# A structural estimation of French farmers' risk preferences: an artefactual field experiment

Douadia BOUGHERARA, Xavier GASSMANN, Laurent PIET

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Douadia BOUGHERARA

*INRA, UMR1302 SMART, F-35000 Rennes, France*
*Agrocampus Ouest, UMR1302 SMART, F-35000 Rennes, France*

Xavier GASSMANN

*INRA, UMR1302 SMART, F-35000 Rennes, France*
*Agrocampus Ouest, UMR1302 SMART, F-35000 Rennes, France*

Laurent PIET

*INRA, UMR1302 SMART, F-35000 Rennes, France*
*Agrocampus Ouest, UMR1302 SMART, F-35000 Rennes, France*

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**Auteur pour la correspondance / Corresponding author**

**Douadia BOUGHERARA**

INRA, UMR SMART
4 allée Adolphe Bobierre, CS 61103
35011 Rennes cedex, France
Email: Douadia.Bougherara@rennes.inra.fr
Téléphone / Phone: +33 (0)2 23 48 56 03
Fax: +33 (0)2 23 48 53 80

# A structural estimation of French farmers' risk preferences: an artefactual field experiment


## Abstract

We designed an artefactual field experiment involving real payments to elicit French farmers' risk preferences. We test for two descriptions of farmers' behaviour: expected utility and cumulative prospect theory and for preference stability across context (price risk and yield risk). We use multiple price lists where farmers make series of choices between two lotteries with varying probabilities and outcomes in the gain and loss domains. 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. We also estimate the reference point and find it not significantly different from zero. Cumulative prospect theory is a better description of farmers' risk attitudes. We find risk preferences vary across context.


**Keywords:** risk attitudes, field experiment, farmer

**JEL classifications:** C93, D81, Q10

# Une estimation structurelle des préférences des agriculteurs pour le risque à partir d'un field experiment en France


## Résumé

Nous réalisons un field experiment impliquant des paiements réels afin de déterminer les préférences pour le risque d'agriculteurs en France. Nous testons deux théories de la décision face au risque et examinons la stabilité des préférences selon le contexte (risque prix ou rendement). Nous utilisons une méthode (multiple price list) dans laquelle les agriculteurs font plusieurs séries de choix entre deux loteries aux gains et aux probabilités de gains variables. Nous considérons à la fois des gains et des pertes. Nous estimons les paramètres de préférences face au risque à partir de modèles structurels. Nos résultats indiquent que les agriculteurs (i) sont faiblement averses au risque dans la théorie de l'utilité espérée, (ii) sont averse à la perte ou déforment les probabilités (surestimant les faibles probabilités et sous-estimant les fortes) dans la théorie des perspectives cumulées. C'est la théorie des perspectives cumulées qui décrit le mieux le comportement des agriculteurs. Nous estimons également le point de référence qui n'apparait pas significativement différent de zéro. Nos résultats indiquent enfin que les préférences ne sont pas stables selon le contexte.



**Mots-clefs :** aversion au risque, field experiment, agriculteur

**Classifications JEL :** C93, D81, Q10

**A Structural Estimation of French Farmers' Risk Preferences: An Artefactual Field Experiment**

# 1 Background and motivation

Risk has always played an important role in agricultural producers' decisions. The agricultural producer faces two main sources of risks: yield and price risks. Farmers' attitude towards risk is an important topic for investigation for two main reasons. First, the context is changing. Agriculture faces environmental challenges that could question the use of risk-reducing inputs such as pesticides or increase difficult-to-predict climatic events (global warming). Price volatility is also an increasing concern for farmers. Globalization makes prices more influenced by supply and demand changes in other parts of the world. Governments also provide less and less price support. In this changing 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. Second, agricultural economics' quest for assessing farmers' preferences for risk is still unsatisfied. The litterature is mainly based on revealed preference studies. Their main advantages is to derive preferences from large samples and real economic decisions. Their drawbacks are to rely on strong hypotheses such as overweighing the role of diminishing marginal utility in decisions [Just and Pope, 2003], to enable to determine a distribution of parameters and not individual parameters and to rely on expected utility theory. There is a need to better assess farmers' preferences for risk (see Reynaud et al. [2010] for a review of main results). Given the changing context in agriculture and these academic limitations, we aim at eliciting farmers' risk preferences using recent developments in field experiments.

