Farmers Risk Behaviour, measurement and modelling

From theoretical foundations to model implementation and interpretation

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CORVINUS UNIVERSITY of BUDAPEST

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

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- Researcher in agricultural and environmental economics at the University of Naples *Federico II*, Department of Agriculture
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- Proficient in Python, Stata, C++, and GIS tools.
- Coauthor of
    - Rommel et al., (2023). *Farmers' risk preferences in 11 European farming systems: A multi-country replication of Bocquého et al. (2014)*. Applied Economic Perspectives and Policy, 45(3), 1374–1399.
    - Lombardi et al. (2025) *Drivers for the adoption of circular eco-innovations in agriculture: insights from a field experiment on olive growers*. Resources, Conservation & Recycling Advances (accepted for publication)

Topics

1. Farmer Risk Preferences - Behavioral Foundations
    1. Microeconomics of risky choices. Introduction to Lotteries
    2. Risk aversion and propension
    3. Expected Utility Theory (EUT) and Cumulative Prospect Theory (CPT)
2. How to elicit farmer's risk preferences
    1. self-reported risky behavior, psychometric scale, multiple price list (MPL)
3. How to set up a MPL experiment
    1. Cost estimation
4. Parameters estimation methods
    1. Maximum Likelihood parameters estimation
    2. The mid-point approach
5. How to collect data using Google Form (and G script)
6. Cost estimation example
7. Data analysis example

Before we start…

Compile and send the questionnaire!

1. Farmer Risk Preferences - Behavioral Foundations

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Risky Alternatives

Lotteries

- *Should I go left (A) or right (B)?* → 1. The choice set
- *Go left:* → 2. The Alternatives
  - *20% probability very fast,*
  - *80% slow (traffic jam)* → 3. The Outcomes, 4. The probabilities
- *Go right:* → 2. The Alternatives
  - *95% probability of medium slow*
  - *5% very slow (accident)* → 3. The Outcomes, 4. The probabilities

The concept of Lotteries

> A simple lottery L is a list of probabilities $L = (p_1, \ldots, p_n)$ with $p_n \geq 0$ for all n and $\sum_n p_n = 1$, where p_n is interpreted as the probability of outcome n occurring.

Lotteries

We take the set of alternatives, denoted here by $\mathcal{L}$, to be the set of all simple lotteries over the set of outcomes:

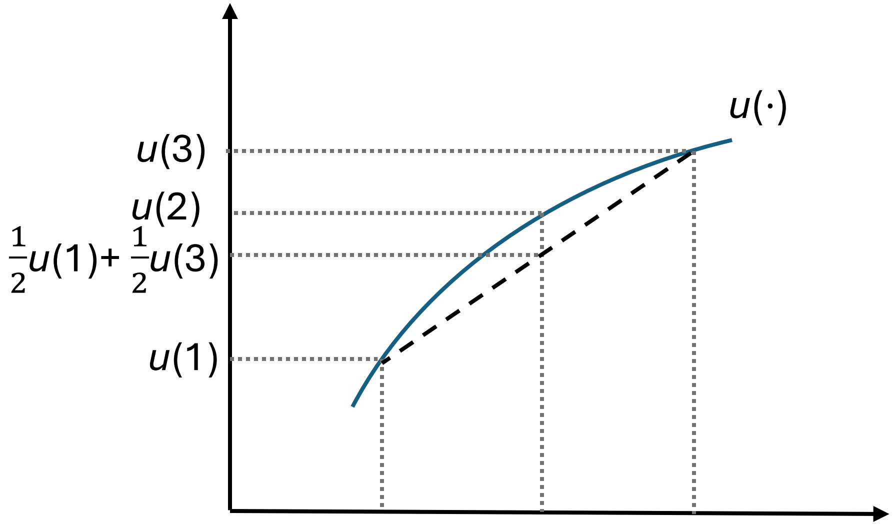
- Assume that the decision maker has a rational preference relation $\succeq$ on $\mathcal{L}$, a complete and transitive relation allowing comparison of any pair of simple lotteries.
- The preference relation $\succeq$ on the space of simple lotteries $\mathcal{L}$ is continuous for any $L, L', L'' \in \mathcal{L}$.
- The preference relation $\succeq$ on the space of simple lotteries $\mathcal{L}$ satisfies the independent axiom if for all $L \in \mathcal{L}$.

The Utility Function

> The utility function U: $\mathcal{L} \rightarrow \mathbb{R}$ has the expected utility form if there is an assignment of numbers ($u_1, \dots, u_N$) to the N outcomes such that for every simple lottery $L = (p_1, \dots, p_N) \in \mathcal{L}$ we have $U(L) = u_1 p_1 + \dots, u_N p_N$.

