Appendix A

Appendix A to the paper "Farmers and Other Experts' Subjective Probability Distributions on Innovation-Related Methane Emission Reductions: An Experimental Comparison Across Elicitation Methods"

Experimental Instructions

The following instructions were presented to participants during the experiment. Each session was conducted online via Zoom, with the experimental instructions delivered through a PowerPoint presentation. Participants completed the activities and questionnaires individually on their laptops without screen sharing.

Please note that the instructions, originally presented in Italian, have been translated into English for this appendix.

SUSTAINABLE INNOVATION WITHIN THE DAIRY SUPPLY CHAIN OF THE AUTONOMOUS PROVINCE OF TRENTO

PART I

INTRODUCTION

- The dairy supply chain of the Province of Trento has indeed a great **economic, environmental, and societal value**.

- In particular, livestock farming has a **fundamental role** in **land management and mountainous landscape maintenance**.

- Approximately 800-900 dairy farms, distributed throughout the Trentino region, ensure the upkeep of about one hundred thousand hectares of grassland and pastureland.

- At the European and global level many initiatives have been launched to address the **reduction of greenhouse gas emissions**, involving the agricultural sector, too.

- The greenhouse gas emissions in the agricultural sectors, like methane, are particularly due to **livestock management**.

- **To improve the sustainability** of the livestock sector and enhance overall environmental sustainability, certain measures can be implemented.

- What are they?

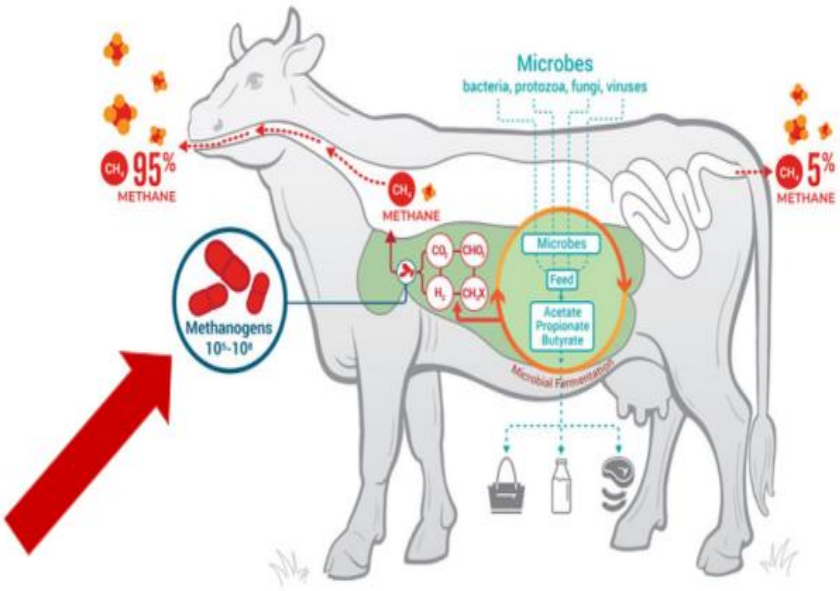
- It is possible to implement several **carbon farming** practices to reduce methane emissions at the farm level.

- Some of the carbon farming practices which can be implemented in livestock farming are the following:

  - Adding specific **essential oils** in daily bovine diets;
  - Planting herbaceous crops capable of storing carbon in the soil;
  - Improving bovine genetics;
  - And others.

- Adding essential oils in bovine diets is a practice that has a short-term efficacy and requires less transformation at the farm level (less costs)

- Essential oils are **rumen modifiers** and can provoke an **inhibition of the methanogenesis process.**



Glasson et al.,2022

- Some of the advantages of essential oils (I):

  - Reduction of enteric methane emissions;

  - Natural composition of the essential oil product;

  - Current market availability;

  - Approval according to Regulation (EC) No 1831/2003 on additives for use in animal nutrition.

- Some other advantages of essential oils (II):

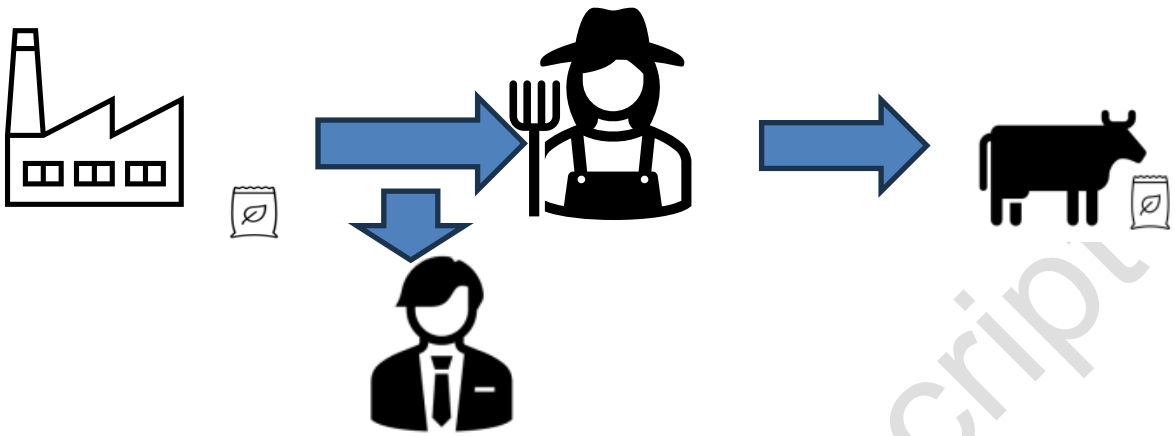
  - Ease of implementing the essential oils practice:
    (i) Purchasing a feed and essential oils premix;
    (ii) Purchasing essential oils to add to the mixer wagon.