There is indeed a recent and growing litterature using field experiments with real payments to structurally derive risk parameters [Harrison and Rutström, 2008]. Although they rely on smaller samples and less context compared to revealed preference studies, these methods enable to control for the decision makers' environment, to provide estimates from structural models, to estimate individual parameters and to use alternatives to expected utility theory [Holt and Laury, 2002; Harrison and Rutström, 2008, 2009; Andersen et al., 2010; Tanaka, Camerer, and Nguyen, 2010]. In this litterature, few papers elicit preferences for farmers and are mainly applied to farmers in developing countries [Binswanger, 1980; Humphrey and Verschoor, 2004; Liu, 2007; Harrison, Humphrey, and Verschoor, 2010]. In this article, we estimate farmers' risk preferences from structural models using field experiments. Actually, we are not interested in recovering the value of the underlying parameters for each farmer in the sample; rather, we want to analyze the impact of variables characterizing the farm and/or the farmer on these parameters. Therefore, we do not estimate individual parameters but average ones for the considered sample.[1] We use a multiple price list elicitation method. The field experiment consists

[1] Alternatively, we could have estimated the parameters at the individual level and then regressed these parameters on a set of socio-economic explanatory variables. But this would have led to a 2-step, indirect, measure of the impact of these variables. We preferred the direct approach adopted here. A model using a random parameters specification would represent an alternative but we could not implement it due to the limited size of our sample (see section 3).

in asking subjects to make series of choices between two lotteries with varying probabilities and outcomes in the gain and loss domains.

The aim of our paper is threefold. First, we estimate risk preferences derived from structural models allowing for alternatives to expected utility theory as in Harrison and Rutström [2008], Andersen et al. [2010] and Harrison, Humphrey, and Verschoor [2010]. We notably test for cumulative prospect theory where probabilities are transformed and preferences differ in the gain and loss domain (loss aversion) according to a reference point. In our estimation, we consider an endogenous variance thus allowing for an effect of learning and fatigue of respondents in answering the questionnaire (65 choices in a row). Second, we test for the stability of risk preferences across contexts as Barseghyan, Prince, and Teitelbaum [2011] who show that for many households risk aversion differs across domains (home vs. auto deductible choices). We test for a variation of risk preferences across two context: yield risk and price risk. Third, while most of the litterature consider an exogenous zero reference point, we allow for an endogenous reference point.

We would like to mention also three studies conducted simultaneously to ours aiming at eliciting preferences for farmers in developped countries and specifically in France [Reynaud et al., 2010; Reynaud and Couture, 2010; Bocquého, Jacquet, and Reynaud, 2011]. Our paper differs in that we consider the stability of risk preferences across context and we consider an endogenous reference point and estimate the variance.

We find that 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). We also estimate the reference point and find it not significantly different from zero. Our study shows that, for our sample, cumulative prospect theory is a better description of farmers' behaviour towards risk than expected utility theory.

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 Structural models

We follow the modeling strategy of Harrison and Rutström [2008] and Andersen et al. [2010] to enable us to identify 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 Constant Relative Risk Aversion (CRRA) utility function specification ($x$ is wealth):

$$u(x) = \frac{x^{(1-r)}}{(1-r)}$$

The coefficient of constant relative risk aversion is the parameter $r = x \times (\frac{-u_{xx}}{u_x})$, where $u_x$ and $u_{xx}$ are the first and second derivatives of $u$ with respect to $x$, respectively. This leads to the following values for $r$ according to risk attitudes: $r > 0$ if the individual is risk averse, $r = 0$ if the individual is risk neutral and $r < 0$ if the individual is risk loving. This function also

allows for decreasing absolute risk aversion, a property often observed in agriculture [Chavas and Holt, 1996; Saha, Shumway, and Talpaz, 1994].
In our experiment, farmers face series of lottery choices $j$ where a choice has to be made between two lotteries A and B: $\{(p_j, y_H^A, y_L^A); (p_j, y_H^B, y_L^B)\}$. 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 each individual and for a given lottery $k \in \{A, B\}$, the expected utility writes:

$$EU^k = p_j.u(y_H^k) + (1 - p_j).u(y_L^k)$$

The difference in expected utilities between the two lotteries writes:

$$\Delta EU = EU^B - EU^A$$

It provides the rule for the individual choosing lottery B. We model the decision as a discrete choice model. We consider a latent variable $y^* = \Delta EU + \varepsilon$ that describes the decision to choose lottery B. We assume $\varepsilon$ follows a standard normal distribution with zero mean and variance $\sigma^2$.

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

This is equivalent to:

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

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:

$$Prob(\text{choose lottery B}) = Prob\left(\frac{y^*}{\sigma} > 0\right) = Prob\left(\frac{1}{\sigma}\Delta EU + u > 0\right)$$

$$= Prob\left(u > -\frac{\Delta EU}{\sigma}\right) = \Phi\left(\frac{\Delta EU}{\sigma}\right)$$

where $\Phi(\cdot)$ is the standard normal distribution function.
We estimate the constant relative risk aversion parameter and the variance $\sigma^2$ using maximum likelihood. The log likelihood function writes:

$$\ln\left(L\left(r : y, \mathbf{X}\right)\right) = \sum_i \left\{\left[\ln\left(\Phi\left(\Delta EU/\sigma\right)\right)\right].\mathbf{I}(y_i = 1) + \left[\ln\left(1 - \Phi\left(\Delta EU/\sigma\right)\right)\right].\mathbf{I}(y_i = 0)\right\}$$

where $\mathbf{I}(\cdot)$ is the indicator function, $y_i = 1$ when lottery B is chosen and $y_i = 0$ when lottery A is chosen, and $\mathbf{X}$ is a vector of individual characteristics.

