_H^A (resp. y_H^B) with probability p_j and a low outcome y_L^A (resp. y_L^B) with probability $1-p_j$. Lottery B has more variable payoffs than lottery A.

For individual *i* and for a given lottery $k \in \{A, B\}$, the expected utility writes:

$$EU_i^k = p_j \times u_i\left(y_H^k\right) + \left(1-p_j\right) \times u_i\left(y_L^k\right)$$

The difference in expected utilities between the two lotteries writes:

$$\nabla EU_i = EU_i^B - EU_i^A$$

It provides the rule for individual *i* choosing lottery B. We model the decision as a discrete choice model (from here, we drop subscript *i* to simplify notations). We consider a latent variable $y^* = \nabla EU + \varepsilon$ that describes the decision to choose lottery B. We assume ε follows a standard normal distribution with zero mean and variance σ.

$$y^* = \nabla EU + \varepsilon \text{ with } \varepsilon \sim \mathrm{N}\left(0, \sigma^2\right)$$

This is equivalent to:

$$\frac{y^*}{\sigma} = \frac{1}{\sigma} \nabla EU + u \text{ with } u \sim \mathrm{N}(0,1)$$

We do not observe y^* but only the choices individuals make so that:

$$\begin{cases} y = 1 & \text{if } y^* > 0 \\ y = 0 & \text{if } y^* \leq 0 \end{cases}$$

The probability to choose lottery B is:

$$\begin{aligned} \mathrm{Prob}(\text{choose lottery B}) &= \mathrm{Prob}\left(\frac{y^*}{\sigma} > 0\right) = \mathrm{Prob}\left(\frac{1}{\sigma}\nabla EU + u > 0\right) \\ &= \mathrm{Prob}\left(u > -\nabla EU/\sigma\right) = \Phi\left(\nabla EU/\sigma\right) \end{aligned}$$

where $\Phi(\bullet)$ is the standard normal distribution function.

We estimate the constant relative risk aversion parameter and the variance σ using maximum likelihood. The log likelihood function writes:

$$\ln L(r : y, \mathbf{X}) = \sum_i \left[\left(\ln \Phi\left(\nabla EU/\sigma\right) \times \mathbf{I}\left(y_i = 1\right)\right) + \left(\ln\left(1 - \Phi\left(\nabla EU/\sigma\right)\right) \times \mathbf{I}\left(y_i = -1\right)\right)\right]$$

where $\mathbf{I}(\bullet)$ is the indicator function, $y_i = 1$ when lottery B is chosen and $y_i = -1$ when lottery A is chosen, $\mathbf{X}$ is a vector of individual characteristics.

2.2. Estimation of a structural model assuming cumulative prospect theory

Under cumulative prospect theory (Tversky and Kahneman, 1992), individuals display differing behaviours in the gain and loss domain. For individual *i* and for a given lottery $k \in \{A, B\}$, the value function utility writes:

$$v^k\left(y^k\right) = \begin{cases} \left(y^k\right)^\alpha & \text{if } y^k > 0 \\ -\lambda\left[\left(-y^k\right)^\alpha\right] & \text{if } y^k < 0 \end{cases}$$

where α is the concavity of the utility function and λ is a loss aversion parameter.

Probabilities are transformed according to the following weighting probability function (Tversky and Kahneman, 1992):

$$\pi(p) = p^\gamma \Big/ \left[p^\gamma + (1-p)^\gamma\right]^{1/\gamma}$$

where γ is a parameter describing the shape of the weighting probability function. $\gamma < 1$ (resp. $\gamma > 1$) implies overweighting (resp. underweighting) of small probabilities and underweighting (resp. overweighting) of high probabilities.

The specifications used in this section collapse to the expected utility specification if $\lambda = 1$ and $\gamma = 1$.