  - No negative effect on the bovine productivity (Elcoso et al., 2019)

  - No organoleptic alterations of the milk product (Bach, 2019)

  - No alteration of the milk composition (Flores et al., 2013)

- Moreover, it is possible to generate **carbon credits** and potentially participate in voluntary carbon markets:



- When purchasing essential oils, the farmer signs a contract with an intermediary that stipulates the acquisition by the intermediary of the carbon credits.
- The amount of carbon credits depends on the reduction in methane emissions achieved.

PART II

OUR STUDY

- We ask you to participate in a brief study that will help us understand your forecasts about the potential reduction in methane emissions in a dairy farm due to adding essential oils.

- Today's study is composed of **two phases**:

- **Phase 1**: Your forecasts about the reduction of methane emissions in a dairy farm

- **Phase 2**: Your attitude towards risk

PHASE 1

- **Phase 1** is composed of **3 similar activities**. In each activity, you will be asked to express your forecasts about the reduction, **in percentage value**, of the methane emissions due to the addition of essential oils in a dairy farm per year.

- During Phase 1, you have the possibility of winning a reward in each activity up to a maximum of €25.

- At the end of the study, one number between 1 and 3 will be randomly extracted to identify one of the three activities and will be used to determine your reward.

The possible reduction in methane emissions from adding essential oils to bovine diets is expressed in intervals extrapolated from the literature.

We ask you to consider **7 intervals** of percentage reduction of methane emissions in a dairy farm (per year usage of essential oils):

1. Between -10% and -9.6%
2. Between -9.5% and -9.1%
3. Between -9% and -8.6%
4. Between -8.5% and 8.1%
5. Between -8% and 7.6%
6. Between -7.5% and 7.1%
7. Between -7% and -6.6%

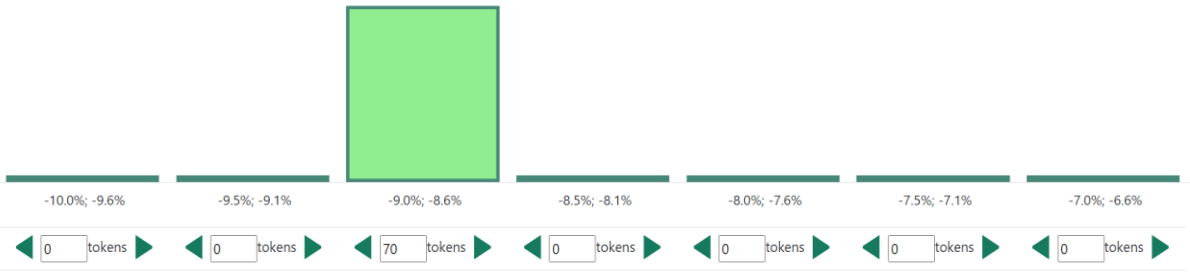
The aim of the study is not to test your knowledge.

- We are interested in your personal opinion.
- There are no right or wrong answers.

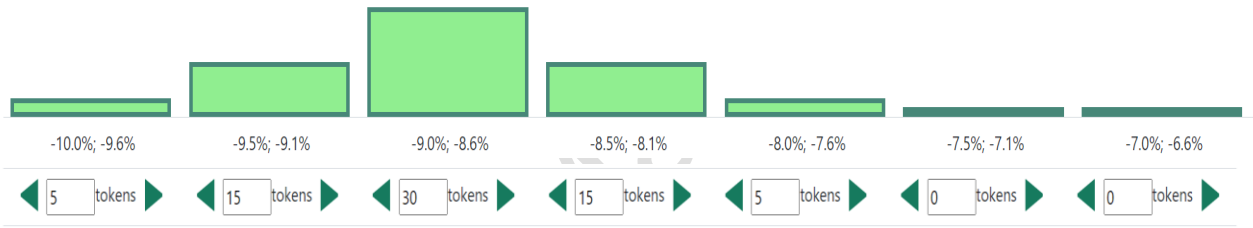
- <u>Instructions for Activity 1</u>
- **How do you indicate your forecasts?**
- You will have **70 tokens available**, and will be asked to distribute them in the 7 intervals, writing down in the boxes the number of tokens you want to allocate per each corresponding column, using the following intuition:
- **The more tokens you allocate in one determined interval, the higher is the probability that the percentage reduction corresponding to the determined interval will happen in future according to you.**
- All 70 tokens must be distributed in one or more intervals.

- Let's see a few examples.
- **Example 1.** If you are sure that the percentage reduction will take a value between -9% and -8.6%, you could choose to distribute the

majority (if not all) of the tokens in the following way:



- **Example 2.** If you are not sure that the percentage reduction will take a value between -9% and -8.6%, you could choose to distribute the tokens over more intervals:

