Pre-Analysis Plan: Quantifying the role of greenhouse gas emissions in consumption choice

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1 Project motivation

The first goal of this project is to better understand the role of greenhouse gas emissions in consumption decisions. Many consumers seem to care about greenhouse gas emissions, but are either badly informed about the emissions attributable to different consumption options or inattentive to these emissions at the moment of choice. This leads to inefficient choices and, correspondingly, inefficiently high psychological costs of enviornmental guilt. This project aims to estimate the magnitude of this internality. The project hereby adds to the literature on imperfect information, salience bias and limited attention, e.g. Tiefenbeck et al. (2018) and Allcott and Taubinsky (2015).

The second goal of this project is to evaluate the provision of emissions labels as a means to overcome this problem and combat climate change by reducing emissions overall. It does so by estimating the causal effect of emission labels on behavior, and by estimating the effect they have on consumers' welfare. In this respect, the project connects to the literature on the welfare evaluation of nudge interventions, e. g. Allcott and Kessler (2019) and Butera et al. (2019).

This project focuses on the consumption of restaurant meals as a concrete consumption context. This is a relevant context, since changing peoples' diets towards more climate friendly options has large potential in reducing overall greenhouse gas emissions. Currently, around 15% of the greenhouse gas emissions of an average German citizen are attributable to his food consumption (Bundesumweltministerium (2019)). Switching to a vegetarian, vegan or so-called climatarian diet can largely reduce this percentage.

In a lab experiment, participants make incentivized choices between different restaurant meal options. The experimental conditions vary in whether information on the greenhouse gas emissions attributable to the meal options is provided and in whether the greenhouse gas emissions attributable to the meal options are offset. Furthermore, additional survey questions provide background information on the subjects, subjects' knowledge of emissions and subjects' willingness-to-pay (WTP) for receiving information on the greenhouse gas emissions attributable to meal options. With the data collected, a theoretical model describing consumption choice in the presence of greenhouse gas emissions will be structurally estimated and used to answer the questions outlined above.

2 Sample

Experiment participants are recruited via hroot from the participant pool of the BonnEconLab. The requirement for participation in the experiment is that the participant does not follow a very restrictive diet (e. g. vegan, lactose-free, gluten-free or halal). Vegetarians are permitted to participate. The reason for this restriction is that people following these restrictive diets

only make up a sub-part of the population and I consider them negligible in determining the effect a CO_2 label has on the population. Vegetarians, in contrast, make up a larger part of the population. In the pre-survey, 20% of participants were vegetarian. Two of the meals shown to participants in the main decision scenarios are the same across all participants (vegetarian meals), while the other two differ. This way, half of the meals shown to non-vegetarians contain meat, while vegetarians are only shown vegetarian meals.

Due to the fact that the experiment procedure differs from usual procedures at the BonnEcon-Lab and that some potential participants may not physically be in Bonn due to the Covid-19 pandemic, it is difficult to predict how successful recruitment will be. I plan for a minimum of 300 and an ideal number of 600 participants. Power calculations based on a pre-survey suggest that a sample size of 300 participants will yield power of over 80% for the main outcomes.

The sample will be restricted as follows for the main analysis:

- The fastest 3% of participants are excluded from the main analysis.
- There are four comprehension questions to check the participants' understanding on the incentivization of WTP. If participants' response to at least one of these questions is incorrect, participants receive an error message and this counts as one error. I expect the average participant to make one to two mistakes as the questions are designed to make the participants further think about the mechanism. Participants who make more than five mistakes are excluded from the main analysis.

3 Experimental Design

3.1 General set-up

Experimental sessions are planned end of June and beginning of July 2021. In each session, participants first fill out a survey online (45 minutes duration) and then pick up their payment in person on the same day and no later than 2 pm. In addition to their payment, participants receive a meal for immediate consumption when picking up their payment. Participants can only sign up for one of the sessions.

The timing of the survey and pick-up of payment was chosen so as to mimic the usual process of choosing a lunch meal as far as possible. Due to COVID-19 regulations, the survey is conducted online instead of in-person. One part of the survey, participants' incentivized guesses of the greenhouse gas emissions and calories attributable to each meal, is adjusted due to this circumstance. For each guess, participants are given 60 seconds - enough time to make their guess, but insufficient time to search for answers online.

