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Abstract: We explore the willingness-to-pay (WTP) to fight climate change in a choice experiment. Since tree planting prevents climate change, subjects are offered to choose between receiving a high amount of money or receiving a lower amount of money plus participating to tree planting action. This allows us to get an individual interval of the WTP to prevent climate change. We also set the experiment to control for framing effects: we measure whether subjects WTP is higher not to prevent a tree planting action (negative framing) than to contribute to it (positive framing). Finally, we measure subjects' individual characteristics like altruism and risk aversion with a questionnaire, to understand the determinants of WTP. The results show that the WTP to prevent climate change is high: subjects are ready to give up half their gains to participate to a tree planting action. Women tend to have a higher WTP. We also find that both altruistic and self-interested motives can explain WTP. Surprisingly, their degree of knowledge of climate change related issues do not influence subjects WTP. Finally, when the choice is negatively phrased, WTP increases: subjects are ready to pay more not to make the number of trees planted decrease than to increase it. This suggests that negative eco-labelling might have a greater impact on consumer preferences than positive labels.

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Introduction

According to the group of experts on climate change (IPPC4) set by the UNO, average temperature on earth should increase by 1.5 to 6°C from now to 2100 with the current level of greenhouse gas (GHG) emissions [14].

Curbing such a phenomenon will be costly, as will be the consequences of the predicted climate changes. Indeed, developing renewable energies, cutting GHG emissions, or replanting trees to catch carbon require financial efforts. How much of our private wealth are we ready to give up fighting climate change? Where does that willingness to pay (WTP) come from? Which mechanisms should implement decision makers to increase it? These are the three questions that motivate our study.

These questions matter because one can consider that important decisions made by policy makers and corporations' CEO are driven by citizens' and customers' preferences. As a consequence, the intensity of the effort that is carried out to fight climate change is dependant on whether such efforts receive full support from the public opinion. Indeed, whether we try to curb emissions through taxes, subsidies, or markets, citizens will end up paying for a part of the cost, as customers and taxpayers.

From a policy maker perspective, understanding where our WTP to fight climate change comes from can help to design the most efficient mechanisms so as to protect climate instead of implementing authoritative regulations. For instance, would the implementation of labels indicating the eco-compatibility level of goods change consumer behaviours? Would an in-depth education to Climate Change at school have an impact on future citizen behaviours? These are questions on which our study gives some insights.

We conducted a choice experiment in which 71 students were asked to make choices between "I get an amount of **X**€ and 10 trees will be planted" and "I get an amount of **Y**€ and nothing more happens", with **X** being lower than **Y**. The difference between **X** and **Y** therefore represents the willingness-to-pay for planting 10 trees. By making **X** vary, we situate the threshold above which a student accepts to choose the lower amount **X**, and symmetrically below which he no longer accepts it. We also set up a negative framing. In this second framing, the number of trees planted diminishes when subjects choose the highest amount **Y**, whereas it remains the same when they choose **X**.

We find that framing has an effect on the WTP for offsetting carbon emissions. Subjects are ready to pay more not to make the number of trees planted decrease than to increase it. Other socio-demographic characteristics influence WTP: gender, income and the

number of siblings. Finally, we find that some behavioural and psychological variables such as environmental concern, risk aversion, and altruism are correlated to the WTP.

The next session presents a short review of the empirical literature on climate change, in which we explain the interest of using an experimental setting. We then present the experimental design. We expose in the section about the data how the behavioural and psychological scores are built, before turning to the results and a discussion.

A short literature review

1. Evaluating WTP to fight climate change: a glimpse into environmental goods valuation

To choose our experimental design, we referred to a wide field of research dealing with environmental goods valuation.

Such valuations are usually made through Contingent Valuation Surveys (CVS). CVS are classified as hypothetical measures, as they are based on answers to a questionnaire. The American Justice has recognized the CVS for cost-benefit analyses, after some dramatic environmental damages occurred. A CVS was for instance used to evaluate the damages caused by the wreck of Exxon petrol tanker Valdes in 1989 (see Carson et al. [5]) that was followed by an oil spill. Displaying photos of the coasts to subjects, they asked them: "What would be the price you would be ready to pay to prevent that such a disaster happens again?" On this basis the CVS helped to estimate a "price" for visiting the coast before the spill, and the court computed the fine that was sentenced from that valuation.

We argue here that such a methodology is not appropriate to measure a WTP to fight climate change. Indeed, the underlying assumption of CVS is that subjects have a conscious valuation of the good. Whereas a CVS can deal with goods that subjects can easily represent to themselves (visiting a natural park…), its use seems problematic when dealing with a more general and abstract environmental good such as the state of climate. The question "How much would you be ready to pay to fight climate change?" might yield random answers.

For this reason, we rather opted for a choice experiment methodology. We base our valuation of the WTP to fight climate change not on answers to an open-ended question but on a multiple dichotomous choice setting with monetary incentives. This methodology has been used for different applications, such as for irradiated food [16]. In our setting, when a subject renounces to receive 10€ in order to fight climate change through tree planting, this implies that her WTP to fight climate change is at least 10€ One can note that the subject

would probably not be able to consciously state her WTP otherwise. This methodology is also called a revealed choice experiment: subjects' preferences are revealed through their choices.

2. Understanding WTP to fight Climate Changes

In addition to our assessment of the WTP to fight Climate Change, we also have an interest in understanding the individual variability of WTP. On this purpose, we focused on the fact that climate is a public good. It led us to consider two fields in the literature.

When sending greenhouse gases into the atmosphere, I accelerate climate change. It has negative consequences not only for me but for every other human being. Climate change induces negative externalities and could therefore be called a public bad. Therefore, WTP to fight Climate Change can stem from mixed motives: either from self-interested or altruistic ones. And both motives are not mutually exclusive. A field we could refer to as dealing with the "preferences when facing climate change" has lately been developed. It emphasizes the self-interested motives that should lead consumers to choose environmentally friendly goods. To our knowledge, there has been no empirical attempt to disentangle the roles of self-interested and altruistic motives in our WTP to prevent Climate Change. This is the second goal of this paper.

2.1 Self-interested motives to fight Climate Change

Fighting Climate Change implies a short term cost for an individual: for instance the price differential between an eco-compatible good and its non eco-compatible substitute. However, there are long-term gains from a social welfare maximization perspective. If many people[1] accept to pay the eco-compatible premium, then as a whole this should limit Climate Change, and reduce the probability to be hit by a natural disaster in the future.

The temporal gap between the costs and the benefits described above, and the uncertainty of the benefit, can help us to assess which individual features are most likely to increase our WTP due to self-interested motives. Let us take an example. Being hit by a tornado is an uncertain event which will take place with higher probability in the future. And such a tornado is more likely to hit your children than you. For this reason, we expect subjects with high risk aversion, with low preference towards the present and with high concern for their offspring to have higher personal interest in fighting Climate Change. This statement is supported by the literature. Martin Weizman [18] shows that when assuming risk aversion,

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[1] We do not consider here the free riders' aspect of this public bad issue.

and an unbounded size of damages caused by Climate Change, agents should sacrifice all their present wealth so as to prevent Climate Change. In the article by Nicholas Stern on the Economics of Climate Change [17], most of the debate hinges on which discount factor should be applied to future flows. The discount factor crucially impacts the valuation of the cost of climate change.

We will consider such personal and self-interested motives listed above.