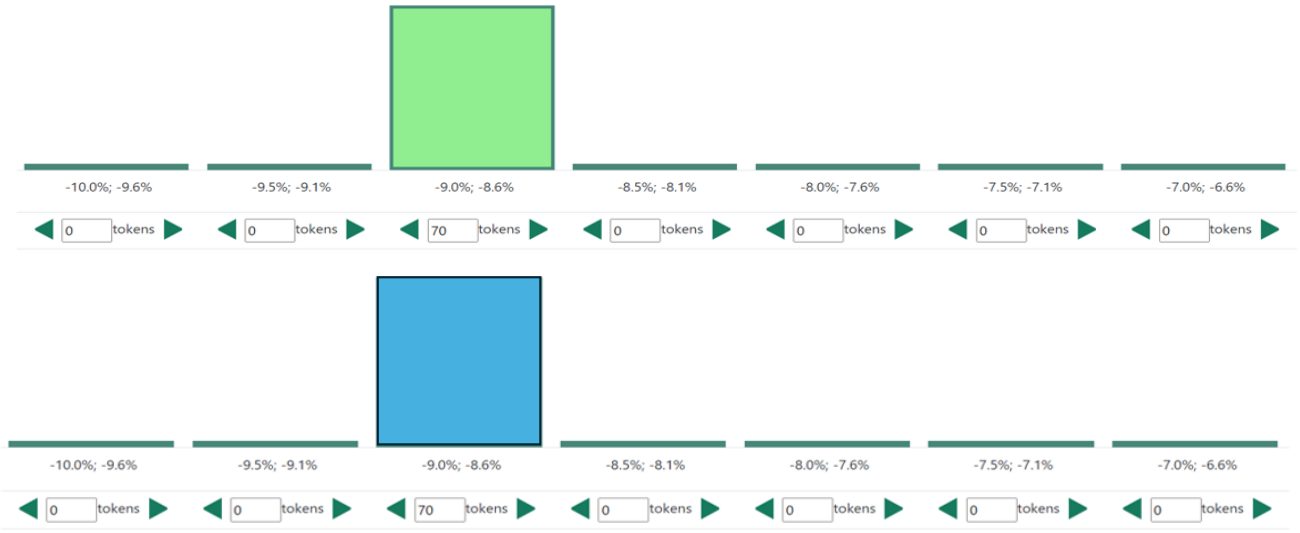


How is your monetary reward calculated for Activity 1?

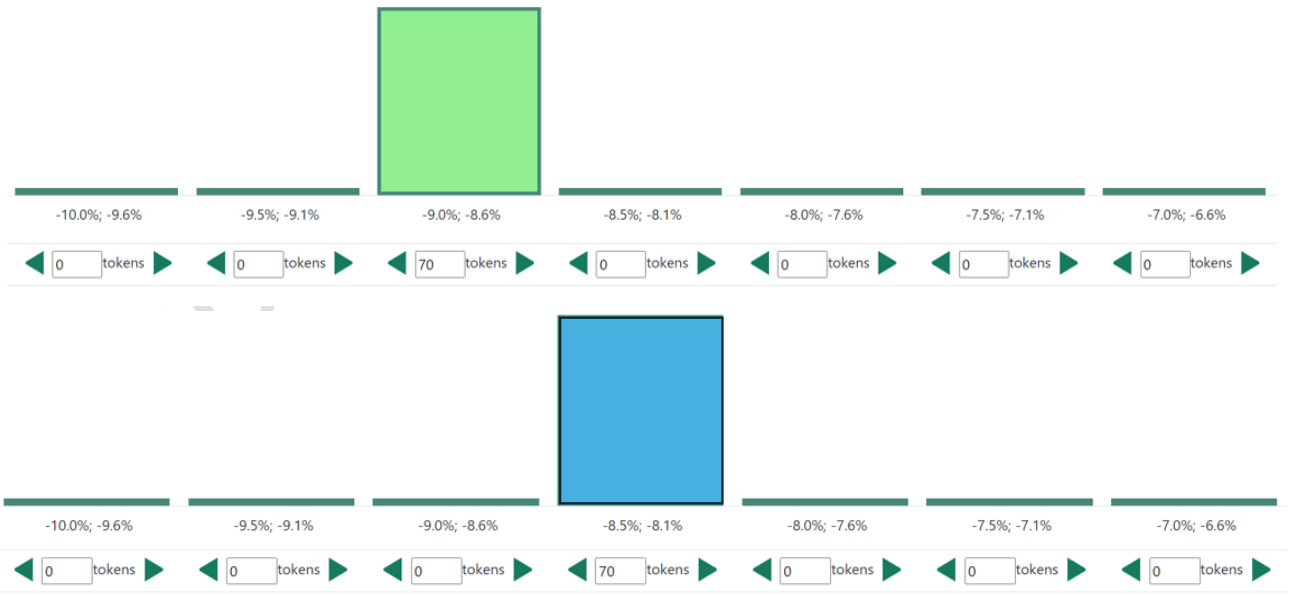
- Your monetary reward depends on the accuracy of your forecasts. Specifically, it depends on the following factors:
  - Your distribution of the tokens in the intervals.
  - The distribution of the tokens created by us based on the scientific data found in the literature.

- More precisely, if and only if your distribution of the 70 tokens in the intervals corresponds exactly to the distribution of the tokens created by us based on the scientific data found in the literature, you will receive €25.
- Otherwise, €0.

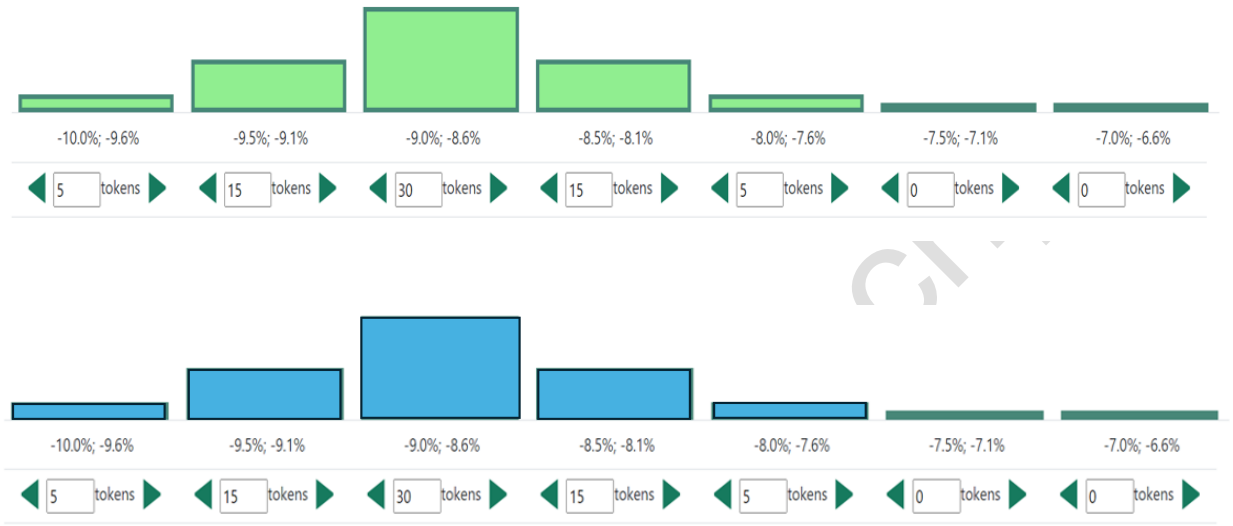
- **Example 1A**. If your distribution of the 70 tokens in intervals (in green) **corresponds exactly** to the distribution of the tokens created by us based on the scientific data found in the literature (in blue), you will receive €25.