4 Experimental Design

4.1 Procedure

Participants are randomly sorted into either one of the two treated groups (T1, T2) or the control (C) group. Depending on the treatment group participants are assigned to, the information conditions under which they make consumption decisions in the core part of the survey differ.

In the course of the survey, participants' willingness to pay (WTP) for various restaurant meals is elicited under different information conditions. Ine one information condition, participants are shown the greenhouse gas emissions caused by each meal. These emission values are calculated using the Eaternity Institute (2020) database. I purchased an Eaternity personal license, and Eaternity has confirmed that I may use this license to calculate values for the experiment.

The experiment procedure is:

1. Questions on demographic information, allergies, eating preferences, current hunger level.
2. WTP elicitation for meals A,B, C and D.
3. Incentivised guess of the emissions attributable to nine meals, including meals A, B, C and D and the cheese sandwich. As a reference point, participants are informed of the emissions attributable to one example meal. For incentivization, additional €0,10 are added to participant's payment for every guess within 30% of the true value. Each guess is restricted to 60 seconds.
4. Repeated WTP elicitation for meals A, B, C and D, now under changed circumstances for the treated groups:
   - T1 is shown the emissions attributable to each meal.
   - T2 is told that the emissions attributable to the meal chosen will be offset.
   - C repeats the original WTP elicitation without any additional information.
5. Repeated WTP elicitation for A, B, C and D, switching conditions for T1 and T2:
   - T1 is told that the emissions attributable to the meal chosen will be offset.
   - T2 is shown the emissions attributable to each meal.
   - C repeats the original WTP elicitation without any additional information.
6. Incentivized guess of the calories attributable to meals A, B, C, D and the cheese sandwich. Groups T1 and T2 are shown emission labels in this procedure, while group C is not.
7. WTP elicitation for receiving emissions information for meals E, F and G.
8. WTP elicitation for meals E, F and G, with information conditions depending on the previous decision.
9. Participants answer questions on attitudes towards the environment and psychological traits such as self control in eating. Further, they are asked how much they would support the introduction of (1) carbon labels or (2) a carbon tax in the student restaurant.

4.2 Details on the elicitation of WTP for meals

In steps 2, 4, 5 and 8 of the survey, participants make a total of 15 consumption decisions. Each decision is a choice between receiving a cheese sandwich or a warm meal. This warm meal is a typical student restaurant meal, and the meals which are handed out to experiment participants after completing the experiment are in fact prepared by Bonn's student restaurant. The cheese sandwich is also prepared by the student restaurant and is a typical cheese sandwich (bread roll, slices of cheese and some lettuce garnish).

Regardless of the decisions participants make in the survey, they always receive one meal at pay-out (i.e. cheese sandwich or warm meal). This mimics usual meal choice: the alternative to not eating a certain meal is not "not eating", but eating something else. The WTP captured for a certain meal is thus relative to the participants' WTP for a cheese sandwich, as it is the participant's WTP to receive the meal instead of the cheese sandwich. If a participant prefers the cheese sandwich, this is interpreted as negative relative WTP for receiving the meal. As the main object of interest in this study is the **change** in WTP for meals which is induced by the treatments, it is secondary whether absolute or relative WTP values are captured and analyzed.

In each of the 15 decisions, participants first state whether they prefer receiving the cheese sandwich or the warm meal at payout, and then state the maximum amount they are willing to pay to exchange the two options if they are handed their less-preferred option. Participants are incentivized to respond truthfully, since one of these decisions is in fact implemented. For this decision, with 50% probability, a participant is handed their preferred option for free. With 50% probability, she is first allocated the less-preferred option, and receives her preferred option only if her WTP lies above a price which is randomly drawn from the interval (0,3), where each value in 5-cent steps is equally likely. If her WTP lies above the price drawn, the drawn price is automatically deducted from the participant payment. If her WTP lies below the price drawn, she receives her less-preferred meal and no amount is deducted.

For each step, the order in which meals are shown to participants is randomized, i.e. there is randomization across meals A, B, C and D, there is randomization across the incentivized emission guesses and there is randomization across meals E, F and G. Further, one aspect of the layout of the design decision - whether the warm meal or the sandwich is shown on the left or right part of the screen - will differ across experimental sessions to ensure that results are not driven by this feature.