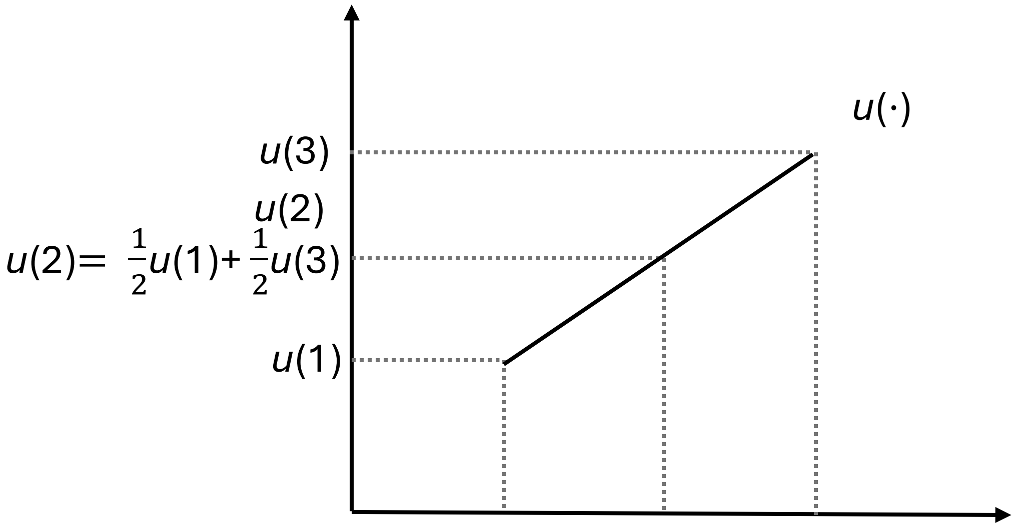
The concept of risk aversion

Risk Aversion



(a)

Risk Neutrality



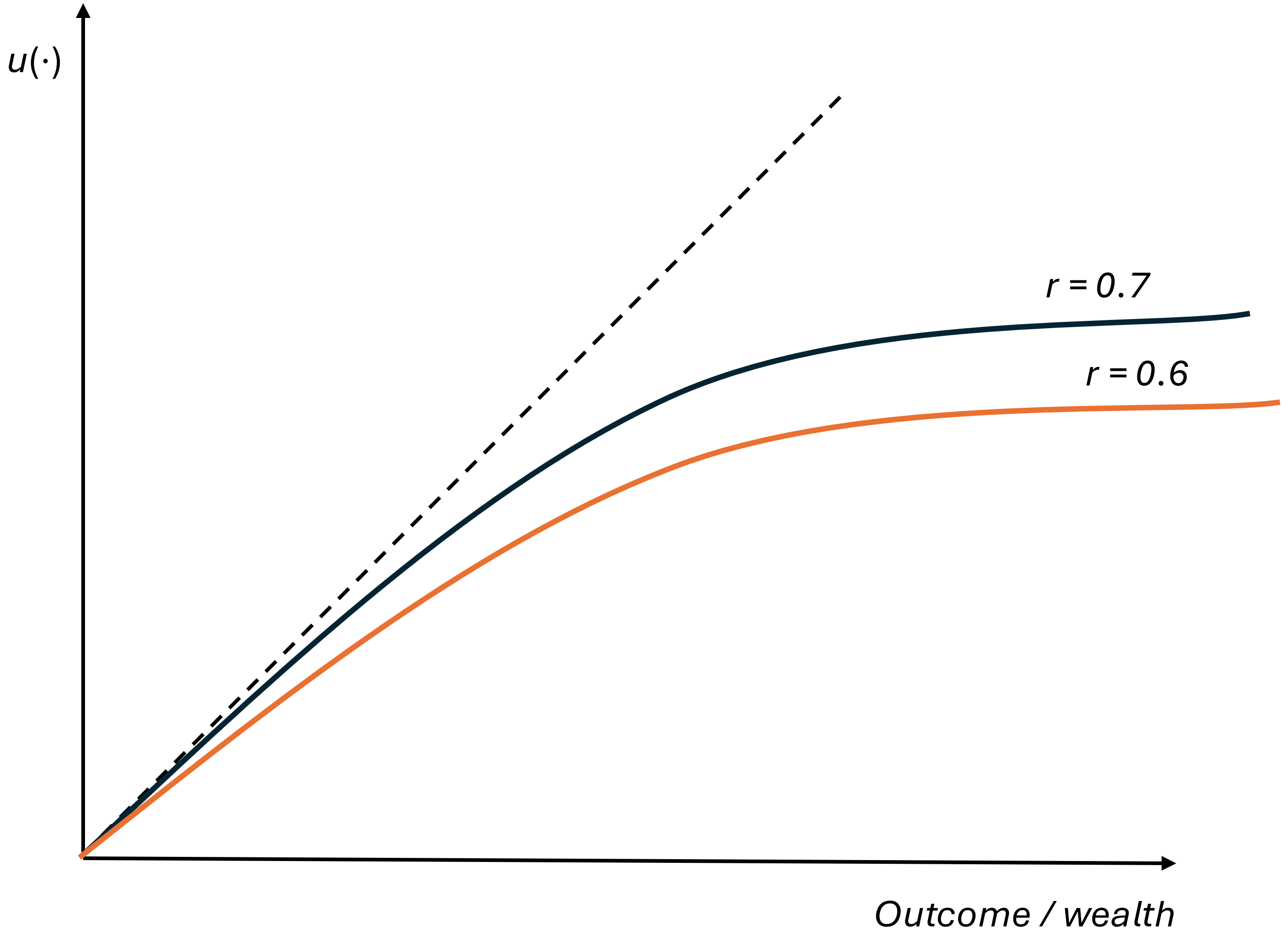
(b)

Risk Aversion is equivalent to the concavity of the Utility function → Marginal utility of money is decreasing

The concept of risk aversion

> Risk aversion is the tendency of people to prefer outcomes with low uncertainty to those outcomes with high uncertainty, even if the average outcome of the latter is equal to or higher in monetary value than the more certain outcome.