2.2 Altruistic motives to fight Climate Change

Along the self-interested determinants of WTP, there might be altruistic ones. One simple way of expressing altruism is to use a linear form in the utility function, as in Costa-Gomes and Zauner [8]. Let the utility of an individual depend upon his payoff and the payoffs of other players in the game. $U_i = \pi_i + \alpha \sum \pi_j$, where α is positive. This model explains why empirical data show that in dictator games, people make positive allocations to anonymous parties. Since the state of climate is a public good, when fighting climate change an individual increases his own sum of discounted pay-offs by decreasing the probability of being hit by a natural disaster some day. But doing so, he increases the sum of discounted pay-offs of every human being as well, because such a probability of disaster is the same for all of us. So that people who have such a α coefficient within their utility function should get higher returns from fighting climate change, and will be ready to pay a higher price for it.

3. Using loss aversion as a mechanism to increase WTP to fight Climate Change?

Finally, after identifying the individual characteristics that explain how the WTP differ from one individual to another, we try to identify mechanisms that can impact and increase the WTP to fight Climate Change. With this purpose in mind, we identified another relevant field, based on the utility function developed by Kahneman, D. and Tversky, A. [15]. They demonstrate that when analyzing an economic situation one uses his present situation as a reference point. Losses are asymmetric to gains around that reference point. The suffering caused by a degradation of our present situation will be greater than the joy created by an equivalent improvement. This is the so-called loss aversion.

In our case, this would mean that the loss of utility that is incurred by an action detrimental to Climate Change is higher than the gain when taking the equivalent positive action. Indeed, when taking such a detrimental action, a subject suffers a loss that can be twofold.

o   A loss of the quality of the environment, with respect to today's quality of the environment.

o   A loss of self-respect if one betrayed one's ideals, with the reference point being one's self-respect previous to the decision.

Subjects should therefore be ready to pay a higher WTP to avoid a detrimental action.

Based on this representation, some research has already been done about the reference point and about a mechanism that could increase or decrease consumers WTP to fight Climate Change: a positive and negative eco-labeling scheme. Grankvist et al. [4] made an experiment in which they asked undergraduates to grade a range of products, presented in pairs of substitutes. The experimenters made appear some eco-labels on the images of the products displayed to the participants, a green one meaning "significantly better than average for the environment", a red one meaning "significantly worse than average for the environment" and a yellow one meaning "average". Average was therefore meant as a control or reference situation. In some cases, one of the two substitute products was given a yellow label and the other one a red one. In other cases, one was given a green label and the other a yellow one. This setting allowed Grankvist et al. to compare the effects on preferences of positive vs. negative labels. The results showed that eco-labeling has an impact on preferences. The impact of negative labeling was stronger than the positive one on people who show weak to medium concerns for environmental issues. On the other hand, the positive labeling had an influence only on people deeply concerned with environmental issues.

In comparison to Granskvist et al.'s work, we use revealed preferences (real choices between monetary amounts) instead of stated preferences. We believe this methodology to be more reliable when dealing with environmental issues, because of the yea-saying bias. It is indeed easy to state to be ready to buy eco-compatible products at a higher cost and it is socially desirable, so that we expect most subjects to say yes whether they care or not for the environment. The choice experiment should reveal subjects' real commitment to ecological issues.

The experiment

1. Our experimental design

We use a methodology inspired both from contingent valuation surveys (Flachaire & Hollard [13]) and revealed preferences experiments (Shogren et al. [16]). The experiment was carried out with 80 subjects, divided in 4 groups. We kept only 71 observations, dropping

subjects who were not students for econometric matters. They started the session filling a questionnaire intended at determining their social background, their revenue, their degree of risk aversion…

Subjects of group 1 were told that the maximum amount they could get is 20€ They were said that the instructors want to replant trees, because replanting trees is an effective way of fighting Climate Change. No mention was made of the positive impact of tree replanting on bio-diversity and local populations, but the mechanism by which trees compensate human emissions of green house gases was explained in detail. The number of trees depended on the choices they would make during the experiment. To make them realize that trees will really be replanted, we told them that the money would be sent online and in front of them to the web site of the project in the end of the experiment. The name of the project was never mentioned, nor the fact that it is carried out by a NGO. This allowed us to describe things with very little context, so that subjects focus their attention only on the effect of their choices on climate change, and not on the NGO carrying out the project.

Subjects of group 1 made three choices. They first had to choose between two proposals:

A. I choose to get 20€ and nothing else happens.

B. I choose to get 10€ and 10 more trees will be replanted in the end of the experiment.

Respondents who chose proposal A in their first choice had then to choose between C and D:

C. I choose to get 20€ and nothing else happens.

D. I choose to get 15€ and 10 more trees will be replanted in the end.

Those who chose proposal B in their first choice had then to choose between E and F:

E. I choose to get 20€ and nothing else happens.

F. I choose to get 5€ and 10 more trees will be replanted in the end.

When choosing proposal B in his first choice, a subject reveals that he is ready to sacrifice at least 10€ so as to replant 10 trees. Which is the reason why we face him to the choice between E and F in his second choice: if he chooses E, then we know that his WTP to fight Climate Change is somewhere in-between 10€ and 15€

Repeating the process three times, we place each subject in one of the eight following groups, which correspond to a range of possible values for his WTP:

Choice 1 | 20€ + 0 tree | Or | 10€ + 10 trees

Choice 2 | 20€ + 0 tree | Or | 15€ + 10 trees | 20€ + 0 tree | Or | 5€ + 10 trees

Choice 3 | 20€ + 0 tree | Or | 17.5€ + 10 trees | 20€ + 0 tree | Or | 12.5€ + 10 trees | 20€ + 0 tree | Or | 7.5€ + 10 trees | 20€ + 0 tree | Or | 2.5€ + 10 trees