- **Example 1B**. If your distribution of the 70 tokens in intervals (in green) **does not correspond exactly** to the distribution of the tokens created by us based on the scientific data found in the literature (in blue), you will receive €0.



- **Example 2A.** If your distribution of the 70 tokens in intervals (in green) **corresponds exactly** to the distribution of the tokens created by us based on the scientific data found in the literature (in blue), you will receive €25.



- **Example 2B.** If your distribution of the 70 tokens in the intervals (in green) **does not correspond** exactly to the distribution of the tokens created by us based on the scientific data found in the literature (in blue), you will receive €0.

NOW YOU CAN INDICATE YOUR FORECAST

- Instructions for Activity 2

- The instrument to express your forecast is the same of Activity 1.

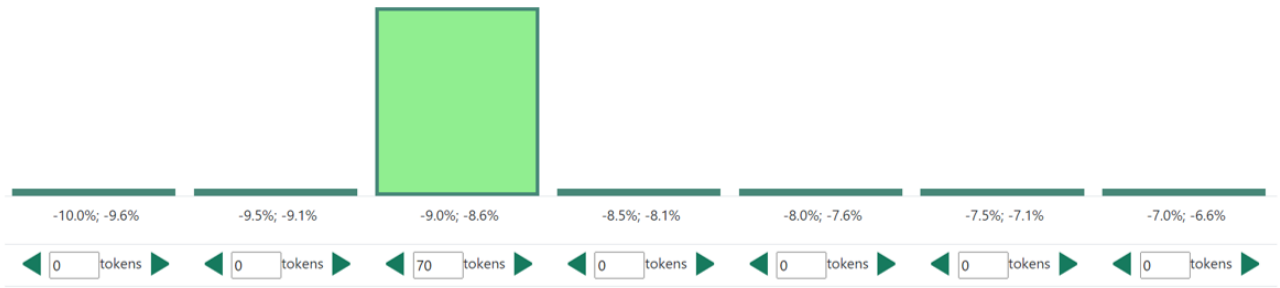
- You will have **70 tokens available**, and will be asked to distribute them in the 7 intervals, writing down in the boxes the number of tokens you want to allocate per each corresponding column, using the following intuition:

- **The more tokens you allocate in one determined interval, the higher is the probability that the percentage reduction corresponding to the determined interval will happen in future according to you.**

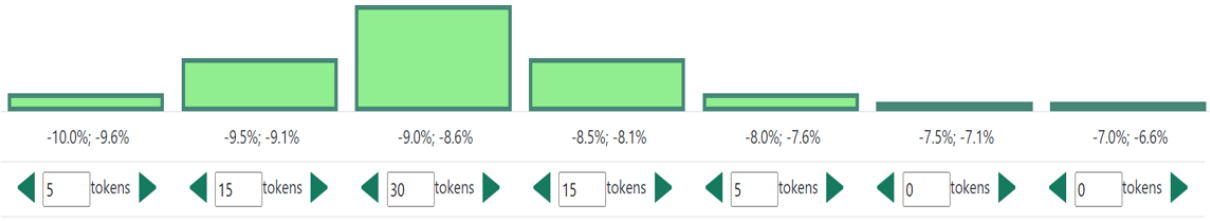
- All 70 tokens must be distributed in one or more intervals.

Let's see a few examples.

- **Example 1.** If you are sure that the percentage reduction will take a value between -9% and -8.6%, you could choose to distribute the majority (if not all) of the tokens in the following way:



- **Example 2.** If you are not sure that the percentage reduction will take a value between -9% and -8.6%, you could choose to distribute the tokens over more intervals:



- **How is your monetary reward calculated for Activity 2?**

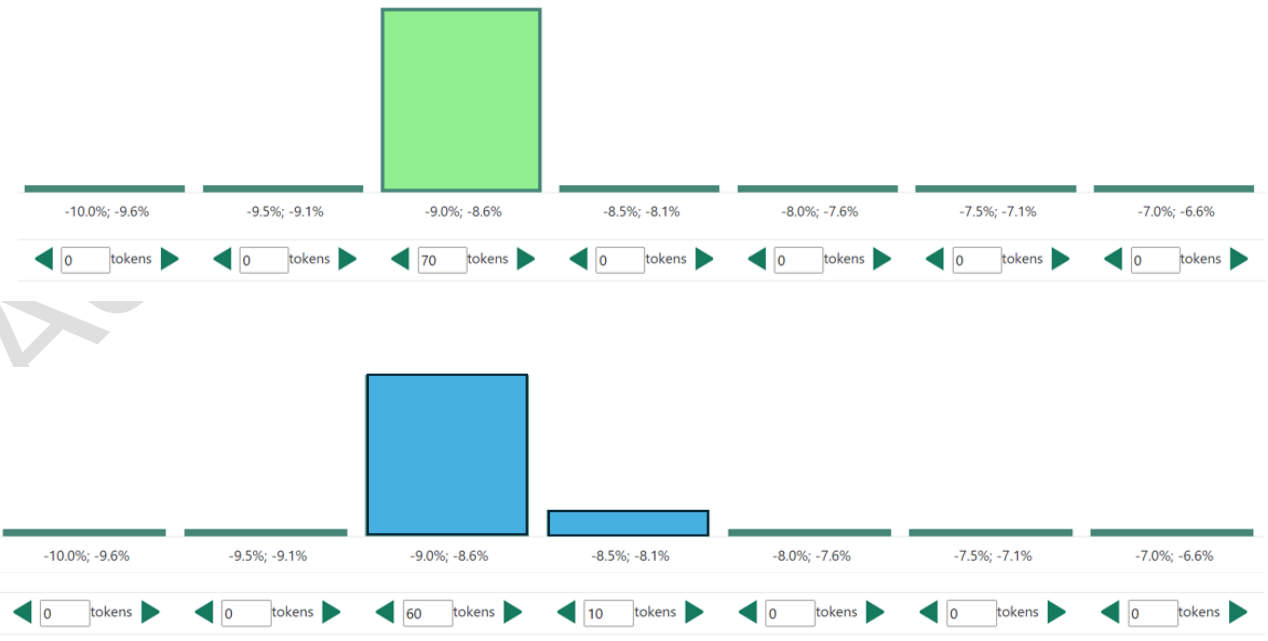
- Your monetary reward depends on the accuracy of your forecasts. Specifically, it depends on the following factors:
    1. Your distribution of the tokens in the intervals.
    2. The distribution of the tokens created by us based on the scientific data found in the literature.