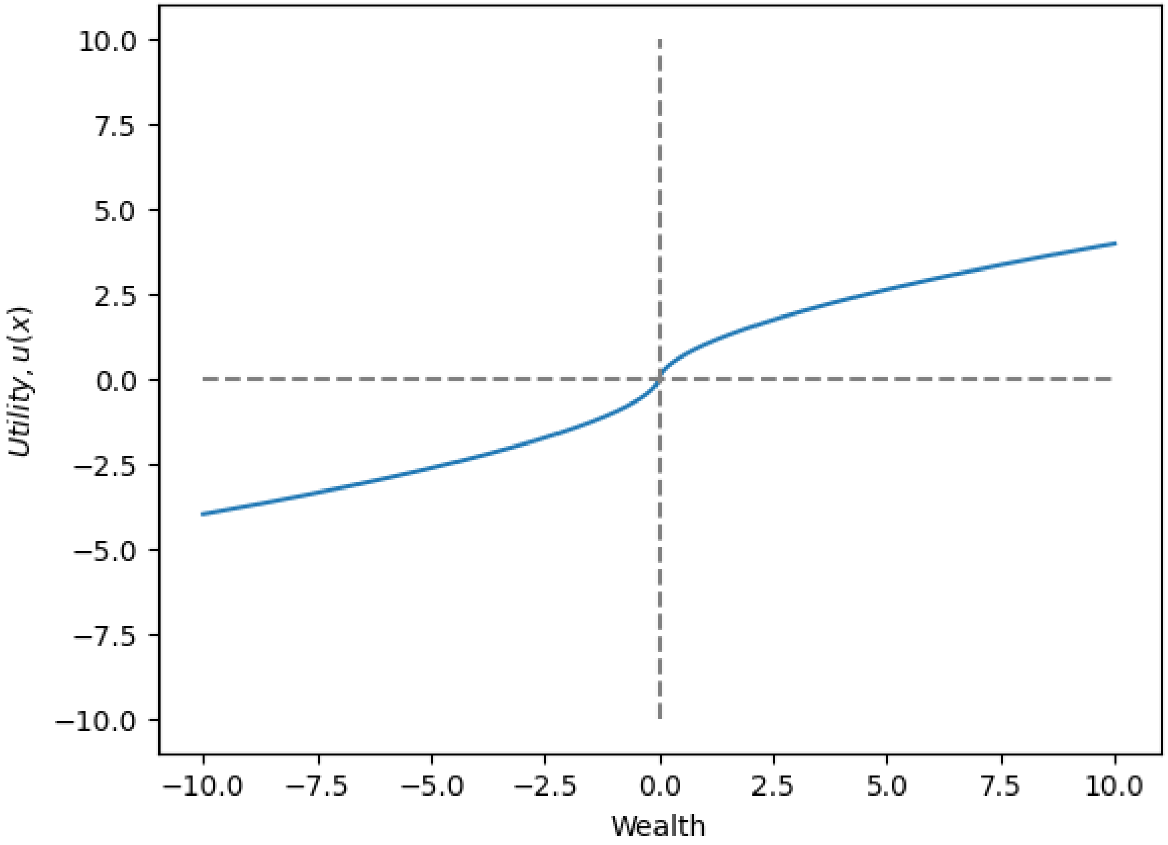
Utility function and risk aversion



Less risk averse

More risk averse

Expected Utility function



Utility can be expressed as a power function:

$U(x) = x^r \; with \; 0 < r \leq 1$

r = anti index of risk aversion

Symmetrical in the loss domain

The Allais paradox

An old and famous challenge to the Expected Utility theory

1° Choice set	**2,500,000 $**	**500,000 $**	**0 $**
$L1$	0	1	0
$L1'$	.10	.89	.01

2° Choice set	**2,500,000 $**	**500,000 $**	**0 $**
$L2$	0	.11	.89
$L2'$	.10	0	.90

- It is common for individuals to express the preferences $L1 \succ L1'$ and $L2' \succ L2$
- These choices are not consistent with the Expected Utility theory

The Allais paradox

An old and famous challenge to the Expected Utility theory

Formally:

- u_{25} = Utility value of the 2,500,000 $ outcome
- u_{05} = Utility value of 500,000 $
- u_0 = Utility of 0 $