Group | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

WTP | 0€ | 2.5€ | 5€ | 7.5€ | 10€ | 12.5€ | 15€ | 17.5€ | 20€
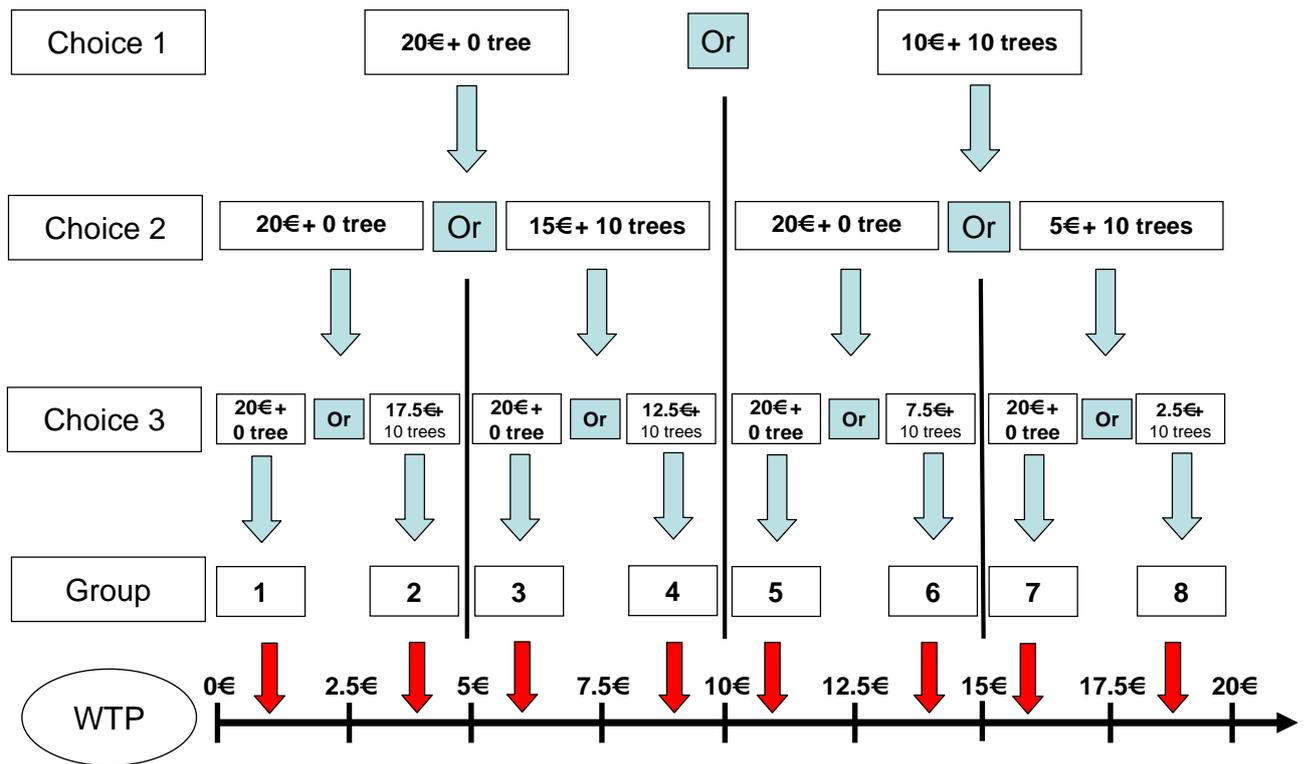
Group 1 are people whose WTP is between 0 and 2.5€, since they always chose the highest amount. Group 2 are people whose WTP is between 2.5€ and 5€ since they accepted to sacrifice 2.5€ in their last choice but refused to sacrifice 5€ in their second choice, etc. Our dependant variable in the regressions is the group number of each individual, that is to say his relative WTP, expressed in eighths of the total amount offered to him.

In the end, we randomly sort one choice per subject, which is the only one to become real. Imagine a subject who chose proposal A in his first choice, then proposal D in his second one, and finally chose to get 20€ against 12.5€ and ten trees in his third one. If his choice 2 is sorted out, he gets 15€ and 10 trees are replanted, regardless of his other choices. On the contrary if his choice 1 is sorted out, he gets 20€ and no trees are replanted. The emphasis was laid on the fact that because only one choice would eventually become real, subjects should make each of their three decisions as if it were the only one they had to make.

## 2. Controlling and testing for effects

2.1. 'Framing Effects'

Group 2's instructions were set somewhat differently. Subjects were told that the instructors want to replant trees, and a lump sum representing the necessary amount to replant

200 trees has already been constituted before the experiment. However, that lump sum can diminish depending on their choices:

Their first choice was put as follows:

A. I choose to get 20€and 10 trees less will be replanted in the end of the experiment.

B. I choose to get 10€and nothing else happens.

Choice 1	20€- 10 trees		Or		10€- 0 tree	
Choice 2	20€- 10 trees	Or	15€- 0 tree	20€- 10 trees	Or	5€- 0 tree
Choice 3	20€ - 10 trees	Or	17.5€ -0 tree	20€ - 10 trees	Or	12.5€ -0 tree	20€ - 10 trees	Or	7.5€ -0 tree	20€ - 10 trees	Or	2.5€ -0 tree
Group	1	2	3	4	5	6	7	8

WTP: 0€ 2.5€ 5€ 7.5€ 10€ 12.5€ 15€ 17.5€ 20€
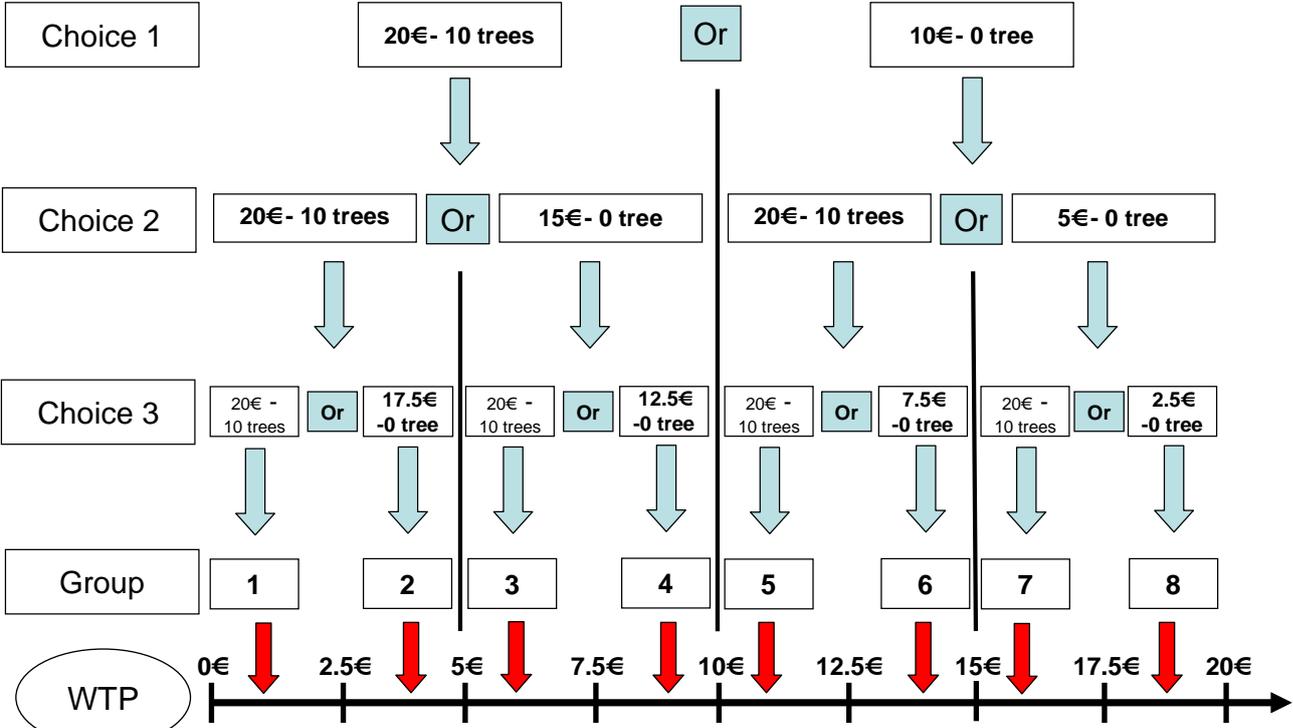
Treatments 1 and 2 are perfectly symmetric: if the number of subjects who choose the lower amount offered to them is the same in the two groups then the number of trees replanted will be the same. This allows us for testing the framing effect on subjects' behaviors.

2.2. Effect of the amount at stake

To determine if as in dictator games (see [5] and [10]), the amount at stake does not influence subjects' choices, we set up the same protocol for groups 3 & 4, but with a maximal stake of 10€ We find that the amount at stake does not change the percentage of money subjects are ready to give up for the environment. On this, see appendix 1.