The structural specification of individual decisions under cumulative prospect theory follows the same pattern as with the expected utility specification. For individual *i* and for a given lottery $k \in \{A, B\}$, the prospective utility writes:

$$PU_i^k = \pi\left(p_j\right) \times v_i\left(y_H^k\right) + \pi\left(1 - p_j\right) \times v_i\left(y_L^k\right)$$

We estimate three parameters (α, λ and γ) and the variance σ using maximum likelihood. The log likelihood function writes:

$$\ln L\left(r : y, \mathbf{X}\right) = \sum_i \left[\left(\ln \Phi\left(\nabla PU/\sigma\right) \times \mathbf{I}\left(y_i = 1\right)\right) + \left(\ln\left(1 - \Phi\left(\nabla PU/\sigma\right)\right) \times \mathbf{I}\left(y_i = -1\right)\right)\right]$$

where $\mathbf{I}(\bullet)$ is the indicator function, $y_i = 1$ when lottery B is chosen and $y_i = -1$ when lottery A is chosen, $\mathbf{X}$ is a vector of individual characteristics.

We now turn to describing the field experiment.

3. Field experiment and sample description

We first describe the field experiment and then the characteristics of the sample.

3.1. Field experiment description

The field experiment took place in the summer 2010. Participants were face-to-face interviewed. We used a multiple price list procedure (see Harrison and Rutström, 2008 for a review). We used two elicitation series we call HL series and TCN series based on the papers of Holt and Laury (2002) and Tanaka et al. (2010) on a sample of 30 French farmers. The experiment consists in asking subjects to make series of 65 choices between two lotteries with varying probabilities and outcomes (choice situations 1 to 30 correspond to the HL series and choice situations 31 to 65 to the TCN series). Choices were presented in the format of Figure 1 where playing a lottery was framed as turning a wheel (like in the well known Wheel of Fortune TV show). The highest potential earning in the experiment is 385€ and the lowest is a loss of 6€.

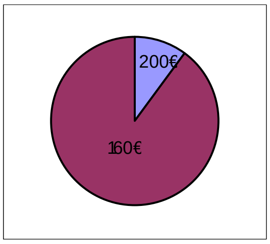
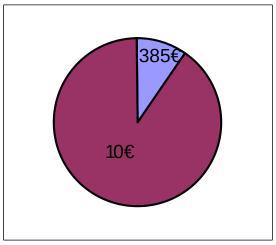
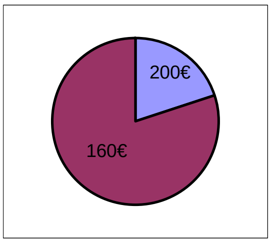
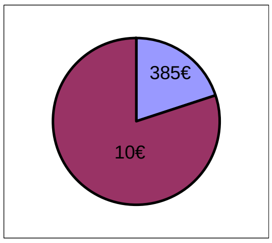
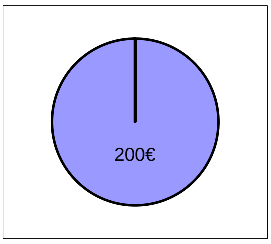
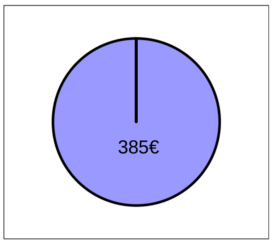
Choice situation	Probability of earning the high outcome	Probability of earning the low outcome	Wheel A	Wheel B	I prefer turning…
1	1 out of 10	9 out of 10			Wheel A ❑ Wheel B ❑
2	2 out of 10	8 out of 10			Wheel A ❑ Wheel B ❑
….					
10	10 out of 10	0 out of 10			Wheel A ❑ Wheel B ❑

Figure 1. Example of choices faced by subjects in the field experiment: situations 1 to 10 based on Holt and Laury (2002)

Individual choices between lotteries enable an estimation of the parameters we described in section 2. There were three variations as compared to the papers of Holt and Laury (2002) and Tanaka et al. (2010). First, in the HL series, the figures corresponding to gains are a hundred times higher than in the baseline treatment of Holt and Laury (2002) (1.65$ becomes 165€). Second, in the TCN series, the figures corresponding to gains and losses are 5,000 times lower than the experiment of Tanaka et al. (2010) (40,000 Vietnamese dongs become 8€). Third, the HL series is played three times to test for pure framing effects: no context as in Holt and Laury (2002) (probability of earning a given amount of money), price context (probability of selling 10% of soft wheat production at a certain price per ton), and margin context (probability of getting a certain margin with a 15% fertilizer reduction). Table 1 shows the characteristics of each of the 65 choice situations.