## 2.2 Estimation of a structural model assuming cumulative prospect theory

This section is motivated by the commonly observed phenomena of choice under risk: "losses loom larger than gains". Under Cumulative Prospect Theory (CPT) [Tversky and Kahneman, 1992], individuals display differing behaviours in the gain and loss domain. The value function writes:

$$v(y) = \begin{cases} (y - y_0)^\alpha \text{ if } y \geq y_0 \\ -\lambda. \left[(-y + y_0)^\alpha\right] \text{ if } y < y_0 \end{cases}$$

where $\alpha$ is the concavity of the utility function, $y_0$ is the reference-point parameter and $\lambda$ is a loss aversion parameter. Some studies have focused on reference-dependent model allowing for a reference point [Schmidt and Zank, 2011; Apesteguia and Ballester, 2009; Köszegi and Rabin, 2006]. According to these studies the reference point is determined by the individual's expectations. We contribute to this stream of research by estimating the reference point. Usually the reference is supposed to be zero. In a first step, we will make such an assumption; in a second step, we will estimate the reference point and test whether it is actually null or not.
Under cumulative prospect theory, probabilities are transformed according to the following weighting probability function [Tversky and Kahneman, 1992]:

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

where $\gamma$ 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. Note that 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:

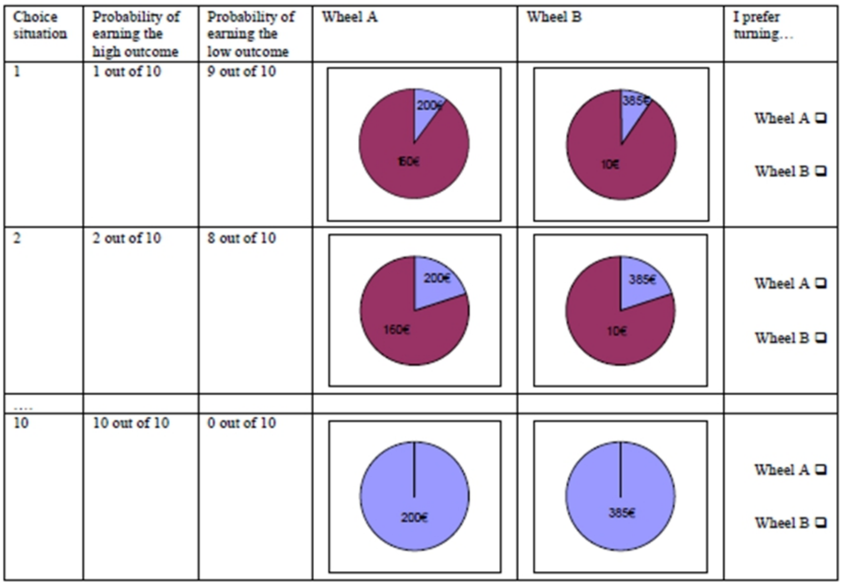
$$PU_i^k = \pi\left(p_j\right).v_i(y_H^k) + \pi\left(1 - p_j\right).v_i(y_L^k)$$

As mentioned before and as a first step, we assume that the reference point is zero. Using the same kind of latent class model as with expected utility, we thus estimate three parameters ($\alpha$, $\lambda$ and $\gamma$) and the variance $\sigma^2$ with maximum likelihood. In this case, the log likelihood function writes:

$$\ln\left(L\left(\alpha, \lambda, \gamma : y, \mathbf{X}\right)\right) = \sum_i \left\{\left[\ln\left(\Phi\left(\Delta PU/\sigma\right)\right)\right].\mathbf{I}(y_i = 1) + \left[\ln\left(1 - \Phi\left(\Delta PU/\sigma\right)\right)\right].\mathbf{I}(y_i = 0)\right\}$$

where $\mathbf{I}(\cdot)$ is the indicator function, $y_i = 1$ when lottery B is chosen and $y_i = 0$ when lottery A is chosen, and $\mathbf{X}$ is a vector of individual characteristics.
We now turn to the description of the field experiment.