To give an overview of our protocol, it is summarized in four treatments. Two dimensions vary: wealth and framing, as explained in the following table.

	20€	10€
Positive Framing	Group 1 : 18 subjects	Group 3 : 19 subjects
Negative Framing	Group 2 : 19 subjects	Group 4 : 15subjects

Data construction: building up scores

To determine individual determinants of WTP, we built up a questionnaire aimed at measuring subjects' degree of risk aversion, preference towards present, altruism, egoism, altruism towards their (future) children, interest for ecological issues and knowledge of these issues. It was largely inspired from Arrondel et al. regarding altruism, preference towards present and risk aversion. Regarding the remaining variables we built up our own questions.

For each question making up a score, subjects are given a number of points between 0 and 1. Then we compute the correlation between the number of points at each question and the sum of the points to the other questions that will be included in the same score. This is the same methodology than the one used by Arrondel et al. We thus make sure that the answers included in the same score measure something close, so as not to add up randomly figures when making up the aggregated score. Correlations are shown in Appendix 6.

We show below the questions used to build up the scores significantly correlated to the WTP for carbon offset in later estimations. Question for other scores appear in Appendix 3.

Altruism score (see correlations)
- o Have you already given your blood? If yes at which frequency?
- o Are you a member of a charity? If yes, how often do you work for it?
- o Would you accept to give one of your organs after your death?

Risk aversion score (see correlations)
- o What would be the maximum price you would pay to participate in the following lottery: gain = 0€ with probability 90% and gain = 500€ with probability 10%?
- o How often do you go to the Casino, play Poker or participate in lotteries?

Preference towards present scores (see correlations)
We built up two scores. The first one measures behavior towards savings and is presented in appendix 3, the second one measures the degree of concern with one's health from the three following questions:
- o How often do you control your weight?
- o How often do you control your food?
- o Do you regularly smoke cigarettes?

Regarding preference towards present, we had included another question, whose answers proved to be uncorrelated to the others: "Do you think it is worth depriving one self of the pleasures of life so as to live longer?" We will talk about it later on, referring to it as the "Achilles" question.

Interest towards ecology score ([see correlations](#))

We invented the following imaginary situation and asked subjects what they would do should they be faced to it. "Imagine you are the French President. Your Finances Minister tells you that you have 1 billion € of extra money you must spend this year. You have to allocate it between the five following ministries: Justice, Housing, Army, Ecology and Culture. Write down your allocation." We looked at two variables: the position into which Ecology comes out of the five ministries, and the percentage of the total sum it receives.

Results

1. Comparison of subjects among treatments ([see tables](#))

Subjects who received "positive" instructions are not perfectly similar to those who received "negative" ones with respect to sex and to the number of previous experiments:

o The proportion of men is much higher in the "negative" groups (65% against 43%)
o Subjects within the "negative" groups participated in more experiments previously.

Groups where the money at stake is 20€ are not perfectly similar to groups where the maximum sum of money to be won is 10€ the proportion of men is higher in the 20€ groups.

2. Graphical approach and descriptive tests

2.1 Graphical approach

For the whole sample, we display below the distribution of WTP. It is very high. On average, people belong to group 3.91, out of the 8 groups described above, where group 1 represents those who were not ready to pay anything and group 8 those who were ready to give up everything. Subjects of the 10€ groups were ready to pay 5.16€ on average for ten trees, when subjects in the 20€ groups were ready to put 9.27€ for it. The second point is that the standard deviation is important. The most extreme values (1 & 8) represent 38% of the distribution. People adopted "everything or nothing" type of behaviors.

Figure 1: WTP of the whole sample
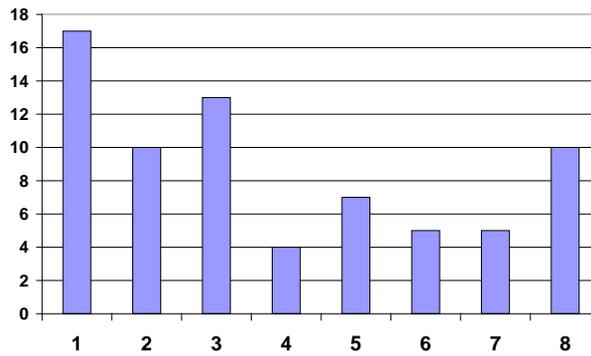
In relation to the comparison of "negative" and "positive" groups' WTP, we do not find a significant difference between the WTP of "negative" groups and "positive" groups. This is due to the fact "negative" groups bear a larger proportion of men than "positive" ones. Since men tend to have a smaller WTP than women, the increase in WTP caused by the "negative" framing is offset by the fact that there are more men within the negative groups. However, when comparing women' WTP in a negative framing to women' WTP in a positive framing, the increase in WTP due to "negative" framing is obvious:

Figure 2: Women's WTP, Negative & Positive Framing
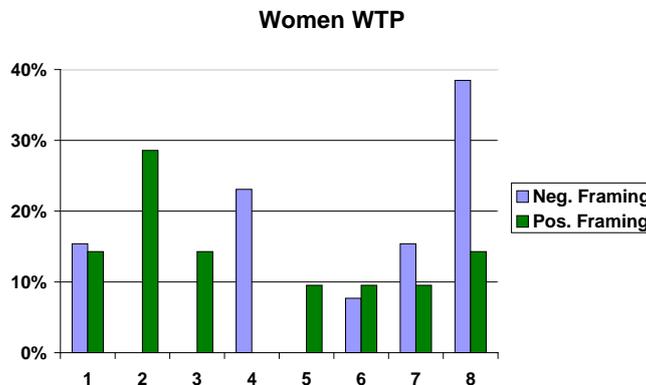
2.2 Descriptive Tests

We display below Mann-Whitney tests. For scores, we divided our sample in two separating people below the mean for this given score from people above the mean.

Framing had an impact on women WTP, significant at an 85% degree of confidence. Sex had a strong impact on WTP. The amount at stake had no significant impact, even if the impact on men is close from being significant at an 80% degree of confidence. People with a higher altruism score had a higher WTP, the difference being significant at an 80% degree of confidence. The fact of having participated or not in previous experiments had a very strong and significant impact on WTP. People with higher interest for the ecology had a significantly

higher WTP at an 85% degree of confidence. Finally, risk adverse people seemed to have a higher WTP, even if the difference is not significant.

Table 1: Mann-Whitney Tests

Variable	WTP Group 1	WTP Group 2	Mann-Whitney p-value
Pos./Neg.Framing	3.68	4.01	0.62
Pos./Neg. Framing, Women	4.01	5.61	0.14
Men / Women	3.31	4.51	0.06
20€/ 10€	3.59	4.08	0.52
20€/ 10€ Men	2.87	3.94	0.21
Low / High Altruism	3.49	4.36	0.17
Many / Few previous exp.	3.42	5.25	0.01
Low / High Interest for Ecology	3.54	4.52	0.15
Risk seeking / Risk averse	3.43	4.22	0.34

3. Linear estimations without the scores as explanatory variables

We leave apart for now the scores we built up previously. A first very simple model can be written using only 6 significant variables. It yields an adjusted R2 of 0.34. The best linear estimation is:

$$WTP = 7,9 - 1,4 \times Frame - 1,8 \times Sexe - 0,9 \times Experiment - 0,7 \times \ln(Income) + 0,3 \times \ln^2(Income) - 0,6 \times Brothers$$

Table 2: OLS regression without scores

Variable	Coefficient	P-value	Significant?
Framing	-1.43	0.01	***
Sexe	-1.82	0.00	***
Nb prev expe	-0.88	0.00	***
Log_income	-1.72	0.00	***
Log_income^2	0.27	0.00	***
Nb Brothers	-0.59	0.02	**
Cons	7.90	0.00	***

Five Control Variables

Everything else being equal, men will be ready to pay 2.3€ less than women in 10€ groups, and 4.5€ less in 20€ groups. A first explanation to this is that as some literature showed, women are more altruistic than men (see Eckel et al. 1998). In dictator games, they found that women donations are twice as big as men'. A second reason is that maternal instinct might on average be stronger than paternal one. Their children future may matter more to women than to men: they could be ready to pay more to preserve earth for them.

