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### **What Drives Individual Willingness to Contribute to Greenhouse Gas Reductions?**

*Johannes Diederich and Timo Goeschl*



# What Drives Individual Willingness to Contribute to Greenhouse Gas Reductions?\*

Johannes Diederich<sup>†</sup>      Timo Goeschl<sup>‡</sup>

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## Abstract

Using a dichotomous choice framework we conduct a large incentivised Internet experiment in order to evaluate willingness-to-pay (WTP) of German citizens for carbon emission reductions. Credible contributions to emission reductions are facilitated by “deleting” allowances of the EU Emission Trading Scheme. Theory suggests that decisions in favor of the emission reduction may not simply be of the traditional type of voluntary public good contribution and that motivational drivers such as altruism, warm glow, image effects, or moral considerations may matter. Preliminary data analysis leads to a negative overall average WTP when not constrained to zero. WTP is higher when people feel responsible for climate change or believe future generations benefit from reductions. Effects from the behavioral drivers cannot be established in the between-subject analysis.

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<sup>†</sup>Email: [diederich@eco.uni-heidelberg.de](mailto:diederich@eco.uni-heidelberg.de)

<sup>‡</sup>Both Department of Economics, Heidelberg University, Bergheimer Str. 20, D-69115 Heidelberg, Germany. Email: [tg203@uni-hd.de](mailto:tg203@uni-hd.de)

<sup>§</sup>Please do not quote.

# 1 Introduction

Currently, climate policy is located in the context of, on the one hand, extremely tight fiscal conditions in many countries and, on the other hand, significant projected climatic changes worldwide. In this context, citizens' willingness to voluntarily incur costs for reducing greenhouse gas (GHG) emissions is a key variable of interest. When dealing with preferences or particularly willingness-to-pay (WTP) for a specific public good<sup>1</sup> such as emission reductions, specific determinants of this WTP are always of particular interest.

This paper strives to expand our knowledge on German citizens' willingness-to-pay for CO<sub>2</sub> emission reductions using an incentivized experiment that was administered via Internet to a large sample of German citizens. In particular, we set out to establish the working of certain motivational drivers known from the public goods literature in WTP for emission reductions. Besides, general socio-economic variables are included in the analysis of determinants of the size of voluntary contribution to this global public good.

Besides the empirical and applied dimension of this problem, to the researcher analysis begins with the question how to approach the problem from the theoretical perspective to guide his analysis. At first glance, an economist may argue that voluntary contributions to reductions of greenhouse gas emissions should not be observed. Recognizing them as contributions to a global public good he or she is aware with Andreoni (1988) that in a large economy average contributions by rational agents converge to zero while only the richest contributes some positive amount. For this economist, observing lifestyle changes, offset behavior, and the formation of private community initiatives for carbon neutrality poses the question "Why would people contribute at all?".

However, a closer look reveals that the usual public good setup may not be quite adequate to describe the problem of emission reductions. In a recent paper, Kotchen (2009) models public good provision where the consumption

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<sup>1</sup>Henceforth sometimes called "willingness to contribute" (WTC) to emphasize the public good character of this demand.

of the aggregate private good has a detrimental effect on the preexisting public good. Direct contributions thus *offset* this impact at first and potentially outweigh it. Kotchen shows that in a large economy with identical rational and perfectly informed individuals, voluntary direct contributions will exactly offset the negative externality in equilibrium. Thus, it is net contributions that converge to zero, a result corresponding to Andreoni (1988). Given this finding, the question to the economist would no longer be “Why would people contribute at all?” but rather “Why does not everyone shop around for offsets all the time?”

One potential answer to the second question emerges from the literature on the public understanding of climate change (e.g. Ungar 2000, Lorenzoni and Pidgeon 2006, Lorenzoni et al. 2007, Sterman and Sweeney 2007). Findings suggest that knowledge about the problem is vastly biased and incomplete. The complexity of the problem, the high inertia of the climatic system, and the uncertainty combined with potentially catastrophic outcomes do not ease understanding. Moreover, perceived social or institutional barriers hinder contributions. To rephrase, on the one hand informational deficiencies seem to move the problem towards the standard public good problem by disguising the externality imposed. On the other hand high transaction costs appear to choke off demand of voluntary contributions.