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



| 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 | 200€ / 160€ | 385€ / 10€ | Wheel A ❑ Wheel B ❑ |
| 2 | 2 out of 10 | 8 out of 10 | 200€ / 160€ | 385€ / 10€ | Wheel A ❑ Wheel B ❑ |
| .... | | | | | |
| 10 | 10 out of 10 | 0 out of 10 | 200€ | 385€ | Wheel A ❑ Wheel B ❑ |

# 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 during summer 2010. Given the expected small size of the sample, we carefully selected a sample as homogenous as possible in terms of agricultural outputs. Participants were farmers from a small cooperative (160 members) in the center of France. The farmers produce mainly high quality wheat and barley for fast foods and breweries. The director of the cooperative and the Research and Development Division of a large technical institute (ARVALIS-Institut du Végétal[2]) were strongly involved in the study so that thirty farmers were invited to participate in our study and all accepted. The sample is clearly not random. We do not aim at deriving general results from our sample but to characterize this specific sample.
Participants were face-to-face interviewed. Each interview lasted about 1 hour and a half. The questionnaire was composed of lottery choices followed by a survey on variables describing the farmer and the farm. For the lottery choice part, we used a multiple price list procedure where farmers made series of choices between two lotteries with varying probabilities and outcomes in the gain and loss domains. 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 lottery choice part was composed of two series . The first series (the HL series) is a variation of the protocole of Holt and Laury [2002] (see Table A.1 in the Appendix). It is only in the gain domain and allows for variations in the risk context (no context in situations 1 to 10, price risk in situations 11 to 20 and yield risk in situations 21 to 30). Note that the context treatments were "pure" framing effects since they differed from the no context treatment only by

[2] http://www.arvalisinstitutduvegetal.fr/en/

Table 1: Treatments

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

the scenario. In describing the contexts, we used a cheap talk method, well known in valuation surveys [Cummings and Taylor, 1999], where we acknowledged the "pure" framing nature of the tasks and incited subjects to act as if they really faced the market choices. The price risk context was framed as follows: *"Suppose you could sell 10% of your wheat production to two potential markets with random prices. Which market would you choose?"*. The yield risk context was framed as a choice between two lotteries with random margins as follows: *"Suppose you could choose between using the usual amount of pesticides (option A) and reducing by 15% your pesticides use (option B) on 10% of you wheat production. Reducing your pesticides use will have an impact on yields but this effect is random depending on climatic conditions so that your margin will be random. Which option would you choose?"*. The "15% decrease in pesticide use" lottery was the riskier lottery (lottery B). The second series (TCN series) is a variation of the protocole of Tanaka, Camerer, and Nguyen [2010] and allows for gains and losses (see Table A.2 in the Appendix). In the whole experiment, the highest potential earning was 385€ and the lowest was a loss of 6€.
The treatments for each of the 65 choice situations are presented in Table 1. There were three variations as compared to the papers of Holt and Laury [2002] and Tanaka, Camerer, and Nguyen [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] and expressed in Euros ( i.e., 1.65$ becomes 165€). Second, in the TCN series, the figures corresponding to gains and losses are 5,000 times lower than in the experiment of Tanaka, Camerer, and Nguyen [2010] (40,000 Vietnamese dongs become 8€). Third, the HL series is played three times to test for framing effects: no context (probability of earning a given amount of money) as in Holt and Laury [2002], price risk context (probability of selling 10% of soft wheat production at a certain price per ton), and yield risk context (probability of getting a certain margin with a 15% fertilizer reduction).
The incentive of the experiment is controlled by randomly drawing one of the 65 choice situations. Then, in the randomly drawn choice situation, the lottery (A or B) chosen by the participant is 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 cover their potential expenses in the loss domain.

## 3.2 Sample description

We collected questionnaires from 30 farmers. Table 2 gives some summary statistics regarding the individuals and their farms. Farmers in the group have relatively high education. Our sample contains farms with relatively large agricultural areas compared to the French national average

Table 2: Summary statistics

| Variables | Description | #Obs | Mean | SD |
|---|---|---|---|---|
| *Describing farmers* | | | | |
| AGE | Age (in years) | 30 | 41.90 | 9.36 |
| EDUC | =1 if "baccalaureat" diploma or higher =0 otherwise | 30 | 0.70 | 0.47 |
| *Describing farms* | | | | |
| UAA | Utilised Agricultural Area (hectares) | 30 | 176.73 | 61.52 |
| COMPANY | =1 if company and 0 otherwise | 30 | 0.60 | 0.50 |
| PARTNERSHIP | =1 if partnership and 0 otherwise | 30 | 0.13 | 0.35 |
| *Describing farmers' risk perception** | | | | |
| RISKPPROD | Perception of output price risk | 30 | 4.60 | 0.67 |
| RISKPINT | Perception of input price risk | 30 | 3.97 | 0.89 |
| RISKCLIM | Perception of climatic risk (yield) | 30 | 3.63 | 1.10 |
| RISKCOM | Perception of output marketing risk | 30 | 3.40 | 1.13 |
| RISKPOL | Perception of risk related to policies | 30 | 3.00 | 1.31 |
| RISKTECH | Perception of technological risk | 30 | 2.20 | 0.96 |

* Farmers were asked to grade their perception of the 6 types of risks related to their activity on a 5-level scale, from 1 ("not risky") to 5 ("very risky").