Let us now interpret the role played by: "number of experiments". Apparently, being a "professional subject" reduces your WTP. In our view, there are several explanations to this. First participating regularly in experiments means that you really need the money you get from them. Second, regular subjects may be less influenced in their decisions by the fact of being are observed, since they are used to it contrary to "new" subjects.

The coefficient in front of logarithm of income is surprising since it is negative, whereas we would have expected richer people to be ready to pay more for the environment. It is easy to explain once recalled that subjects are students. A student who needs to work for a living is probably not coming from a rich social background. Moreover, the relationship is quadratic: the coefficient in front of logincome^2 is positive. When the income gets over a certain threshold (563€ in our case), it starts having a positive impact on WTP. The income for which the negative effect on WTP is the strongest is 23€ income has a negative impact on WTP only for students who need to work for a living, but earn very little money. For those who come from a sufficiently rich family background not to work, and for those who earn sufficient money, the impact of wealth on WTP is positive.

The coefficient before the number of brothers is surprising as well since one would have expected the fact to live in a numerous family to be likely to develop family altruism and concern for next generations. But numerous families are also well-known for developing a "will to survive" among children. The child, as a little wolf among a numerous pack, learns how to fight for his food! This could explain why the coefficient is negative.

The role of framing

We are finally left with "framing". The first point to be noted is that the two only variables required for "framing" to have a significant influence at the 95% confidence level on WTP are "sex" and "number of previous experiments", that is to say the two only variables with respect to which our "negative" and "positive" groups of subjects significantly differ. This is a strong result: subjects are ready to pay more not to take an action accelerating Climate Change than to take an action speeding it down. This validates our approach from a reference point perspective. Kahneman and Tversky's loss aversion seems to apply, since the fact to be in negative framing increases WTP by 1.43 according to our 6 variables model.

4. Linear estimations including the scores as explanatory variables

Then we enrich that model with "opinion based" variables, the scores we built up previously. Since making regressions based on people's opinion can yield unstable results due

to the fact that the explanatory variables themselves are not very stable or reliable, we used the following rules before accepting a score into the model:

o The variables composing the total score, if not statistically significant by themselves, should at least all influence WTP into the same direction when taken individually.

o The starting point from which we will test all these new variables will be the model made up of the 6 factual variables described above (except for risk aversion).

We show below the results for the scores which prove to be significant determinants of the WTP. Results for other scores are presented in Appendix 4.

Altruism (see table)

The three variables composing the altruism score all influence WTP positively, all of them being significant by themselves at an 80% level of confidence. The aggregated score has therefore a positive influence on WTP, significant at a 95% level of confidence.

Understanding this is easy. As developed above, altruistic people are expected to take into account other people well-being into their own utility function. Since fighting climate change increases not only your future payoffs but also those of every human being, returns of such an action should be higher to altruistic people, who should be ready to pay more for it.

Preference towards the present

Two of the variables of the savings score influence WTP negatively but the aggregated score has no significant influence (see table). Regarding the score of self-care, we find that it has an impact only on men' WTP (see table). The influence is negative, which is surprising if we regard this score as a score of preference towards present. We would indeed expect people with a lower preference towards present to be ready to pay more to fight climate change.

However, we are concerned that these measures of preference toward the present designed by Arrondel et al. may be less relevant for a sample of young students that for an adult population. At an age when health is not an issue, taking care of your weight etc. is rather a sign of deep concern with one's image, above all for a man. The score we created might have more to do with narcissism than with preference towards present. This explains its negative influence on WTP.

Preference towards present is difficult to measure. In our view, none of the two scores we built up perfectly measure it. The only variable reflecting pure preference towards present in our questionnaire is the answer to the Achilles question. It impacts positively the WTP, as we would have expected preference towards present to do, but not significantly.

Interest towards the ecology ([see table](#))

Both variables included within the score of interest towards ecology influence positively subject's WTP, with one being significant at a 90% level of confidence. The aggregated score is significant at a 90% level of confidence.

Risk Aversion ([see table](#))

All the variables have a negative impact on WTP. If the aggregated score has no significant influence within the six variables model, we find it is very significant when adding it to a nine variables model (the six variables discussed above & the three scores which proved to have a significant influence). Moreover, when regressing the risk aversion score alone on WTP, we find that it is almost significant by himself (p-value = 0.14). We therefore decided to include it within the model.

The correlation of risk aversion and WTP shows that Climate change is associated to a more risky world in subjects mind: those who are risk averse are prone to pay more to fight it.

Final Regression

For this final model including scores we use a GLS estimation, which yields a R^2 of 0.56. All the variables are significant at a 90% confidence level. Scores have been normalized in [0; 1] so as to be able to compare coefficients. On top of the variables evoked above, we included an interaction variable expressing the fact that the effect of framing is stronger on women than on men. For supplementary econometric analysis see appendix 5.

Table 3: a GLS estimation

Variable	Coefficient	P-value	Significant?
Framing	-1.94	0.01	***
Sexe	-1.48	0.04	**
Nb_experiments	-0.85	0.00	***
Log_income	-1.59	0.00	***
Log_income^2	0.24	0.00	***
Brothers	-0.46	0.02	**
Altruism	2.86	0.01	***
Interest Ecology	1.53	0.04	**
Self Care*Men	-3.73	0.00	***
Risk Seeking	-2.51	0.07	*
Sex*Framing	1.42	0.10	*
Cons	8.62	0.00	***

Discussion and elements of conclusion

We have presented a design based on the dichotomous choice experiment setting to assess the WTP for fighting Climate Change. Our second objective was to identify some of the main determinants of the high WTP.

1. Evaluating WTP to fight Climate Change

The results show that the average WTP is high. The average WTP is almost 10€when the maximum amount at stake is 20€ The average WTP is higher than 5€when it is 10€ This means that a majority of students was ready to give up 50% of the amounts offered to them.

But can we interpret the WTP we find as the maximum premium for an eco-compatible characteristic on a good? Obviously the choice experiment we implemented has some shortcomings. We only observed one-shot decisions on the contrary to the repeated choices made in supermarkets by consumers. The observed offers would certainly have significantly decreased, had we asked students to repeat the same choice two or three times. Moreover, the monetary amounts at stake are small. We nevertheless chose them so that they were significant to students. Another limit can be pointed out. Students know that they are being observed which might have increased their willingness to pay. Finally, the questionnaire they filled in before making their choices might have influenced their behavior. After answering that you regularly donate your blood, you might feel obliged to give up an important part of the money offered to you to plant ten trees, to be consistent with yourself. Only two subjects mentioned the questionnaire in their final remarks. We thus expect such forced-consistency effects not to have been too important, even if we can not be sure of it.