If $L1 \succ L1'$ then

$$u_{05} > (.10)u_{25} + (.89)\, u_{05} + (.01)\, u_0$$

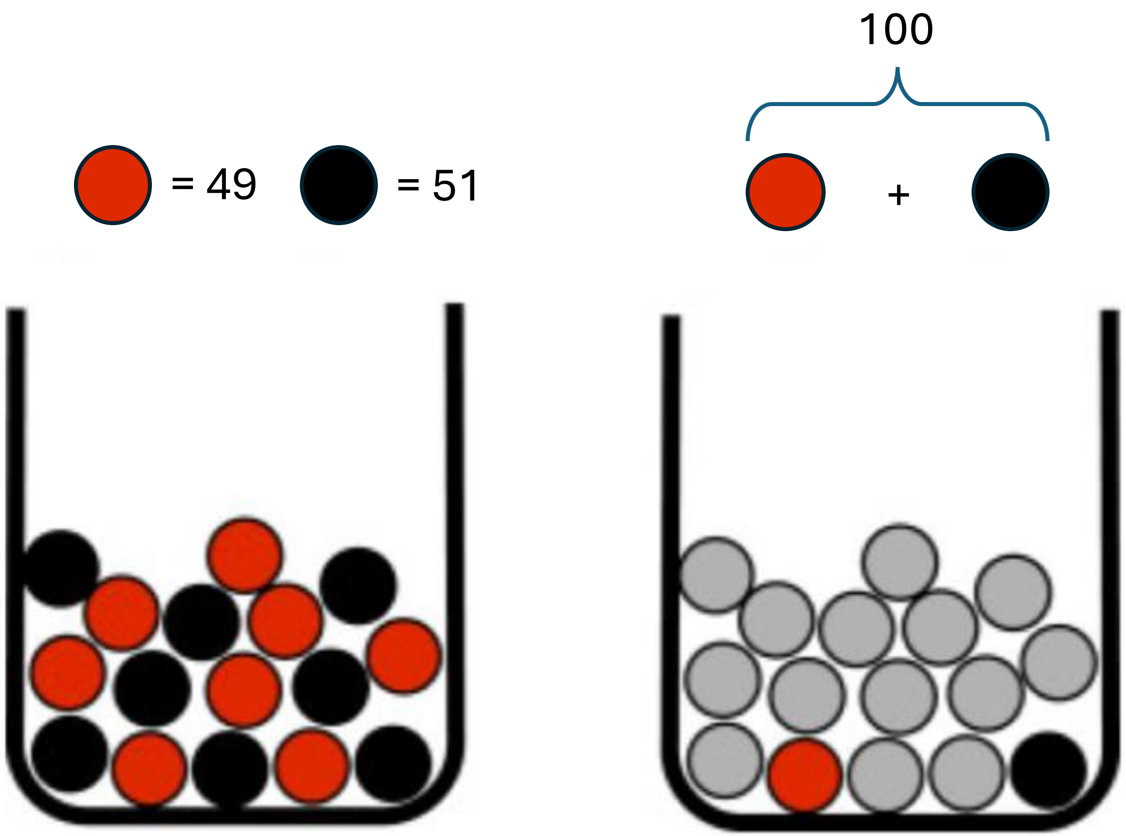
Adding (.89) u_0 - (.89) u_{05} t o both sides, we get

$$(.11)u_{05} + (.89)\, u_0 > (.10)u_{25} + (.90)\, u_0$$

Therefore, any individual who prefer $L1 \succ L1'$ must have $L2' \succ L2$

The Ellsberg paradox

A second old and famous challenge to the Expected Utility theory



Two choice situations:

1. A prize of 1000 $ if the ball chosen is black
2. A prize of 1000 $ if the ball chosen is red

Most of the people will chose the ball from the first urn in both choice situations!