- More precisely, if your distribution of the 70 tokens in intervals corresponds **with a good approximation** to the distribution of the tokens created by us based on the scientific data found in the literature, you will receive €25. Otherwise, you would receive €0.
- **What does good approximation mean?** For each interval, you have a margin of error of 10% for the distribution of tokens created by us which allows you to get the economic reward.

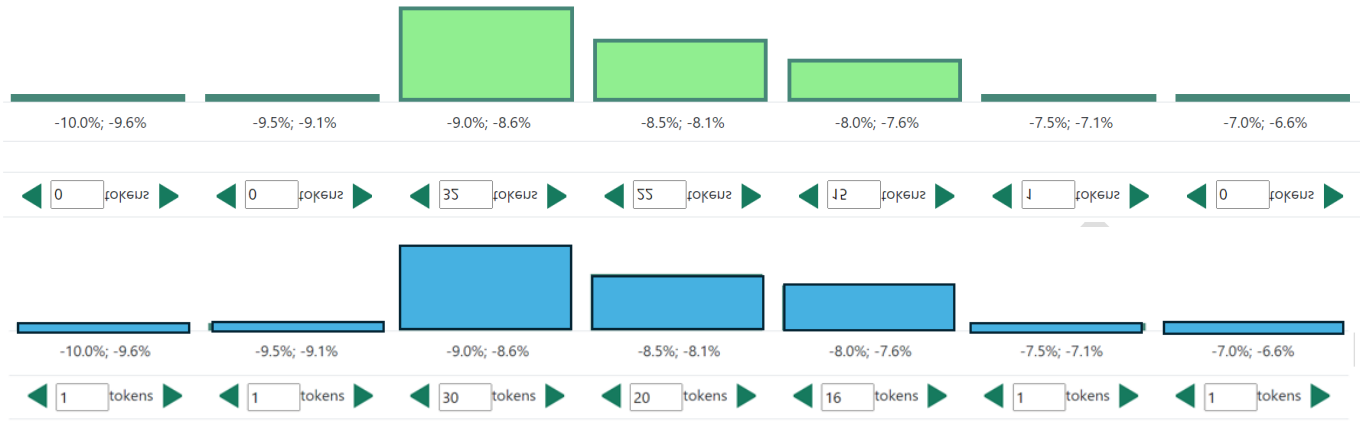
Let's see a few examples.

Example 1A. If your distribution (in green) **corresponds** to the distribution created by us (in blue) **with a good approximation,** you will receive €25.

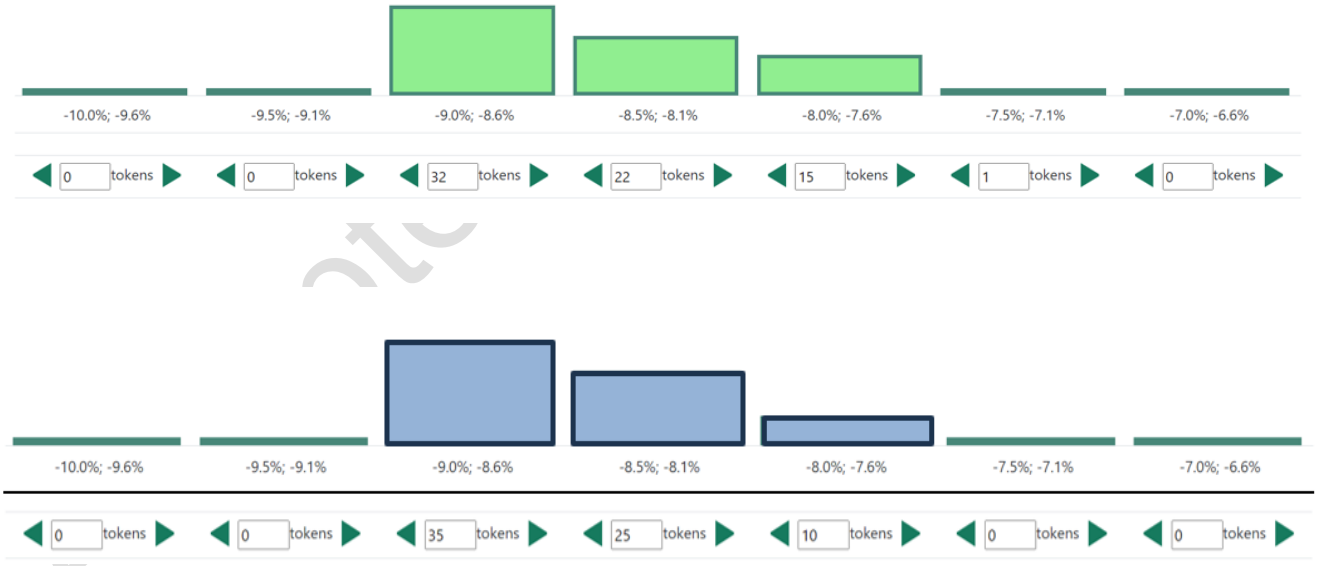
Example 1B. If your distribution (in green) **does not correspond** to the distribution created by us (in blue) **with a good approximation,** you will receive €0.