Still, this high average WTP shows that when putting in an explicit way the consequences of a choice on Climate Change, subjects are ready to give up a great amount of money for it. Even if this is merely a speculative hypothesis, the main difference between what we observed in the lab and what we would observe in real life may come from the fact that you will never find in a supermarket a label stating: "if you buy this product, you are accelerating Climate Change". In our view, both the precise information and the reference to Climate Change we gave to subjects have impacted their choices. We believe that if we had put things in a less accurate way such as: "we want to replant trees because this is good for the environment", we would have found lower WTP. In this perspective, it would be interesting to carry out an experiment to test the information effect.

We now focus on the determinants of the WTP to fight Climate Change that, in our view, brings more to the discussion than the evaluation of absolute amounts.

2. Understanding WTP to fight Climate Change

About the altruistic motives

Does our WTP to fight Climate Change come from self-interested or altruistic motives? Many elements in our analysis suggest that it has more to do with an altruistic gesture. Firstly the fact that when passing from a 20€ to a 10€ stake, the average WTP is divided by two in absolute terms, and remains almost constant in relative terms (50% of the total amount), indicates that subjects refer themselves more to their personal conception of justice than to a price they would put on the ten trees when making their decisions. If they had been reasoning in terms of a price, that price would have remained constant regardless of the maximal amount at stake. Since the relative amount of WTP remains constant, it shows that they try to make a fair repartition between their own gains and the action of planting ten trees. In addition, the variable "degree of altruism" positively impacts WTP, and the variable "self-concern" negatively influences it among men, which tends to corroborate the altruistic thesis.

About the self-interested motives

We evoked three variables that are supposed to impact positively our WTP according to the theoretical literature about Climate Change: a high risk aversion, a low preference towards the present, and a high degree of concern for the offspring.

In our sample, the variable of risk aversion impacts positively and significantly the WTP. We set carefully the econometric model to control for "income" (and for "pocket money" even if it does not appear into the model due to lack of significance). Therefore we conclude that risk aversion does not impact the WTP because of a decreasing marginal utility of money. It is an ambitious task to show that self-interested motives play a role in the WTP to fight climate change. But we believe that the previous result indicates that the Climate Change is clearly associated to a future risky world in subjects' mind. And it seems that those who dread a risky world the most are ready to pay more for preventing it to happen.

Regarding the preferences towards present, we only set one variable to measure it per se. This is the Achilles' question. It proves to impact the WTP positively as we expected. In addition, the impact is pretty strong when focusing on the sample of women only. But it is not significant (p-value = 0.33). Therefore, we cannot draw any conclusion from our data about

preference towards the present. Whether it is due to the fact that preferences towards the present have nothing to do with WTP or that our measurement is far from being sufficiently accurate, we cannot conclude at this point. Similarly, we find a positive but not significant influence of the offspring altruism on WTP. The estimation for this latter variable could almost be significant (at an 80% confidence level). Here again, we cannot really conclude whether that lack of significance comes from the design and the sample, or from an absence of correlation between the two variables.

Finally, the maximal amount of money at stake has no impact on the overall sample but seems to impact negatively men WTP as we showed through a Mann-Whitney test. This result shows that men could be somewhere in-between a "personal justice" and a "paying the right price" rule when making their decisions. However, the variable is not significant when included into the regressions.

To conclude, both altruistic and self-interested motives seem to have some relevance to understand WTP to fight climate change. These two approaches are not contradictory anyway. However, altruistic motives seem stronger from a statistical point of view.

3. Building up mechanisms to increase the WTP to fight Climate Change

Educating to Climate Change consequences

Let us now come to the most important point of our discussion. Once understood subjects' WTP, what mechanisms could a policy maker use to increase this WTP?

For a policy maker, the first mechanism we had envisioned when designing this experiment is to increase the degree of knowledge of the population on the issue related to Climate Change. Our results here turn out to be deceiving, since there is absolutely no positive influence of their degree of knowledge on these issues on subjects WTP. Does it come from a lack of accuracy of our measurement of that knowledge? The questions we used to build up the score are highly correlated (see table 9). This suggests that these questions have indeed something in common. We avoided MCQ, so that subjects could not answer randomly. Most of the questions were simple and easy to grade: either you know that the energy which generates the most greenhouse gases emissions is coal and you get 1 point, or you do not know it but believe it is petrol, which is wrong, but not absurd and then get 0, or you believe it is electricity, which is wrong and absurd, and you will then get -1. All the questions we used were related to Climate Change.

The flaw in our measurement might come from the fact that none of these questions intends at measuring what the subjects know of the potential consequences of Climate Change. But this would have meant asking very precise questions ("Of how many degrees temperature on earth will rise during the 21st century?") for which we would have gotten nothing but rough and guessed estimates. For these reasons we believe that this score reflects an objective degree of knowledge on Climate Change related issues. And however surprising it might seem, how much you know about Climate Change does not increase your WTP to fight it.

Finally, another limit could come from the order we chose in our experimental setting: the questions come first and the choice experiment questions next.

Positive and Negative Eco-Labeling

The second mechanism we thought of is to make the appearance of positive and negative eco-labels on products packaging mandatory. This is already the case for electric appliances in the EU. When buying a dishwasher, a letter going from A (low consumption of electricity) to G (high consumption) indicates to the consumer its degree of eco compatibility. These labels are innovative with respect to what existed previously since they are mandatory and unique. They also allow consumers to compare substitute goods on a unique scale of comparison. But above all they include negative grades.

Our results suggest that consumers might be more sensitive to negative grades than to positive ones. WTP is much higher to prevent an action that is detrimental to the environment than to take a favorable one. In the 20€ group, passing from a negative to a positive framing provokes an increase in WTP by almost 3€ The figure is 1.5€ in the 10€ groups. That framing effect is extremely strong on women but less significant on men. Even if the transposition of this to real life is somewhat speculative, we would expect consumers to be ready to bear a greater price differential to buy an "orange" good instead of a "red" one, than to buy a "green" one instead of an "orange" one, referring to the colors used by Grankvist et al. [4].

From a policy maker perspective, implementing such labels could be a way to drive the least eco-compatible firms out of the market, and to start a race for "not being the least green" among firms of an industry. This scheme would suppose grades to be updated regularly and awarded on a relative basis (each firm should be graded with respect to the levels of eco-compatibility of competition). Still, this requires being able to measure the

carbon footprint of every product, which is far from being easy in all industries, and at a cost that should not overwhelm the value of the product.

Acknowledgements

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Appendix

Appendix 1: why did doubling the amount at stake did not change subjects' behavior?

Observing that people behavior was not affected by the change in money at stake from 20 to 10€ might give us some hints on the functional form of their utility. Even if this is beyond the scope of this paper, we present below a quick discussion on whether subjects' utility is additively or multiplicatively separable in environment and private consumption.

Assume subjects have the following utility function, additively separable in money and trees, and linear in money. The program they solve is therefore as follows, where T is a dummy variable which takes value 1 if the subject chooses tree replanting and 0 otherwise:

$$\max_{T,M} U(T,M) = V(T) + M$$
$$s.t.: p_T \times T + M \leq W$$

Their WTP is the price at which they are indifferent between planting trees or not, which yields: $V(1) + W - WTP = W + V(0) \Rightarrow WTP = V(1) - V(0)$ (*)

Equation (*) implies that in such a case of additively separable utilities, subjects WTP will be independent of their wealth.