Which decision is relevant for pay-out is partly pre-determined for logistic reasons, but not known to the participants. Great care was taken to ensure that participants are not able to guess which of the decisions is relevant for pay-out. For each participant, there are a total of seven meals playing a role in her 15 payout decisions. These seven meals differ depending on whether the participant is vegetarian or not. On each day, the meal which is relevant for payout is the same across non-vegetarian participants and the same across vegetarian participants. However, the relevant meal differs across days. It is thus not possible for participants to potentially learn from experiment participants from previous days which of the meals is relevant. Further, all meals asked for in the experiment are typical student restaurant meals and are regularly offered by the student restaurant in Bonn, so that participants should not be inferring that one of the meals is unlikely to be relevant.

4.3 Incentivization of the elicitation of WTP for emissions information

For the WTP elicitation for meals E, F and G in step 7 of the survey, participants have the opportunity to purchase emissions information for these meals. Participants decide whether they prefer the information to be shown, and indicate a WTP for their preferred display option. With 50% probability, a participant's preferred display option is implemented for free. With 50% probability, she is first allocated the less-preferred display option, and receives her preferred option only if her WTP lies above a price which is randomly drawn. The price drawn for this information is only deducted from participants' payment if one of the final three decisions is the

decision relevant for payout. Under these information conditions, the WTP for meals E, F and G is elicited.

5 Main Outcomes

The primary outcome I aim to estimate is the reduced form between-subject treatment effect of providing carbon labels on WTP for meals. I will estimate the reduced form treatment effect of being shown information on emissions on WTP based on a meal by participant fixed effects approach. Previous literature gives broad indications on the effect which is to be expected: Brunner et al. (2018) found that the introduction of food labels in a university restaurant correlated with an decrease of 3.6% in overall carbon emissions. Further, Camilleri et al. (2019) found that in a lab experiment, providing participants with emission-labels led to less purchase of beef soup (versus vegetable soup).

I expect that the introduction of labels will lead to lower WTP for meal options with a higher carbon label than the cheese sandwich. I expect this decrease to be larger, the higher the carbon emissions of the meal. (**Hypothesis 1**).

Further, I will estimate the reduced form treatment effect of emissions being offset on WTP based on a meal by participant fixed effects approach. Diederich and Goeschl (2017) found an average positive WTP for carbon offsetting.

I expect that carbon offsetting will lead to higher WTP for meal options to which the individual attributes higher carbon emissions than to the cheese sandwich. I expect this increase to be larger, the higher the perceived carbon emissions of the meal (**Hypothesis 2**).

5.1 Further outcomes

- WTP for carbon labels without and with having experienced carbon labels previously (as elicited in step 7) suggests the (expected) effect on welfare of being provided with these labels. The carbon labels tested in the experiment were designed together with Bonn's student restaurant and the student restaurant is considering implementing these labels on a large scale in the future.

- Participant's guesses for the emissions attributable to meals can be tested for their accuracy. Camilleri et al. (2019) found that people are insufficiently sensitive to the magnitude of differences in emissions between food items. I expect consumers to overestimate the emissions of low- and underestimate the emissions of high-carbon meals.

- The data gathered in step 2 can be used to construct a demand curve for each meal, allowing to evaluate the effect a carbon tax would have. Thus, one can compare the effectiveness of carbon labels versus carbon tax as policy instruments.

- In step (9) of the experiment, participants are asked for their approval of (1) the introduction of carbon labels and (2) the introduction of a carbon tax in the student restaurant. I will examine whether approval in the treated groups differs from approval in the control group. Further, these answers can be used as a check on the WTP which participants indicate for being shown emissions information.

- Suggestive within-subject estimates of treatment effects can be constructed by comparing the WTP for a given meal of a given treated subject with her baseline WTP for the meal. This allows for some heterogeneity analysis. The effectiveness of the label might differ depending on (1) subjects' education, (2) subjects' income, (3) subjects' environmental attitude, (4) subjects' degree of self control in eating. The same factors might influence subjects' WTP for being shown the label.