(80 hectares). A majority of the farms are governed as a company[3](the farmer rents the capital from the company), few as a partnership[4] (the farmer offers his capital to the partnership) and the remaining are individual farms. They perceive their production activities as very risky in terms of output prices, input prices and weather-related events. Farming is perceived as risky in the sample. This consolidates the motivation of our survey. Our analysis limits itself only to the following variables: EDUC, COMPANY and PARTNERSHIP.[5]

# 4 Empirical results

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

## 4.1 Econometric estimation of risk attitudes under expected utility theory

We consider choice situations 1 to 58 only: situations 59-65 cannot be used in this framework since they involve losses and the CRRA utility function specification does not allow for "negative wealth".

Table 3 gives the maximum likelihood estimation results using clustering for individuals. We estimate the CRRA parameter along with the variance of the residuals. We allow for the variance to vary as a function of the series (HL or TCN). A variable called TYPE enables us to get the impact of the TCN series as compared to the HL series.

The estimated parameter, the constant in model (1), though not significantly different from zero at the 10% level, 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.

[3]Stands for "Exploitation Agricole à Responsabilité Limitée" (EARL) or "Société Civile d'Exploitation Agricole" (SCEA) in France

[4]Stands for "Groupement Agricole d'Exploitation en Commun" (GAEC) in France.

[5]This means that, in some model specifications, the estimated parameters will be expressed as linear combinations of a set of -possibly different- explanatory variables, including a constant.

Table 3: ML estimation of CRRA parameter and variance under expected utility theory (Situations 1 to 58 and clustering for individuals)

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

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 that 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 still display small risk aversion.

With model (3), we turn to studying the effects of farm's and farmer's characteristics on risk aversion. We use one variable describing the farmer (EDUC) and two variables describing the legal status of the farm (PARTNERSHIP and COMPANY). We keep the dummies for framing effects. The reference is no context, farmers without high school diploma and individual farms. We find that the estimated CRRA parameter is now 0.133, which is a little higher, and more significant but still not at the 10% level. 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). Farmers who belong to partnership or company farms are likely to be more risk averse. However, the status of the farm also 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) as cumulative prospect theory explicitly accommodates for losses, there again using clustering for individuals. Estimation results are presented in Table 4.

Consider first models (4) to (6). We assume that the reference point is zero. The three models are: baseline, with framing dummies, and with individual characteristics. We also test for parameters' equality to one; especially recall that the expected utility theory implies $\gamma = 1$ and $\lambda = 1$.

Table 4: ML estimation of parameters and variance under cumulative prospect theory (Situation 1 to 65 and clustering for individuals)