Example 2A. If your distribution (in green) **corresponds** to the distribution created by us (in blue) **with a good approximation,** you will receive €25.



Example 2B. If your distribution (in green) **does not correspond** to the distribution created by us (in blue) **with a good approximation,** you will receive €0.



<u>NOW YOU CAN INDICATE YOUR FORECAST</u>

- Instructions for Activity 3

- The instrument to express your forecast is the same as Activity 1 and 2

- You will have **70 tokens available**, and will be asked to distribute them in the 7 intervals using the following intuition:

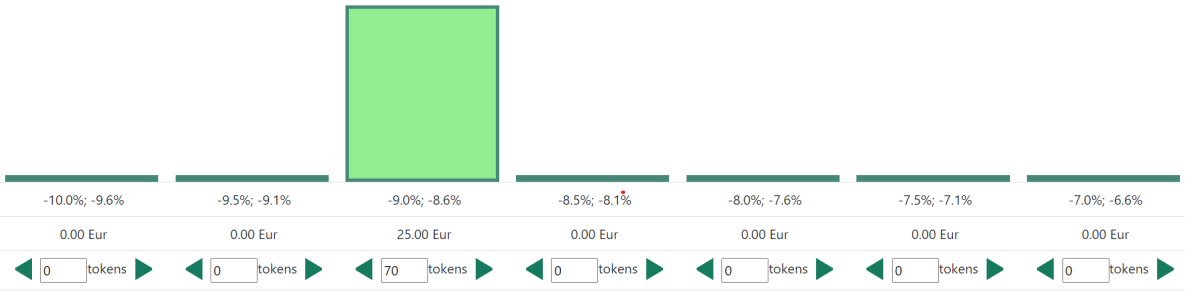
- **The more tokens you allocate in one determined interval, the higher the probability that the percentage reduction corresponding to the determined interval will happen in the future according to you.**

- *A potential monetary reward is generated for each interval according to the number of tokens distributed in each of them.*

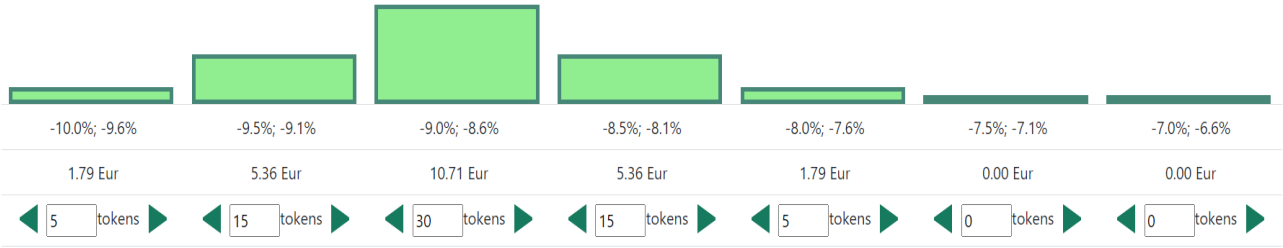
- All 70 tokens must be distributed in one or more intervals.

- Let's see a few examples.

- **Example 1.** If you are sure that the percentage of reduction will have one of the values between -9% and -8.6%, you could choose to distribute the majority (if not all) of tokens in the following way:



- **Example 2.** If, instead, you are not sure that the percentage or reduction will have one of the values between -7.5% and -7.1%, you could choose to distribute to tokens in the following way:



- How is your monetary reward calculated for Activity 3?

- Your monetary reward depends on the accuracy of your forecasts. Specifically, it depends on the following factors:

  1. Your distribution of the tokens in intervals.
  2. The distribution of the tokens created by us based on the scientific data found in the literature.

- More specifically, we prepared a **virtual box** containing 70 tickets. On each ticket there is written one of the intervals of reductions of methane emissions.

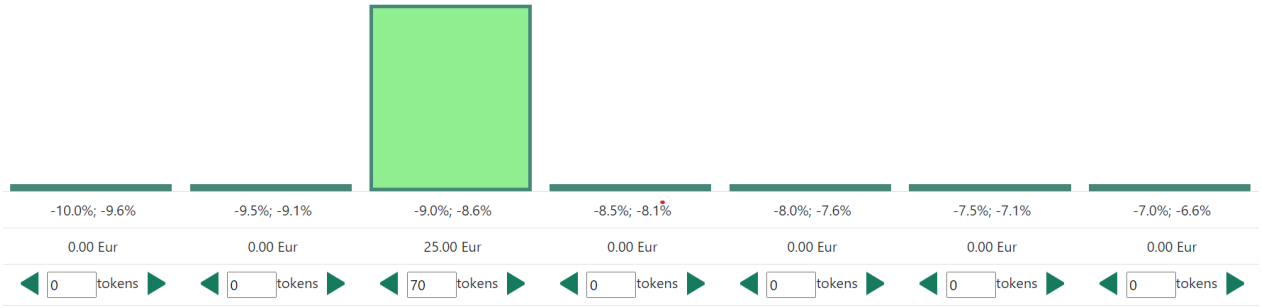
(-10%; -9.6%)	(-9.5%;-9.1%)	(-9%;-8.6%)	(-8.5%;-8.1%)	(-8%;-7.6%)	(-7.5%;-7.1%)	(-7%;-6.6%)

- The proportion of the tickets in the virtual box reflects the distribution of tokens created by us based on the scientific data found in the literature.

- One ticket will be randomly extracted from the virtual box and used to determine your monetary rewards. How?