- One might argue that pariticipants shown emissions labels use these labels to infer nutritional characteristics of the meal. To check whether this is the case, I have participants guess the calories attributable to meals in step (6). The control group is not shown emission labels for this guess, while the treated groups are shown the emission labels. If it is the case that participants infer nutritional information from emissions labels, the guesses made by the two groups should systematically differ.

5.2 Structural model

To estimate the size of the internality and the welfare effects of providing information, the data gathered in the experiment will be used to estimate a structural model describing consumption choice in the presence of greenhouse gas emissions as well as welfare with and without the provision of emissions information. Observations from the experiment design provide insights into the structural model as follows:

- Participants' baseline WTP for a meal gives an indication of the utility consumers derive from a meal in the presence of concerns regarding greenhouse gas emissions and in the presence of the internality.

- Participants' WTP for a meal under carbon offsetting gives an indication of the utility consumers derive from a meal when environmental concerns are reduced.

- Participants' guesses of the emissions attributable to each meal combined with the change in WTP occurring due to carbon offsetting gives a quantification of the environmental guilt perceived for each (perceived) kg of emissions caused.

- Participants' WTP for a meal when shown emissions information gives an indication of the choices consumers make in the absence of the internality.

- Participants' WTP for being shown emissions information for their meal choices aggregates the change in welfare consumers experience when being shown the label:

  - increase in welfare due to the removal of the internality (this term can be quantified based on the above items)
  - change in welfare due to other emotional costs or benefits of seeing the label

6 Power analysis

In this section, I provide estimates of the minimum detectable effect (MDE) sizes of the treatments on willingness to pay for meals as well as the minimum detectable difference between control and treatment group in WTP for being shown emissions information. For the purpose of this power analysis, I conducted a hypothetical pre-survey on the 7th of May and 10th of May 2021.

The standard errors e of the treatment effect on WTP observed in the pre-survey are rescaled to treatment group sizes in the main study, using the scaling factor $\delta = \sqrt{\frac{1}{n_{Treatment}} + \frac{1}{n_{Control}}} / \sqrt{\frac{1}{n_{Treatment,pre-study}} + \frac{1}{n_{Control,pre-study}}}$, with $n_{Treatment}$ referring to the size of the treatment group in the main study, and $n_{Control}$ referring to the size of the control group in the main study. In the pre-study, the size of the control group was 40, and that of the treated group 80. I set the significance level (α) for a two-sided test to 0.05 and the power level (β) to 0.8. The resulting MDE, i.e. the minimum detectable difference between treatment groups, is $MDE = (t_{1-\frac{\alpha}{2}} + t_{1-\beta}) * e * \delta = 2.802 * e * \delta$

Depending on how many participants can be recruited for the experiment, minimum detectable effect sizes differ.

With 300 participants in the experiment:

	Treatment	Outcome	Standard error pre-survey	Treatment group	Control group	Scaling factor (δ)	MDE	Percent average WTP
I	Label*GHG	WTP(meal)	0.157	200	100	0.63	0.278	17%
II	Offset*E(GHG)	WTP(meal)	0.014	200	100	0.63	0.024	1.5%

The outcome variable is the WTP which participants state for a meal. "Label*GHG" refers to the interaction of being shown the label with the true greenhouse gas emissions of the meal in question. As stated in Hypothesis 1, I expect this effect to be negative, as WTP should decrease more the higher the greenhouse gas emissions of the meal. "Offset*E(GHG)" refers to the interaction of emissions being offset with participants' expected (guessed) greenhouse gas emissions. As stated in Hypothesis 2, I expect this effect to be positive, as WTP should increase more the higher the greenhouse gas emissions of the meal. If standard error and effect sizes are comparable between the hypothetical pre-survey and the main study, the effects of treatments (I) and (II) can be detected with a sample of 300 participants.

With 600 participants in the experiment:

	Treatment	Outcome	Standard error pre-survey	Treatment group	Control group	Scaling factor (δ)	MDE	Percent average WTP
I	Label*GHG	WTP(meal)	0.157	400	200	0.45	0.197	12%
II	Offset*E(GHG)	WTP(meal)	0.014	400	200	0.45	0.017	1%

With a sample of 600 participants, effects (I) and (II) are detectable with more precision.

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