| **Reference point** | **Exogenous** ($y_0 = 0$) | | | **Endogenous** | | |
|---|---|---|---|---|---|---|
| | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** |
| **Estimated parameter** | Coefficient (Robust SE) | Coefficient (Robust SE) | Coefficient (Robust SE) | Coefficient (Robust SE) | Coefficient (Robust SE) | Coefficient (Robust SE) |
| $\sigma$ | | | | | | |
| constant | 3.229*** | 1.910** | 1.371 | -0.570 | -1.042 | -0.092 |
| | (0.786) | (0.821) | (1.425) | (0.900) | (3.599) | (1.030) |
| TYPE | 4.964*** | 3.527*** | 2.391 | 3.555*** | 3.882** | 3.710*** |
| | (0.853) | (1.021) | (1.617) | (0. 564) | (1.977) | (0.540) |
| $\alpha$ | | | | | | |
| constant | 0.803*** | 0.605*** | 1.002*** | 0.428*** | 0.419*** | 0.470*** |
| | (0.115) | (0.136) | (0.105) | (0.074) | (0.125) | (0.105) |
| PRICEFRAME | | 0.255** | -0.089 | | -0.023 | 0.012 |
| | | (0.128) | (0.078) | | (0.033) | (0.028) |
| MARGINFRAME | | 0.301** | -0.078 | | -0.029 | -0.009 |
| | | (0.137) | (0.077) | | (0.0.37) | (0.041) |
| EDUC | | | -0.004 | | | 0.037 |
| | | | (0.095) | | | (0.043) |
| PARTNERSHIP | | | -0.439* | | | 0.040 |
| | | | (0.234) | | | (0.040) |
| COMPANY | | | -0.032 | | | -0.033 |
| | | | (0.054) | | | (0.035) |
| $\lambda$ | | | | | | |
| constant | 2.489*** | 2.111*** | 0.041 | 1.802*** | 1.679 | 1.132* |
| | (0.697) | (0.349) | (5.512) | (0. 347) | (1.664) | (0.669) |
| EDUC | | | 1.740*** | | | 0.343 |
| | | | (0.483) | | | (0.655) |
| PARTNERSHIP | | | 0.594 | | | 0.344 |
| | | | (5.500) | | | (0.565) |
| COMPANY | | | 53.377 | | | 0.543 |
| | | | (45.586) | | | (0.515) |
| $\gamma$ | | | | | | |
| constant | 1.036*** | 0.884*** | 0.048*** | 0.759*** | 0.759*** | 0.864*** |
| | (0.171) | (0.146) | (0.011) | (0.080) | (0.078) | (0.236) |
| PRICEFRAME | | -0.535*** | 0.218* | | 2.965*** | -0.113 |
| | | (0.096) | (0.114) | | (0.791) | (0.123) |
| MARGINFRAME | | -0.599*** | 0.187** | | -0.025 | -0.156 |
| | | (0.103) | (0.091) | | (0.373) | (0.175) |
| EDUC | | | 0.025 | | | -0.080 |
| | | | (0.032) | | | (0.247) |
| PARTNERSHIP | | | 0.531*** | | | -0.226** |
| | | | (0.083) | | | (0.103) |
| COMPANY | | | -0.010 | | | 0.033 |
| | | | (0.008) | | | (0.227) |
| $y_0$ | | | | | | |
| constant | | | | -722.374 | -1187.917 | -511.616 |
| | | | | (928.894) | (6359.847) | (427.390) |
| **#Obs** | 1950 | 1950 | 1950 | 1950 | 1950 | 1950 |
| **Log likelihood** | -1025.35 (N/A) | -1013.07* | -1096.83*** | -984.80 (N/A) | -981.10 | -957.31*** |
| **Is the hypothesis rejected?** | | | | | | |
| $\alpha$: constant=1 | Yes*** | Yes** | No | Yes*** | Yes*** | Yes*** |
| $\lambda$: constant=1 | Yes** | Yes** | No | Yes** | No | No |
| $\gamma$: constant=1 | No | No | Yes*** | Yes*** | Yes*** | No |
| $y_0$: constant=0 | | | | No | No | No |

Note: *** significant at 1% level; ** significant at 5% level; * significant at 10% level

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, which conforms to theory: the estimated $\alpha$ parameter is 0.803 in model (4) and 0.605 in model (5) and 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 $\lambda$ 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 $\gamma$ 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 in the gain domain and the HL series only. They are thus controlled for only in the estimation of $\alpha$ and $\gamma$. 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 framed treatments.
Then, we add individual characteristics in model (6). We find that the value function is linear in the gain and the loss domain. The estimated parameter is 1.002 and is no longer significantly different from one (chisq test: 0, p=0.983). Contrary to the results of the previous models, we find no evidence of loss aversion (chisq test: 0.03, p=0.862) when individual characteristics are controlled for, but evidence of probability weighting remains (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 that status of the farm impacts the $\alpha$ and $\gamma$ parameters. We also find that education tends to increase loss aversion.
Finally, we estimate the reference point in models (7), (8) and (9). This point is assumed to be the same across all 65 questions. Those models provide the results on the constants, framing effect and individual characteristics. We find that the reference point is not significantly different from zero in the three models (chisq test: 0.6, p=0.436 in model (7), chisq test: 0.03, p=0.852 in model (8) and chisq test: 1.43, p=0.231 in model (9)). We find no evidence that farmers' reference point is different from zero. Unfortunately, the small size of our sample does not allow further investigation regarding the reference point, the model failing to converge when more explanatory variables are included. We find evidence for risk aversion in the three models. However, we find evidence for loss aversion only in model (7) but not in model (8) and (9). Furthermore there is significant evidence of probability weighting in model (7) and (8), but not in model (9): the constant part of $\gamma$ is significantly different from $0$ but not from $1$. When the reference point is controlled for, there are no longer significant framing effects (except for a very significant price frame effect on probability weighting in model (8)).

# 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 theory and cumulative prospect theory. We use two elicitation methods based on the procedures proposed by Holt and Laury [2002] and Tanaka, Camerer, and Nguyen [2010] on a sample of 30 French farmers. We estimated the parameters describing farmers' risk preferences derived from structural models. We find that farmers are slightly risk averse in the expected utility framework. In the cumulative prospect theory frame, we find that farmers display either loss aversion or probability weighting, tending to overweight small probabilities and to underweight high probabilities. Our results are coherent with previous studies. We find the $r$ parameter to be around 0.2 in the expected utility framework where Holt and Laury [2002] found a parameter around 0.3 in low real payoffs. With another sample of French farmers, Reynaud and Couture [2010] found an $r$ parameter equal to 0.14 and 0.36 respectively for a low and a high payoff. In the cumulative prospect theory framework, Tanaka, Camerer, and Nguyen [2010] found an $\alpha$ parameter around 0.60 ($\alpha$=0.605 in model (5)), a probability weighting parameter $\gamma$ around 0.74 ($\gamma$=0.884 in model (5)) and a loss aversion parameter $\lambda$ around 2.63 ($\lambda$=2.111 in model (5)). Moreover, we cannot reject the hypothesis of a zero reference point. Our study shows that, for our sample, cumulative prospect theory is a better description of farmers' behaviour towards risk than expected utility theory.