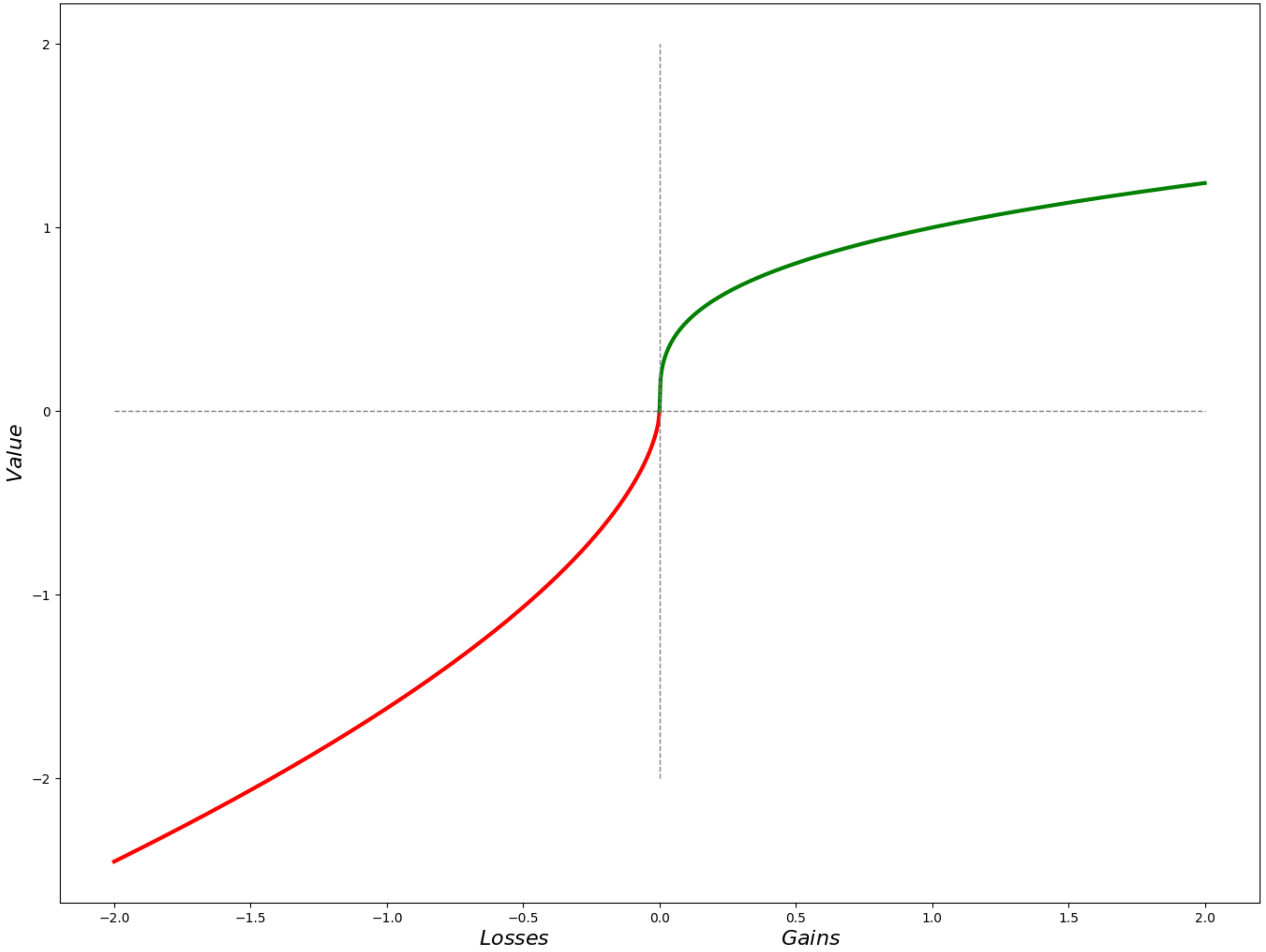
Cumulative Prospect Theory

- Introduced by Amos Tversky and Daniel Kahneman in 1992
- As the EUT, the cumulative prospect theory (CPT) is a model for descriptive decisions under risk and uncertainty.

Two main difference from the EUT:

1. People have different risk attitudes towards gains and losses
2. People tend to overweight extreme events, but underweight "average" events.

Cumulative Prospect Theory

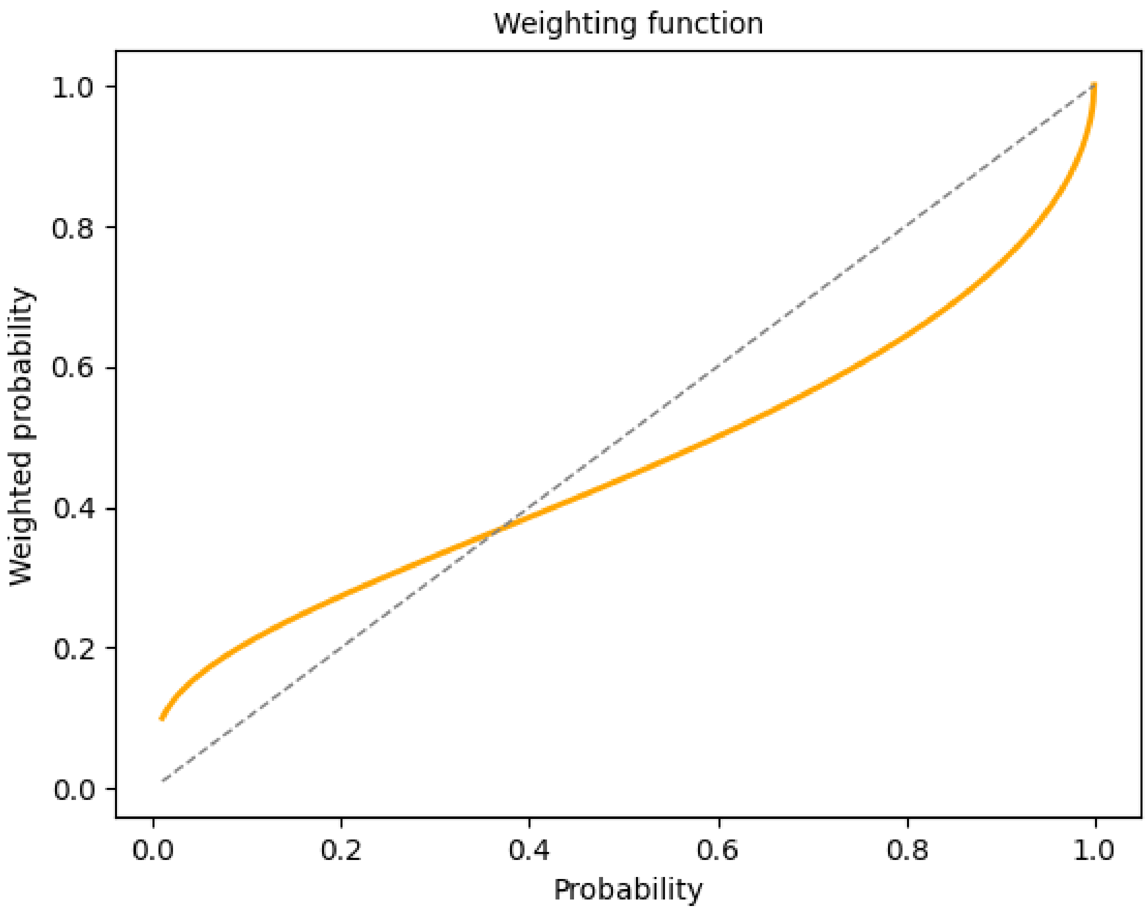


1. People have different risk attitudes towards gains and losses

$$\begin{cases} y^{\sigma} if\ y > 0 \\ 0\ if\ y = 0 \\ -\lambda(-y)^{\sigma} if\ y < 0 \end{cases}$$

σ = anti index of risk aversion in the gain domain
λ= anti index of loss aversion

Cumulative Prospect Theory



1. People tend to overweight extreme events, but underweight "average" events.

$$\omega(p) = e^{-(-\ln p)^{\gamma}}$$

γ = anti-index of probability distortion towards overweighting of small probabilities

Empirical validation – Our study


APPLIED ECONOMIC PERSPECTIVES AND POLICY

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Farmers' risk preferences in 11 European farming systems: A multi-country replication of Bocquého et al. (2014)