Choice situations	Series	Reference	Framing	Domain
1-10	HL series	Holt and Laury (2002) Baseline*100	No	Gain
11-20		Holt and Laury (2002) Baseline*100	Price risk frame	Gain
21-30		Holt and Laury (2002) Baseline*100	Yield risk frame	Gain
31-58	TCN series	Tanaka et al. (2010) Baseline/5,000	No	Gain
59-65				Loss

Table 1. Choice situations faced by farmers in the field experiment

The incentive of the experiment is controlled by randomly drawing the choice situation (thus the lottery chosen by the participant) that will be played for earnings. Then, out of the 30 participants, 3 participants were randomly drawn for real payments. All participants received a show-up fee (20€) to cover their expense for coming to the experiment and to potentially cover their expenses in the loss domain.

3.2. Sample description

We collected questionnaires from 30 farmers. Table 2 gives summary statistics. Farmers in the group are relatively well educated. They perceive their production activities as very risky in terms of output prices. Then, risks related to input prices and climatic risks are considered as very important.

Variable	**Description**	**#Obs**	**Mean**	**SD**	**Min**	**Max**
Variables describing farmers						
AGE	Age (in years)	30	41.90	9.36	23	56
EDUC	=1 if "baccalaureat" diploma or higher and 0 otherwise	30	0.70	0.47	0	1
Variables describing farms						
SAU	UAA (hectares)	30	176.73	61.52	74	297
ETS	=1 if company and 0 otherwise	30	0.60	0.50	0	1
GAEC	=1 if partnership and 0 otherwise	30	0.13	0.35	0	1
Variables on farmers' perception of risk in their production activity (1=not risky to 5=very risky)						
RISKPPROD	Perception of output price risk	30	4.60	0.67	3	5
RISKPINT	Perception of input price risk	30	3.97	0.89	2	5
RISKCLIM	Perception of climatic risk (yield)	30	3.63	1.10	2	5
RISKCOM	Perception of output marketing risk	30	3.40	1.13	1	5
RISKPOL	Perception of risk related to policies	30	3.00	1.31	1	5
RISKTECH	Perception of technological risk	30	2.20	0.96	1	4

Table 2. Summary statistics

4. Empirical results

We present and discuss our results first in the framework of expected utility theory and then of the cumulative prospect theory.

4.1. Econometric estimation of risk attitudes under expected utility theory

We consider choice situations 1 to 58. As situations 59 to 65 involve losses and the CRRA utility function specification does not allow for "negative wealth", we drop situations 59-65. Table 3 gives the maximum likelihood estimation results using clustering for individuals. We estimate the CRRA parameter along with the variance. We allow for variance to vary as a function of the series (HL or TCN). A variable called TYPE enables us to get the impact of the TNC series as compared to the HL series.

Estimated parameters	**(1)** Coefficient (Robust SE)	**(1)** P>|z|	**(2)** Coefficient (Robust SE)	**(2)** P>|z|	**(3)** Coefficient (Robust SE)	**(3)** P>|z|
σ						
constant	3.768 (0.559)	0.000	3.732 (0.553)	0.000	3.711 (0.520)	0.000
TYPE	5.811 (0.774)	0.000	5.987 (0.807)	0.000	5.788 (0.677)	0.000
r						
constant	0.125 (0.098)	0.203	0.114 (0.100)	0.251	0.133 (0.104)	0.198
PRICEFRAME			0.009 (0.033)	0.792	-0.005 (0.033)	0.868
MARGINFRAME			0.041 (0.038)	0.279	0.036 (0.038)	0.341
EDUC					-0.070 (0.047)	0.137
GAEC					0.054 (0.072)	0.448
ETS					0.058 (0.042)	0.170
#Observations		**1740**		**1740**		**1740**
Log likelihood		**-902.98 (ns)**		**-901.63 (ns)**		**-887.77 (ns)**