This study is a first step into a better understanding of farmers' behaviour towards risky situations using recent advances in experimental economics. 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 that we did not control for (such as 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 simpler and always played 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 was resolved here by the show-up fee. But, this fee in itself might play the role of an insurance mechanism. Future work aims at alleviating these limitations.

# References


Andersen, S., G.W. Harrison, M.I. Lau, and E. Rutström. 2010. "Behavioral econometrics for psychologists." *Journal of Economic Psychology* 31:553–576.

Apesteguia, J., and M. Ballester. 2009. "A theory of reference-dependent behavior." *Economic Theory* 40:427–455.

Barseghyan, L., J. Prince, and J.C. Teitelbaum. 2011. "Are Risk Preferences Stable across Contexts? Evidence from Insurance Data." *American Economic Review* 101:591–631.

Binswanger, H.P. 1980. "Attitudes toward Risk: Experimental Measurement in Rural India." *American Journal of Agricultural Economics* 62:395–407.

Bocquého, G., F. Jacquet, and A. Reynaud. 2011. "Expected Utility or Prospect Theory maximizers? Results from a structural model based on field-experiment data." XIIIth Congress of the European Association of Agricultural Economists, Zurich (Switzerland), August 30-September 2.

Chavas, J.P., and M.T. Holt. 1996. "Economic Behavior Under Uncertainty: A Joint Analysis of Risk Preferences and Technology." *Review of Economics and Statistics* 78:329–335.

Cummings, R.G., and L.O. Taylor. 1999. "Unbiased Value Estimates for Environmental Goods: A Cheap Talk Design for the Contingent Valuation Method." *American Economic Review* 89:649–665.

Harrison, G., and E. Rutström. 2009. "Expected utility theory and prospect theory: one wedding and a decent funeral." *Experimental Economics* 12:133–158.

—. 2008. "Risk aversion in the laboratory." In J. Cox and G. Harrison, eds. *Risk Aversion in Experiments*. Bingley: Emerald, vol. Research in Experimental Economics.

Harrison, G.W., S.J. Humphrey, and A. Verschoor. 2010. "Choice under Uncertainty: Evidence from Ethiopia, India and Uganda." *Economic Journal* 120:80–104.

Holt, C.A., and S.K. Laury. 2002. "Risk Aversion and Incentive Effects." *American Economic Review* 92:1644–1655.

Humphrey, S.J., and A. Verschoor. 2004. "Decision-making Under Risk among Small Farmers in East Uganda." *Journal of African Economies* 13:44–101.

Just, R.E., and R.D. Pope. 2003. "Agricultural Risk Analysis: Adequacy of Models, Data, and Issues." *American Journal of Agricultural Economics* 85:1249–1256.

Köszegi, B., and M. Rabin. 2006. "A Model of Reference-Dependent Preferences." *Quarterly Journal of Economics* 121:1133–1165.

Liu, E. 2007. "Time to Change What to Sow: Risk Preferences and Technology Adoption Decisions of Cotton Farmers in China." PhD dissertation.

Reynaud, A., and S. Couture. 2010. “Stability of Risk Preference Measures: Results From a Field Experiment on French Farmers.” Working paper, Toulouse School of Economics.

Reynaud, A., S. Couture, J. Dury, and J.E. Bergez. 2010. “Farmers’ risk attitude: Reconcialiating stated and revealed preference approaches?” World Congress of Environmental and Resource Economists, Montreal (Canada), June 28-July 2.

Saha, A., C.R. Shumway, and H. Talpaz. 1994. “Joint Estimation of Risk Preference Structure and Technology Using Expo-Power Utility.” *American Journal of Agricultural Economics* 76:173–184.

Schmidt, U., and H. Zank. 2011. “A Genuine Foundation for Prospect Theory.” Working paper.

Tanaka, T., C.F. Camerer, and Q. Nguyen. 2010. “Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam.” *American Economic Review* 100:557–71.

Tversky, A., and D. Kahneman. 1992. “Advances in prospect theory: Cumulative representation of uncertainty.” *Journal of Risk and Uncertainty* 5:297–323.