Jens Rommel, Julian Sagebiel, Marieke Cornelia Baaken, Jesús Barreiro-Hurlé, Douadia Bougherara, Luigi Cembalo, Marija Cerjak, Tajana Čop, Mikołaj Czajkowski, María Espinosa-Goded ... See all authors

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Abstract

We replicate Bocquého et al. (2014), who used multiple price lists to investigate the risk preferences of 107 French farmers. We collected new data from 1430 participants in 11 European farming systems. In agreement with the original study, farmers' risk preferences are best described by Cumulative Prospect Theory. Structural model estimates show that farmers in the new samples are, on average, less loss averse and more susceptible to probability distortion than in the original study. Explorative analyses indicate differences between estimation approaches, as well as heterogeneity between

- **11** European Farming Systems
- **1430** participants
- **Multiple Price List** to elicit farmers risk preferences
- Two specifications of the **EUT** and the **CPT** tested

Rommel et al., 2022 – The structural models

EUT power function

- $(\ ) = \begin{cases} \quad ^{r} & ℎ□ \geq 0 \\ -(- \ )^{r}□ & ℎ□ < 0 \end{cases}$

EUT expo-power function

- $(\ ) = \begin{cases} \frac{1-e^{(-\beta y^{\alpha})}}{\beta} & ℎ□ \geq 0 \\ \frac{1-e^{\beta(-y)^{\alpha}}}{\beta} & ℎ□ < 0 \end{cases}$

CPT

- $\begin{cases} \quad ^{\sigma} & ℎ□ > 0 \\ 0□ & ℎ□ = 0 \\ - \ (- \ )^{\sigma} & ℎ□ < 0 \end{cases}$
- $(\ ) = □^{-(-\ln p)^{\gamma}}$

Constant relative risk aversion

- r = anti-index of risk aversion
- r < 1 -> risk aversion
- r = 1 -> rationality
- r > 1 -> propension

Rommel et al., 2022 – The structural models

EUT power function

- $(\ ) = \begin{cases} {}^{r} & h\square \geq 0 \\ -(-\ )^{r}\square & h\square < 0 \end{cases}$

EUT expo-power function

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CPT

- $\begin{cases} {}^{\sigma} & h\square > 0 \\ 0\square & h\square = 0 \\ -\ (-\ )^{\sigma} & h\square < 0 \end{cases}$
- $(\ ) = \square^{-(-\ln p)^{\gamma}}$

Varying relative risk aversion

- α, β = anti-index of risk aversion

Rommel et al., 2022 – The structural models

EUT power function

- $(\ ) = \begin{cases} {}^{r} & \hbar\square \geq 0 \\ -(-\ )^{r}\square & \hbar\square < 0 \end{cases}$

EUT expo-power function

- $(\ ) = \begin{cases} \frac{1-e^{(-\beta y^{\alpha})}}{\beta} & \hbar\square \geq 0 \\ \frac{1-e^{\beta(-y)^{\alpha}}}{\beta} & \hbar\square < 0 \end{cases}$

CPT

- $\begin{cases} {}^{\sigma} & \hbar\square > 0 \\ 0\square & \hbar\square = 0 \\ -\ (-\ )^{\sigma} & \hbar\square < 0 \end{cases}$
- $(\ ) = \square^{-(-\ln p)^{\gamma}}$

Cumulative Prospect Theory

- σ = anti-index of risk aversion in the gain domain
- λ= anti-index of loss aversion
- γ = *anti-index of probability distortion*

Rommel et al., 2022 – The results

Structural model	Parameters estimates	BIC
EUT power function $$u(y) = \begin{cases} y^r con\ y \geq 0 \\ -(-y)^r con\ y < 0 \end{cases}$$	r = 0,213 [min=0,12 ; max=0,24]	62619.736
EUT expo-power function $$u(y) = \begin{cases} \dfrac{1 - e^{(-\beta y^{\alpha})}}{\beta} con\ y \geq 0 \\ \dfrac{1 - e^{\beta(-y)^{\alpha}}}{\beta} con\ y < 0 \end{cases}$$	α = 0,218 [min = 0,18; max = 0,25] β = 0,018 [min = -0,164; max = 0,23]	62629.623
CPT $$\begin{cases} y^{\sigma} con\ y > 0 \\ 0\ con\ y = 0 \\ -\lambda(-y)^{\sigma} con\ y < 0 \end{cases}$$ $$\omega(p) = e^{-(\ln p)^{\gamma}}$$	σ = 0,313 [min = 0,282; max = 0,334] λ = 1,62 [min = 1,457; max = 2,20] γ = 0,573 [min = 0,643; max = 0,468]	**58837.075**

Rommel et al., 2022


APPLIED ECONOMIC PERSPECTIVES AND POLICY

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- The study **successfully** confirmed that **CPT provides a better fit** to describe farmers' risk attitudes than EUT

2. How to elicit farmer's risk preferences

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How to elicit farmer's risk preferences

Risk aversion is a latent psychological trait

- It is not directly observable
- It cannot be measured directly (like individuals age or income)

Different approaches are used to reveal or estimate risk preferences

Approaches to measure risk preferences

Stated risk preferences

Ask individuals directly about their willingness to take risks.

- Based on self-reports or hypothetical choices

VS

Reveled preferences

Incentivized Tasks

- Infer preferences from choices made in controlled, payoff-relevant environments.
- Based on actual choices with real monetary stakes

Stated risk preferences

Ask individuals directly about their willingness to take risks.