On the contrary, if we assume the two utilities not to be additively separable but multiplicatively separable in trees and money, and linear in money, then the maximization program of the subjects is:

$$\max_{T,M} U(T,M) = V(T) \times M$$
$$s.t.: p_T \times T + M \leq W$$

This yields, assuming $V(0) \neq 0 : V(1) \times (W - WTP) = V(0) \times W \Rightarrow WTP = \frac{V(1) - V(0)}{V(0)} \times W$ (**)

Equation (**) implies that in such a case of multiplicatively separable utilities, subjects WTP will be linearly increasing with their wealth.

What our results suggest, since we find that WTP is linearly increasing with wealth, is that subjects utility might be multiplicatively separable: the state of the environment and private consumption are not perfect substitutes.

That question is far from being just theoretical. Assume society is made up of one single representative agent, who has to decide upon a positive growth rate of production till the end of time. Growth increases the output but decreases the quality of the environment at

the same rate g. Initial output and initial quality of the environment are normalized to one without loss of generality.

If we assume that climate and private consumption are additively separable (perfect substitutes), the maximization program is: $\underset{g \geq 0}{Max} \sum_t \beta^t \left[(1+g)^t + (1-g)^t \right]$ where β is a discount factor, and yields $g = \dfrac{\beta}{1-\beta} \succ 0$. Assuming that they are multiplicatively separable (imperfect substitutes), the maximization program is: $\underset{g}{Max} \sum_t \beta^t \left[(1+g)^t \times (1-g)^t \right]$ and yields $g = 0$.

This result is driven by a very simple and polar model. But it conveys a basic intuition: under additively separable preferences economic growth can compensate for the loss in welfare provoked by environment degradation. But such compensation is less obvious when these two goods are imperfect substitutes.

Appendix 2: Why did we choose to replant trees?

The question deserves to be answered, since we could have chosen to support another cause such as carbon burial.

Firstly, tree replanting is a very commonly known way of fighting Climate Change, whereas carbon burial is still very experimental. More than 60% of the subjects in our sample were aware of the link between Climate Change and reforestation before we told them. Then, from a symbolic perspective, it is easier to represent yourself what does it mean to replant ten trees than to bury one ton of CO_2. This is for the pros.

Within the cons, there is firstly the fact that tree replanting has positive effects on Climate Change but also on bio-diversity for instance. WTP of subjects to replant trees might thus not come from their will to maintain the temperature on earth at acceptable levels, but from a desire to protect animal and vegetal species. To control for this, we tested before the experiment whether subjects were aware of the positive effects of reforestation on bio-diversity. That variable proves to be insignificant in the regressions.

Then, a recently published paper by the Max Planck institute and misinterpreted by the medias threw the doubt among public opinions on whether tree replanting is effective against Climate Change. None of the subjects mentioned it in his final questionnaire, nor put in doubt the efficiency of tree replanting in fighting Climate Change.

Appendix 3: Other Scores

The altruism towards one's children score ([see correlations](#))

It is built up from the answers of subjects to the three following questions:

- o Ideally, how many children would you like to have?
- o Do you agree to say that having children means committing for life?
- o Do you agree to say that their children's happiness is more important than their own happiness for parents?

Correlations here are pretty weak due to the fact the number of children subjects would ideally like to have is weakly correlated to the two other variables, whereas Happiness and Commitment are strongly correlated (p-value : 0.13). However, since the numbers of children is a very intuitive variable to measure how important to you is the fact of building up a family, we decided to maintain it in the score.

The attitude towards one's savings score ([see correlations](#))

It is built up from the answers of subjects to the three following questions:

- o On a scale from 0 to 10, where 0 would represent a person living in the present and 10 a person very far-sighted, where would you situate yourself?
- o Do you think that parents should transmit to their children the taste for saving?
- o Are you worried about the future of retirement pensions in France?

Correlations are very good, with only one not being significant at a 95% level of confidence. Denominating that score "Savings" is justified in our view since the variable which structures best that score is the second one, which is very strongly correlated to the first and the third one (p-value = 0.14 and 0.01), when the correlation between the first and the third is weaker.

The score of knowledge of ecological issues ([see the correlations](#))

It is built up from subjects' answers to five questions:

- o Do you know the name of the French Minister in charge of Ecology?
- o Which are the greenhouse gases you know?
- o Which energy generates the more greenhouse gases?
- o Do you know technologies to prevent global warming?
- o What are the benefits of tree planting for the environment?

Apart from the last one, these questions were asked once completed the experiment, so as not to give insights to subjects on the topic of the experiment before it started, and not to influence their choices neither. Correlations are very strong and significant.

Appendix 4: Regressions for Other Scores

Knowledge of ecological issues (see table)

Among the five variables included in the score of "knowledge of ecology", two have a positive but non significant influence on WTP, whereas three have a negative and non significant influence. The total score has no influence. This is an important result too: your degree of knowledge of environmental issues has no impact on WTP to fight Climate Change.

Family Altruism (see table)

The three variables included in the family altruism score do not all impact WTP into the same direction. The number of children one wants to have has a negative impact on WTP. The fact of thinking that children's happiness is more important than their own happiness to parents positively impacts WTP, just as the fact to state that having children means committing for life. The aggregated score has a positive impact on WTP, but non significant.

Other Variables

Before concluding this, let us just note that some variables that we would have expected to find into the regression are not into it: preference towards present, family altruism and money at stake.

Table 4: Other Interesting Variables

Variable	Coefficient	P-value	Significant?
Family Altruism	0.90	0.36	( )
Family Altruism wtht child	0.47	0.22	●
Achille*Women	0.99	0.33	●
Money at Stake*Men	-0.63	0.37	( )

Regarding Family Altruism, once gotten rid of the number of children one wants to have, the variable is not far from being significant. The only reason we find to explain why we need to get rid of that variable is that the answer to that question might be more influenced by parent's example than by one's own desire for having children. Our population is young

and far from taking such a decision as having a child. The correlation between the number of brothers and sisters one has and the number of children one wants is pretty strong (0.2).

Regarding preference towards present, the Achilles question has a positive influence on WTP as expected, stronger on women, but far from being significant. Either because preference towards present has nothing to do with WTP to fight Climate Change, either because one binary opinion question is not enough to get an accurate measure of preference towards present. We would rather opt for the second option. Finally, the amount of money at stake seems to influence only men, and has the expected negative impact on WTP.

Appendix 5: econometric tests

Testing for the normality and homoscedasticity of the residuals

The figure below shows kernel density estimate of the residuals in the OLS model and the normal density. One immediately sees that the two distributions are very similar.

Figure 3: Density of the residuals
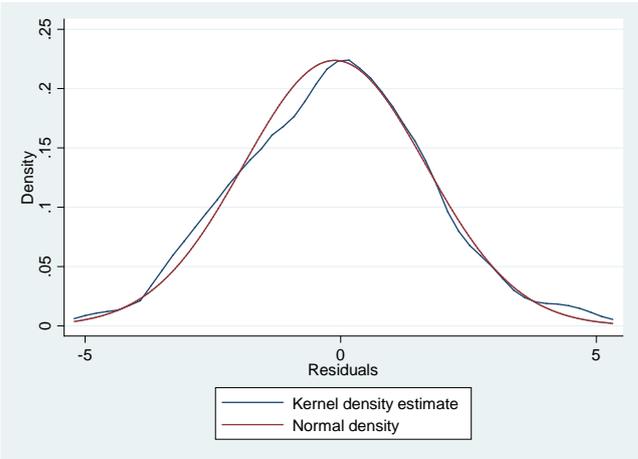
Then, we carry out a Breusch-Pagan test which yields a p-value of 0.71, which means that we do not reject the assumption that variance is constant among residuals.