Table 3. ML estimation of CRRA parameter and variance under EUT – Situations 1 to 58 and clustering for individuals

The estimated parameter, the constant in model (1), suggests small risk aversion in the sample (r=0.125>0). The risk preference parameter is elicited in three frames: no context, output price risk and yield risk. We control for framing effects by adding dummies (the reference is no frame) in model (2): PRICEFRAME equals one if output price risk frame and zero otherwise, and MARGINFRAME equals one if yield risk frame and zero otherwise. We find there are no significant framing effects. The constant gives an estimate of the CRRA parameter (r=0.114>0) when there is no context. Individuals are still risk averse but slightly less.

We turn to studying the effects of farm's and farmer's characteristics on risk aversion in model (3). We use one variable describing the farmer (EDUC) and two variables describing the farm status (GAEC and ETS). The dummies for framing effects remain. The reference is no context and farmers without high school diploma, with farms with sole proprietorship. We find that the estimated CRRA parameter is now 0.133, which is a little higher but still not significant. Framing has still no significant effect on risk attitudes. More educated people tend to be less risk averse. Indeed, the variable EDUC has a negative effect on the CRRA parameter although not significantly (p=0.137). The status of the farm has no significant impact on attitudes towards risk.

4.2. Econometric estimation of risk attitudes under CPT

We now consider all choice situations (1 to 65). Using clustering for individuals, the estimation results are in Table 4. We present three models: baseline, with framing dummies, and with individual characteristics. We also test for parameters equality to one. Recall especially that expected utility theory implies $\lambda = 1$ and $\gamma = 1$.

Estimated parameters	(4) Coefficient (Robust SE)	P>|z|	(5) Coefficient (Robust SE)	P>|z|	(6) Coefficient (Robust SE)	P>|z|
σ						
constant	3.229 (0.786)	0.000	1.910 (0.821)	0.020	1.371 (1.425)	0.336
TYPE	4.964 (0.853)	0.000	3.527 (1.021)	0.001	2.391 (1.617)	0.139
α						
constant	0.803 (0.115)	0.000	0.605 (0.136)	0.000	1.002 (0.105)	0.000
PRICEFRAME			0.255 (0.128)	0.047	-0.089 (0.078)	0.252
MARGINFRAME			0.301 (0.137)	0.027	-0.078 (0.077)	0.314
EDUC					-0.004 (0.095)	0.962
GAEC					-0.439 (0.234)	0.061
ETS					-0.032 (0.054)	0.553
λ						
constant	2.489 (0.697)	0.000	2.111 (0.349)	0.000	0.041 (5.512)	0.994
EDUC					1.740 (0.483)	0.000
GAEC					0.594 (5.500)	0.914
ETS					53.377 (45.586)	0.242
γ						
constant	1.036 (0.171)	0.000	0.884 (0.146)	0.000	0.048 (0.011)	0.000
PRICEFRAME			-0.535 (0.096)	0.000	0.218 (0.114)	0.055
MARGINFRAME			-0.599 (0.103)	0.000	0.187 (0.091)	0.039
EDUC					0.025 (0.032)	0.429
GAEC					0.531 (0.083)	0.000
ETS					-0.010 (0.008)	0.233
#Observations	1950		1950		1950	
Log likelihood	-1025.35 (ns)		-1013.07 (10%)		-1096.83 (1%)	
Hypotheses can be rejected?						
α : constant=1	Yes (1%)		Yes (5%)		No	
λ : constant=1	Yes (5%)		Yes (5%)		No	
γ : constant=1	No		No		Yes (1%)	