Example:

- Likert scale questions

"Some people like taking risks whilst others are more reluctant to do so. How would you describe your own attitude with respect to a risky decision:"

	Very reluctant	Rather reluctant	Nor willing nor reluctant	Rather willing	Very willing	Do not know
In general (in all decision domains)						
In your farm production choices						
In farm financial and investment choices						
In decisions related to markets and sales for your agricultural products						

Stated risk preferences

Pros

- Low cost,
- Easy to implement.

Cons

- *Hypothetical bias*
- Less precise

Incentivized Tasks

Offering rewards or benefits to motivate individuals to complete specific actions or tasks.

Pros

- Improve participation rates while reduce dropout rates
- **Increase data quality:** participants may take the research more seriously and provide more accurate and complete responses if they are being rewarded for their efforts

Cons

- Costly

Multiple Price List

Introduced by Holt and Laury (2002) and is widely used in behavioural economics.

Participants face a series of paired **choices** between:

- **Option A**: a **safer** lottery (lower variance),
- **Option B**: a **riskier** lottery (higher variance, possibly higher expected payoff).

- The probability of the high payoff increase each choice -> riskier option gradually more attractive.
- The row number where switch from choosing **A** to choosing **B** occurs is used to estimate a risk aversion.

Revealed preferences – Incentivized Tasks

Multiple Price List

Introduced by Holt and Laury (2002) and is widely used in behavioural economics.

Table 1. The Ten Paired Lottery-Choice Decisions with Low Payoffs

Option A	Option B	Expected Payoff Difference
1/10 of $2.00, 9/10 of $1.60	1/10 of $3.85, 9/10 of $0.10	$1.17
2/10 of $2.00, 8/10 of $1.60	2/10 of $3.85, 8/10 of $0.10	$0.83
3/10 of $2.00, 7/10 of $1.60	3/10 of $3.85, 7/10 of $0.10	$0.50
4/10 of $2.00, 6/10 of $1.60	4/10 of $3.85, 6/10 of $0.10	$0.16
5/10 of $2.00, 5/10 of $1.60	5/10 of $3.85, 5/10 of $0.10	-$0.18
6/10 of $2.00, 4/10 of $1.60	6/10 of $3.85, 4/10 of $0.10	-$0.51
7/10 of $2.00, 3/10 of $1.60	7/10 of $3.85, 3/10 of $0.10	-$0.85
8/10 of $2.00, 2/10 of $1.60	8/10 of $3.85, 2/10 of $0.10	-$1.18
9/10 of $2.00, 1/10 of $1.60	9/10 of $3.85, 1/10 of $0.10	-$1.52
10/10 of $2.00, 0/10 of $1.60	10/10 of $3.85, 0/10 of $0.10	-$1.85

Revealed preferences – Incentivized Tasks

Multiple Price List

Introduced by Holt and Laury (2002) and is widely used in behavioural economics.

Table 3. Risk Aversion Classifications Based

Number of Safe Choices	Range of Relative Risk Aversion for $U(x) = x^{1-r}/(1-r)$	Risk Preference Classification
0-1	$r < -0.95$	highly risk loving
2	$-0.95 < r < -0.49$	very risk loving
3	$-0.49 < r < -0.15$	risk loving
4	$-0.15 < r < 0.15$	risk neutral
5	$0.15 < r < 0.41$	slightly risk averse
6	$0.41 < r < 0.68$	risk averse
7	$0.68 < r < 0.97$	very risk averse
8	$0.97 < r < 1.37$	highly risk averse
9-10	$1.37 < r$	stay in bed

Revealed preferences – Incentivized Tasks

Multiple Price List

Introduced by Holt and Laury (2002)

Pros

- **Incentivized** - Choices have real monetary consequences
- **Structured-** Standardized for comparison across individuals and studies

Cons

- Possible **inconsistent behaviour**
- **Framing Effects** - Results can vary depending on stakes, probabilities, and context
- Cognitive demanding – The task may be hard to understand

Revealed preferences – Incentivized Tasks

Multiple Price List

Developed by [Tanaka et al. (2010)]

Table 2—Three Series of Pairwise Lottery Choices (*in 1,000 dong*)

Option A		Option B		Expected payoff difference (A–B)
Series 1				
Balls 1–3	Balls 4–10	Ball 1	Balls 2–10	
40	10	68	5	7.7
40	10	75	5	7.0
40	10	83	5	6.0
40	10	93	5	5.2
40	10	106	5	3.9
40	10	125	5	2.0
40	10	150	5	–0.5
40	10	185	5	–4.0
40	10	220	5	–7.5
40	10	300	5	–15.5
40	10	400	5	–25.5
40	10	600	5	–45.5
40	10	1,000	5	–85.5
40	10	1,700	5	–155.5
Series 2				
Balls 1–9	Ball 10	Balls 1–7	Balls 8–10	
40	30	54	5	–0.3
40	30	56	5	–1.7
40	30	58	5	–3.1
40	30	60	5	–4.5
40	30	62	5	–5.9
40	30	65	5	–8.0
40	30	68	5	–10.1
40	30	72	5	–12.9
40	30	77	5	–16.4
40	30	83	5	–20.6
40	30	90	5	–25.5
40	30	100	5	–32.5
40	30	110	5	–39.5
40	30	130	5	–53.5
Series 3				
Balls 1–5	Balls 6–10	Balls 1–5	Balls 6–10	
25	–4	30	–21	6.0
4	–4	30	–21	–4.5
1	–4	30	–21	–6.0
1	–4	30	–16	–8.5
1	–8	30	–16	–10.5
1	–8	30	–14	–11.5
1	–8	30	–11	–13.0