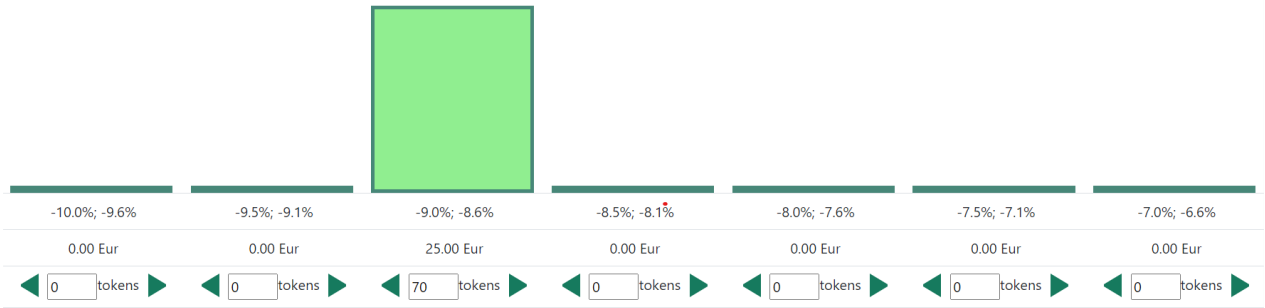
- Let's see a few examples:

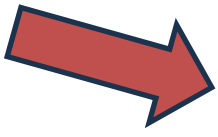
- **Example 1A.** Let's consider the following as your distribution (in green). You will receive a monetary reward based on the ticket randomly extracted from the virtual box. In this case, the randomly extracted ticket is (-9%, -8.6%) and you will receive €25.



(-9%, -8.6%)

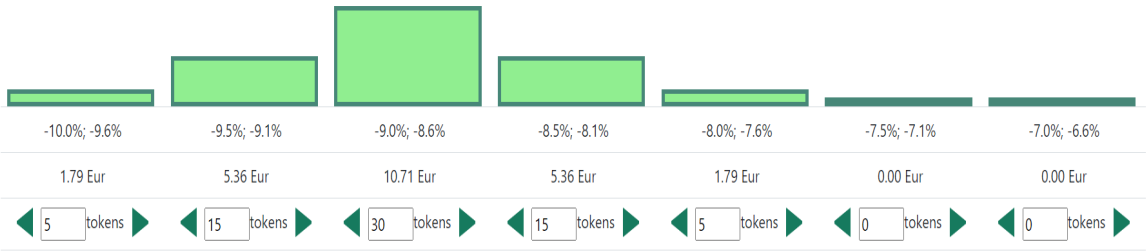
Example 1B. Let's consider the following as your distribution (in green). You will receive a monetary reward based on the ticket randomly extracted from the virtual box. In this case, the randomly extracted ticket is (-7%, -6.6%) and you will receive €0.

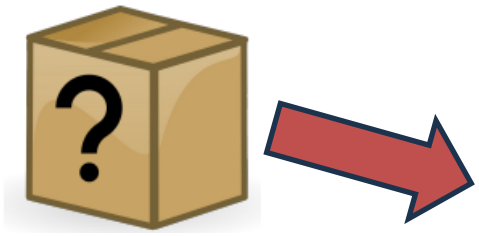




(-7%, -6.6%)

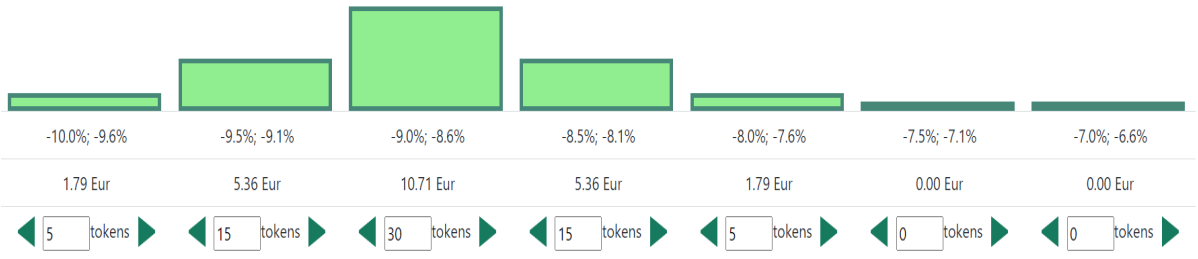
Example 2A. Let's consider the following as your distribution (in green). You will receive a monetary reward based on the ticket randomly extracted from the virtual box. In this case, the randomly extracted ticket is (-9%, -8.6%) and you will receive €10.71.

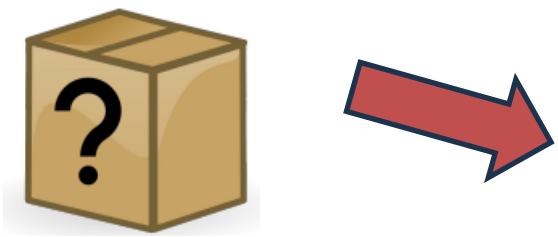




(-9%, -8.6%)

Example 2B. Let's consider the following as your distribution (in green). You will receive a monetary reward based on the ticket randomly extracted from the virtual box. In this case, the randomly extracted ticket is (-7%, -6.6%) and you will receive €0.





(-7%, -6.6%)

NOW YOU CAN INDICATE YOUR FORECAST

PHASE 2

- In Phase 2, we ask you to indicate how much you agree with the following statements on risky situations.

- We remind you that your answers are anonymous and that there are no right or wrong answers.

- Now we proceed to casually extract a number between 1 and 3 to decide which of the three activities (Activity 1, Activity 2, Activity 3) will be used to determine your monetary reward.

- The percentage reduction in methane emissions based on the scientific data in the literature is then compared to your forecast in the activity extracted.

- Eventually, the monetary reward is determined according to the rule defined in the corresponding activity.

Thank you for your participation!

About the questionnaire:

Domain-Specific Risk-Taking (Adult) Scale—RT scale

For each of the following statements, please indicate the likelihood that you would engage in the described activity or behaviour if you were to find yourself in that situation. Provide a rating from *Extremely Unlikely* to *Extremely Likely* (on a 5-point scale).