# Appendix

Table A.1: Choice situations 1 to 30 adapted from Holt and Laury [2002]

| Choice | Lottery A | | | | Lottery B | | | |
|---|---|---|---|---|---|---|---|---|
| situations | Prob | Outcome | Prob | Outcome | Prob | Outcome | Prob | Outcome |
| 1,11,21 | 0.1 | 200 | 0.9 | 160 | 0.1 | 385 | 0.9 | 10 |
| 2,12,22 | 0.2 | 200 | 0.8 | 160 | 0.2 | 385 | 0.8 | 10 |
| 3,13,23 | 0.3 | 200 | 0.7 | 160 | 0.3 | 385 | 0.7 | 10 |
| 4,14,24 | 0.4 | 200 | 0.6 | 160 | 0.4 | 385 | 0.6 | 10 |
| 5,15,25 | 0.5 | 200 | 0.5 | 160 | 0.5 | 385 | 0.5 | 10 |
| 6,16,26 | 0.6 | 200 | 0.4 | 160 | 0.6 | 385 | 0.4 | 10 |
| 7,17,27 | 0.7 | 200 | 0.3 | 160 | 0.7 | 385 | 0.3 | 10 |
| 8,18,28 | 0.8 | 200 | 0.2 | 160 | 0.8 | 385 | 0.2 | 10 |
| 9,19,29 | 0.9 | 200 | 0.1 | 160 | 0.9 | 385 | 0.1 | 10 |
| 10,20,30 | 1 | 200 | 0 | 160 | 1 | 385 | 0 | 10 |

Table A.2: Choice situations 31 to 65 from Tanaka, Camerer, and Nguyen [2010]

| Choice | Lottery A | | | | Lottery B | | | |
|---|---|---|---|---|---|---|---|---|
| situations | Prob | Outcome | Prob | Outcome | Prob | Outcome | Prob | Outcome |
| *Panel 1* | | | | | | | | |
| 31 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 68,000 | 0.9 | 5,000 |
| 32 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 75,000 | 0.9 | 5,000 |
| 33 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 83,000 | 0.9 | 5,000 |
| 34 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 93,000 | 0.9 | 5,000 |
| 35 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 106,000 | 0.9 | 5,000 |
| 36 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 125,000 | 0.9 | 5,000 |
| 37 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 150,000 | 0.9 | 5,000 |
| 38 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 185,000 | 0.9 | 5,000 |
| 39 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 220,000 | 0.9 | 5,000 |
| 40 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 300,000 | 0.9 | 5,000 |
| 41 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 400,000 | 0.9 | 5,000 |
| 42 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 600,000 | 0.9 | 5,000 |
| 43 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 1,000,000 | 0.9 | 5,000 |
| 44 | 0.3 | 40,000 | 0.7 | 10,000 | 0.1 | 1,700,000 | 0.9 | 5,000 |
| *Panel 2* | | | | | | | | |
| 45 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 54,000 | 0.3 | 5,000 |
| 46 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 56,000 | 0.3 | 5,000 |
| 47 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 58,000 | 0.3 | 5,000 |
| 48 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 60,000 | 0.3 | 5,000 |
| 49 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 62,000 | 0.3 | 5,000 |
| 50 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 65,000 | 0.3 | 5,000 |
| 51 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 68,000 | 0.3 | 5,000 |
| 52 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 72,000 | 0.3 | 5,000 |
| 53 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 77,000 | 0.3 | 5,000 |
| 54 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 83,000 | 0.3 | 5,000 |
| 55 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 90,000 | 0.3 | 5,000 |
| 56 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 100,000 | 0.3 | 5,000 |
| 57 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 110,000 | 0.3 | 5,000 |
| 58 | 0.9 | 40,000 | 0.1 | 30,000 | 0.7 | 130,000 | 0.3 | 5,000 |
| *Panel 3* | | | | | | | | |
| 59 | 0.5 | 25,000 | 0.5 | -4,000 | 0.5 | 30,000 | 0.5 | -21,000 |
| 60 | 0.5 | 4,000 | 0.5 | -4,000 | 0.5 | 30,000 | 0.5 | -21,000 |
| 61 | 0.5 | 1,000 | 0.5 | -4,000 | 0.5 | 30,000 | 0.5 | -21,000 |
| 62 | 0.5 | 1,000 | 0.5 | -4,000 | 0.5 | 30,000 | 0.5 | -16,000 |
| 63 | 0.5 | 1,000 | 0.5 | -8,000 | 0.5 | 30,000 | 0.5 | -16,000 |
| 64 | 0.5 | 1,000 | 0.5 | -8,000 | 0.5 | 30,000 | 0.5 | -14,000 |
| 65 | 0.5 | 1,000 | 0.5 | -8,000 | 0.5 | 30,000 | 0.5 | -11,000 |

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