Revealed preferences – Incentivized Tasks

Multiple Price List

Developed by Tanaka et al. (2010)

- Lotteries involving both gains and losses.
- Designed to elicit the three prospect theory parameters:
  - σ = anti index of risk aversion in the gain domain
  - λ= anti index of loss aversion
  - γ = anti-index of probability distortion towards overweighting of small probabilities

Revealed preferences – Incentivized Tasks

Multiple Price List

Developed by Tanaka et al. (2010)

- Participants had to choose the switching point
- Ensuring monotonicity and avoiding inconsistent behaviour

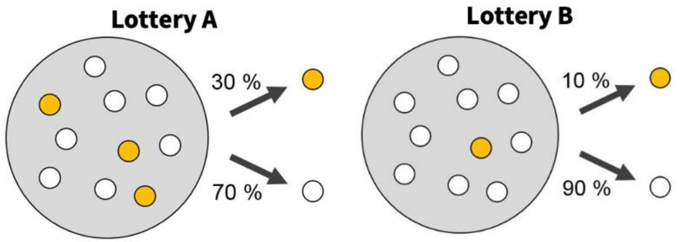
Allow the parameters approximation by the **mid-point approach**

Revealed preferences – Incentivized Tasks

Multiple Price List

Further advanced by Bocquého et al. (2014) and Rommel et al. (2022)

- Participants had to choose the switching point
- Deletion two rows from the first price list
- Use of visual aid to help the understanding



Row	Yellow (30%)	White (70%)	Yellow (10%)	White (90%)
1	400 P	100 P	680 P	50 P
2	400 P	100 P	750 P	50 P
3	400 P	100 P	830 P	50 P
4	400 P	100 P	930 P	50 P
5	400 P	100 P	1060 P	50 P
6	400 P	100 P	1250 P	50 P
7	400 P	100 P	1500 P	50 P
8	400 P	100 P	1850 P	50 P
9	400 P	100 P	2200 P	50 P
10	400 P	100 P	3000 P	50 P
11	400 P	100 P	4000 P	50 P
12	400 P	100 P	6000 P	50 P

3. How to set up a MPL experiment

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1. Identification of the research questions and methodology

Research question:

- *“Do farmers with higher loss aversion have lower intention to adopt sustainable innovations?”*

Methodology

- Multiple Price List as in Rommel et al. (2022)

2. Choose the implementation mode

In person (using paper or tablet)

Pros

- Clear instructions
- Better control
- Possible rural outreach

Cons

- Logistically demanding

On-line

Pros

- Cheap (easier for the interviewers)
- Fast

Cons

- Requires digital access

With farmers, assisted tablet surveys may work best

3. Experiment design and survey draft

1. Design of the MPL tables

- Use MPL from literature to enhance the relevance of the study

2. Platform selection

- Google Form, Qualtrix, etc

3. Experiment design and survey draft

3. Randomization Protocol

- Use physical dice (in-person) or platform-based randomizer
- Ensure the randomizer to:
  1. Select the **row** (bundle of Lotteries) to be played
  2. **Play** the Lottery chosen by the respondents
  3. Select the respondent to be paid (optional)

3. Experiment design and survey draft

3. Randomization Protocol

Example:

- **Row Random selection** → Row 6 is selected
- **Read the respondent choice** → In row 6, participant *x* had chosen the Option B (10% chance €12.50, 90% 0.50€)
- **Outcome random selection** → *White ball is extracted*, participant *x* gains €12.50

4. Determine the sample size

- The decision should be based on the **trade-off** between **statistical power** and **budget constraints**
- Consider subgroup comparisons (e.g., adopters vs non-adopters)
    - Aim for **at least 150 observations**
    - With subgroup comparisons, increase the sample size to **~300**

5. Estimate the total cost

Fixed costs:

- Platform (e.g., Qualtrix)
- Interviewers (if in-person experiment)

Variable costs:

- Incentives
    - Chose if every respondent is paid, or only one randomly selected

6. Data collection

- Interviewers training (optional)

- Piloting (optional, but very suggested)
  - with 10–15 people to check for general understanding of the task and switching behaviour consistency

7. Data analysis

- Coding switching points
- Select and implement the estimation strategy

Mid-point approach

Pros

- Easy to implement

Cons

- Less precise

Maximum Likelihood

Pros

- High precision

Cons

- Coding skills
- More assumptions

7. Data analysis

Maximum Likelihood estimation

- Define the Likelihood function (the function of the probability of an individual to choose a switching point given its risk aversion)
- Compute the likelihood for each participants of their choices.
- Find the parameter values that maximize the product of these probabilities

7. Data analysis

Mid-point approach

- Each possible configuration of answers correspond to a range of the parameters
- The switching points chosen by the participants tell us the interval they belong to.
- The midpoint of that interval is used as their estimate

7. Data analysis

Mid-point approach (example)

- Participant x chosen Switching Points: 7,2,4.
- Corresponding interval:
  - σ [0.60, 0.70] ->Midpoint estimation: 0.65
  - λ [1.8, 2.2] ->Midpoint estimation: 2.0
  - γ [0.45, 0.55] ->Midpoint estimation: 0.50

Farmers Risk Behaviour, measurement and modelling

All the material can be found here ->

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