1. Admitting that your tastes are different from those of a friend. (S)
2. Betting a day's income at the horse races. (F)
3. Investing 10% of your annual income in a moderate growth mutual fund. (F)
4. Disagreeing with an authority figure on a major issue. (S)
5. Betting a day's income at a high-stakes poker game. (F)
6. Investing 5% of your annual income in a very speculative stock. (F)
7. Betting a day's income on the outcome of a sporting event (F)
8. Investing 10% of your annual income in a new business venture. (F)
9. Choosing a career that you truly enjoy over a more secure one. (S)
10. Speaking your mind about an unpopular issue in a meeting at work. (S)
11. Moving to a city far away from your extended family. (S)

Note. F = Financial, S = Social.

An additional question has been asked only to farmers:

Q: Would you be willing to purchase essential oil as a feed additive to reduce methane emissions in your dairy farm?

A: Yes/No/I don't know

Appendix B – Additional Analyses

Table 4. Wilcoxon signed-rank test of equality of distributions of different methods (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM = IM	0.57	0.5	0.15	0.05*	0.61	0.56	0.47
IM = QSR	0.62	0.24	0.07*	0.18	0.21	0.72	0.16
FM = QSR	0.18	0.16	0.66	0.48	0.1	0.78	0.45

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5. Kolmogorov-Smirnov test of equality of distributions when FM and QSR were the first methods (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM_first = QSR_first	0.18	0.04**	0.15	0.86	0.09*	0	0

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6. Kolmogorov-Smirnov test of equality of distributions of dairy sector and students (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM	0.41	0.17	0.05*	0.17	0.02**	0.87	0.67
IM	0.03**	0.15	0.7	0.87	0.66	0.96	0.15
QSR	0.77	0.08*	0.44	0.46	0.13	0.96	0.77

Note: *p<0.1; **p<0.05; ***p<0.01

Robustness Checks

The same analysis presented in the manuscript is conducted on a subsample including only farmers, excluding experts, using both non-parametric and parametric approaches.

Table 7. Wilcoxon signed-rank test of equality of distributions of different methods (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM = IM	0.516	0.549	0.189	0.065	0.597	0.585	0.453
IM = QSR	0.532	0.220	0.364	0.097	0.562	0.727	0.223
FM = QSR	0.307	0.152	0.984	0.821	0.172	0.757	0.402

Note: *p<0.1; **p<0.05; ***p<0.01

Table 8. Kolmogorov-Smirnov test of equality of distributions when FM and QSR were the first methods (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM_first = QSR_first	0.31	0.1	0.22	0.94	0.19	0.004***	0.007***

Note: *p<0.1; **p<0.05; ***p<0.01

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Table 9. Kolmogorov-Smirnov test of equality of distributions of farmers and students (for each interval)

Hypothesis: ($P_{i,k}$)	1	2	3	4	5	6	7
FM	0.73	0.23	0.14	0.13	0.004***	0.15	0.98
IM	0.22	0.57	0.47	0.89	0.08*	0.43	0.05
QSR	0.85	0.17	0.17	0.77	0.07	0.41	0.76

483 Note: *p<0.1; **p<0.05; ***p<0.01
484

Table 10. Effect of elicitation methods on subjective probabilities (for each interval)

Dep. Var.: ($P_{i,k}$)	1	2	3	4	5	6	7
FM	0.229	0.191	-0.037	-0.013	0.316	-0.213	-0.505
	(0.639)	(0.587)	(0.523)	(0.556)	(0.542)	(0.612)	(0.597)
IM	0.065	0.157	0.077	0.162	-0.021	0.002	-0.478
	(0.658)	(0.591)	(0.514)	(0.540)	(0.572)	(0.586)	(0.593)
Constant	-2.197***	-1.958***	-1.514***	-1.708***	-1.785***	-1.864***	-1.625***
	(0.471)	(0.430)	(0.368)	(0.392)	(0.403)	(0.415)	(0.381)
Observations	150	150	150	150	150	150	150
LL	-31.972	-25.859	-34.713	-26.217	-31.916	-29.657	-41.190

485 Note: *p<0.1; **p<0.05; ***p<0.01
486 LL stands for Log-Likelihood
487 Robust standard error in brackets
488

Table 11. Effect of confirmatory bias on subjective probabilities (for each interval)

Dep. Var.: ($P_{i,k}$)	1	2	3	4	5	6	7
FM_first	-0.031	-0.476	0.429	0.442	0.132	-0.178	-0.566
	(0.523)	(0.483)	(0.428)	(0.452)	(0.449)	(0.492)	(0.504)
Constant	-2.080***	-1.622***	-1.729***	-1.893***	-1.746***	-1.844***	-1.678***
	(0.368)	(0.311)	(0.323)	(0.342)	(0.325)	(0.336)	(0.317)

Observations	150	150	150	150	150	150	150
LL	-32.086	-25.448	-34.218	-26.296	-32.669	-29.739	-40.552

Note: *p<0.1; **p<0.05; ***p<0.01
LL stand for Log-Likelihood
Robust standard error in brackets

Table 13. Effect of being a farmer on subjective probabilities (for each interval)

Dep. Var.: ($P_{i,k}$)	1	2	3	4	5	6	7
Farmer	0.189	-0.167	0.346	0.017	-0.707	-0.066	0.360
	(0.528)	(0.491)	(0.426)	(0.454)	(0.499)	(0.504)	(0.493)
Constant	-2.175***	-1.775***	-1.648***	-1.663***	-1.436***	-1.904***	-2.088***
	(0.348)	(0.299)	(0.286)	(0.288)	(0.268)	(0.314)	(0.336)
Observations	150	150	150	150	150	150	150
LL	-31.874	-25.685	-34.185	-26.204	-32.318	-30.117	-40.779

Note: *p<0.1; **p<0.05; ***p<0.01
LL stands for Log-Likelihood
Robust standard error in brackets