Table 4. ML estimation of parameters and variance under cumulative prospect theory – Situations 1 to 65 and clustering for individuals

Let us discuss first the results on the constants in models (4) and (5). We find that the value function is concave in the gain domain and convex in the loss domain. The estimated α

parameter is 0.803 in model (4) and 0.605 in model (5). It is significantly different from one (chisq test: 2.94; p=0.086 in model (4) and chisq test: 8.52; p=0.004 in model (5)). We find that farmers in the sample exhibit loss aversion. The estimated λ parameter is 2.489 in model (4) and 2.111 in model (5) and is significantly higher than one (chisq test: 4.56; p=0.033 in model (4) and chisq test: 10.13; p=0.002 in model (5)). However, there is no significant evidence of probability weighing in both models. The estimated γ parameter is not significantly different from one (chisq test: 0.05; p=0.832 in model (4) and chisq test: 0.64; p=0.425 in model (5)).

In model (5), we control for framing effects. Note that framing effects were introduced in the field experiment only in the gain domain. They are controlled for in the estimation only for the α and γ equations. They appear to play a significant role. The price frame and the margin frame impact positively the curvature of the value function (5% significance) but negatively the probability weighing parameter (1% significance). Especially, farmers tend to overweight small probabilities and underweight high probabilities in the framing treatments.

Finally, we add individual characteristics to explain the parameters in model (6). We find that the value function is linear in the gain and the loss domain. The estimated α parameter is 1.002 and is not significantly different from one (chisq test: 0; p=0.983). Contrary to the results of the previous models, when individual characteristics are controlled for, we find no evidence of loss aversion (chisq test: 0.03; p=0.862) but evidence of probability weighting (chisq test: 7280; p=0.000). Framing effects still significantly impact the probability weighting function but not the curvature of the value function. Now in a price or margin frame, farmers tend to overweight less small probabilities. Individual characteristics play a role in this. We find the status of the farm impacts the α and γ parameters. We also find that education tends to increase loss aversion.

5. Conclusion and discussion

In the context of increasing risks in agriculture, we designed a field experiment involving real payments to elicit farmers' risk preferences. We especially tested for two descriptions of farmers' behaviour: expected utility and cumulative prospect theory. We use two elicitation methods based on the procedures of Holt and Laury (2002) and Tanaka et al. (2010) on a sample of 30 French farmers. We estimated parameters describing farmers' risk preferences derived from structural models. We find farmers are slightly risk averse in the expected utility framework. In the cumulative prospect theory frame, we find farmers display either loss aversion or probability weighting, tending to overweight small probabilities and to underweight high probabilities. In our study, expected utility is not a good description of farmers' behaviour towards risk.

This study is a first step into a better understanding of farmers' behaviour towards risky situations using recent advances in field experiments. Several characteristics of our study should be kept in mind however. First, we used the multiple price list procedure because it is easy to implement and to understand for subjects. It may however involve framing effects (suggesting the middle row and making clear the experiment objective) though Harrison and Rutström (2008) indicate the bias is not systematic. Second, our sample is small. We would need either to increase the number of choices made by subjects or to increase the number of subjects. The first proposition seems difficult to implement since asking for 65 choices was already a lot for subjects. We showed that the variance increased in the TCN series as compared to the HL series. This may also be due to fatigue effects, the HL being played always first. Our study would benefit from increasing the number of interviewed farmers to better test for the effect of individual characteristics, to elicit individual parameters and to determine the effect of risk attitudes on behaviours such as production choices and insurance demand. Third, the loss domain is not easy to implement in the field. Indeed, one cannot ask participants in the experiment to pay the experimenter if the lottery involves a loss. This is resolved by the show-up fee. But, this fee in itself plays the role of an insurance mechanism. Moreover, the experiment implicitly sets the reference point in the cumulative prospect theory at a zero level. This is a hypothesis. Future study aims at working on these limitations and trying to elicit other parameters such as time preferences and ambiguity aversion.

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