Multinomial Logit estimations (see tables)

Our dependant variable is not continuous but multinomial and ordered. It can take values from 1 to 8. Due to its extended span of values it makes sense to use the OLS model. It might still be worth checking whether regressions with multinomial models yield the same results. However, due to the limited number of data points, these models might prove inefficient in our case. For instance, WTP has taken few times the values 4, 5, 6 and 7. To get

rid of that issue of sample size, we will also test multinomial models on subjects WTP after their second choice and not after their third one (only four possible values: 1, 2, 3 or 4). Finally, not to get meaningless results we restrain ourselves to our 6 variables model.

The first thing to be said is that these regressions confirm the results we got from the OLS: all the variables impact WTP into the direction they are supposed to, apart from a very small number of exceptions. Moreover, their influence on the WTP is significant when WTP is far from the value 1 which is the reference value in both cases. In the first regression, all the variables are significant for WTP=8, and 4 of them for WTP=7, whereas in the second one all are significant for WTP=4.

But more than just confirming our results, these regressions give us new insights on WTP. Not trying to model linearly WTP helps us understanding the extreme behavior we observed on figure 1. Being a woman and being placed into a negative framing makes it more likely for you to give up more than three quarters of the sum offered to you, which can be regarded as an extreme behavior.

Testing for robustness: the Boot-Strap regression

Finally, to ensure the robustness of our White-Robust estimator we performed boot-strap estimation. Its results are perfectly similar to the White-Robust model.

Appendix 6: Tables

Table 5: Comparison of "negative subjects" to "positive subjects" *(Back)*

Variable	Negative Framing	Positive Framing	Diff. Significant?
Age	23.7	22.1	( )
Sex	65%	43%	*
Major in Sciences	58%	51%	( )
Year of study	2.96	2.89	( )
Nb. experiments	2.29	1.70	***
Father's job	0.5	0.62	( )
Mother's job	-0.25	-0.16	( )
Pocket Money	160€	142€	( )
Work Income	315€	189€	( )

Table 6: Comparison of "20€subjects" to "10€subjects" *(Back)*

Variable	10€	20€	Diff. Significant?
Age	22.9	22.8	( )
Sex	44%	63%	*
Nb. experiments	1.94	2.05	( )

Father's job	0.52	0.59	( )
Pocket Money	174€	130€	( )
Work Income	299€	207€	( )

Table 7: Correlations in Altruism Score *([Back](#))*

	Correl to other variables	p-value
Organ	0.14	0.25
Blood	0.18	0.12
Charity	0.16	0.18

Table 8: Correlations in Family Altruism Score *([Back](#))*

	Correl to other variables	p-value
Nb children	0.05	0.69
Commitment	0.10	0.38
Happiness	0.14	0.23

Table 9: Correlations in Risk Aversion Score *([Back](#))*

	Correl to other variables	p-value
Lottery Job	0.22	0.06
Money Games	0.16	0.16
Money Lottery	0.24	0.04

Table 10: Correlations in Savings Score *([Back](#))*

	Correl to other variables	p-value
Far-sighted Scale	0.17	0.14
Retirement	0.26	0.02
Saving Children	0.31	0.01

Table 11: Correlations in Self Care Score *([Back](#))*

	Correl to other variables	p-value
Weight	0.45	0.00
Food	0.34	0.00
Cigarette	0.18	0.12

Table 12: Correlations in Interest in Ecology Score *([Back](#))*

	% Ecology	p-value
Rank Ecology	0.82	0.00

Table 13: Correlations in Knowledge Score *([Back](#))*

	Correl to other variables	p-value
Tree Planting	0.57	0.00
Ministry	0.30	0.01
Gases	0.38	0.00
Energy	0.40	0.00
Technologies	0.58	0.00

Table 14: Altruism *([Back](#))*

Variable	Coefficient	P-value	Significant?
Blood	0.85	0.20	( )
Charity	1.41	0.17	( )
Organ	1.11	0.07	*
Altruism	2.51	0.02	**

Table 15: Risk Aversion *([Back](#))*

Variable	Coefficient	P-value	Significant?
Money Games	-1.25	0.29	( )
Lottery Money	-1.45	0.12	*
Risk Aversion 2	-1.26	0.07	*

Table 16: Savings *([Back](#))*

Variable	Coefficient	P-value	Significant?
Far-sighted	0.00	0.99	( )
Retirement	-0.40	0.49	( )
Saving children	-0.31	0.61	( )
Saving score	-0.61	0.52	( )

Table 17: Self Care * Men *([Back](#))*

Variable	Coefficient	P-value	Significant?
Weight*Men	-2.02	0.00	***
Food*Men	-0.43	0.58	( )
Cigarette*Men	-0.75	0.29	( )
Self Care*Men	-0.81	0.05	**

Table 18: Interest for Ecology *([Back](#))*

Variable	Coefficient	P-value	Significant?
Rank Ecology	0.44	0.18	( )
% Ecology	0.65	0.07	*
Interest Ecology	1.16	0.10	*

Table 19: Knowledge of Ecological issues *(Back)*

Variable	Coefficient	P-value	Significant?
Tree Planting	0.31	0.41	( )
Ministry	0.44	0.45	( )
Gases	-0.20	0.67	( )
Energy	-0.54	0.36	( )
Technologies	-0.76	0.16	( )
Knowledge Ecolo	-0.03	0.98	( )

Table 20: Family Altruism *(Back)*

Variable	Coefficient	P-value	Significant?
Nb children	-0.15	0.67	( )
Commitment	0.33	0.55	( )
Happiness	0.19	0.82	( )
Family Altruism	0.31	0.78	( )

Table 21: Multinomial Logit estimation of final WTP *(Back)*

	WTP = 2		WTP = 3		WTP = 4		WTP = 5		WTP = 6		WTP = 7		WTP = 8	
	+/-	signif.	+/-	signif.	+/-	signif.	+/-	signif.	+/-	signif.	+/-	signif.	+/-	signif.
Framing	+	*	+	( )	-	*	-	( )	-	( )	-	*	-	*
Sex	-	( )	+	( )	-	**	-	( )	-	( )	-	**	-	***
Nb expe	+	( )	-	( )	-	( )	-	**	-	**	-	*	-	**
Income	+	( )	-	( )	-	*	+	( )	-	*	-	( )	-	***
Income^2	-	*	-	( )	+	*	-	( )	+	*	+	( )	+	***
Brothers	-	( )	-	( )	-	( )	-	( )	+	( )	-	**	-	**

Table 22: Multinomial Logit estimation of intermediate WTP *(Back)*

	WTP = 2		WTP = 3		WTP = 4	
	+/-	signif.	+/-	signif.	+/-	signif.
Framing	-	( )	-	*	-	**
Sex	-	( )	-	( )	-	***
Nb expe	-	( )	-	***	-	**
Income	-	*	-	*	-	***
Income^2	+	*	+	( )	+	***
Brothers	-	( )	+	( )	-	***