If these dampening effects are the case, then the first question of our economist regains legitimacy. That is, if people’s imperfect information status brings the problem closer to the usual public good setup, then why do we observe voluntary action? Manifold answers to this question have been examined in the literature on donations and pro-social behavior in general. On the forefront, motivational drivers have been established in the public goods literature that push private provision of public goods above the pure Nash equilibrium. Among the first, Cornes and Sandler (1984) and, semi-nally, Andreoni (1990) propose to take into account private utility gains from the act of giving itself. Termed ‘*warm glow*’ this motivation has also been discussed for large economies (Ribar and Wilhelm 2002) and experimentally tested for (Palfrey and Prisbrey 1997, Goeree et al. 2002, Eckel et al. 2005, Crumpler and Grossman 2008). The natural counterpart to ‘warm glow’ was

altruism, from which it was disentangled, because of the public nature of the good (Bergstrom et al. 1986).

Two other major categories of motives are social and moral norms. The first category, to which we will refer to as *image motivation*, is characterized by (1) the visibility of the contribution or pro-social action and (2) by some norm causing external (social) approval or sanctioning (Akerlof 1980, Hollander 1990, Benabou and Tirole 2006, Ariely et al. 2009). The second category also relies on some norm serving as benchmark but sanctioning takes place internally. Therefore, it is referred to as *moral norm* (Brekke et al. 2003).

In this research, we experimentally test for the described forces pulling at people’s willingness to contribute (WTC) to reductions in CO<sub>2</sub> emissions. Our theory-guided experiment is designed to disentangle altruistic, image related, and ‘warm glow’ related motives in both a between-subject and a within-subject manner by four different treatments. Similarly, we explore preferences for a different instrument for contributing to emission reductions, which points to moral motivations, in another treatment. Real and credible contributions during experiments are facilitated by purchasing and deleting either allowances of the EU Emission Trading System (EUAs) or sustainable Certified Emission Reductions (GS-CERs) using the Clean Development Mechanism of the Kyoto Protocol and the “Gold Standard”. By varying the opportunity costs for abating one ton of carbon dioxide we are able to test for differences in WTC between treatments. Data of socio-economic variables of our subjects allows to include these determinants in the statistical analysis. Our approach combines and advances various strands in the literature: We use a random utility model (RUM) for analysis of the dichotomous choice task in the experiment. The preference modeling is enhanced by a combined modeling the motives as it has been done in the public goods literature for single motives. For realism, we explicitly model the offset character of contributions drawing from Kotchen (2009). Models are fit using maximum likelihood estimation.

Analysis being yet incomplete, we find significant positive influence on WTP for CO<sub>2</sub> reductions when subjects believe that future generations will benefit from these actions and when they believe to have personally con-

tributed to climate change. Likewise, WTP increases with education but decreases with the number of children living in the household (not controlling for income). Nevertheless, WTP for a subject that is average in all observed variables is zero. Treatment differences to capture the described motives do not lead to significant changes in WTP in between-subject comparisons, while the testing for within-subjects effects is pending. As expected, a higher price (opportunity cost) for the emission reduction significantly lowers the probability of choosing this option.

The remainder of this article is structured as follows: Section 2 introduces a theoretical framework. Section 3 describes setup and procedures of the experiment. Section 4 introduces design and analysis of the treatments as they come out of the random utility framework. Section 5 presents the statistical analysis and results.

## 2 A model

This section sets out to approach the problem from a theoretical perspective. Although we will begin statistical analysis using the standard approach of assuming utility to be linear in covariates, this section illustrates how think about incorporating the relevant behavioral motives in the modeling. To statistically analyze the subjects' dichotomous choices we will then naturally employ a random utility model in section 4 (McFadden 1974, Hanemann 1984).

Consider a global society with  $N$  agents. Let  $G$  denote the public good connected with climate protection and  $x$  denote an aggregate consumption good which serves as the numéraire. Each agent  $i = 1, \dots, N$  maximizes an impurely altruistic utility function where utility is derived from the level of the public good,  $G$ , well as from the size of the private contribution,  $g_i$ , (Cornes and Sandler 1984, Andreoni 1990)

$$U_i(x_i, G, g_i, I(\mathbf{y}_i, \mathbf{p}; \mathbf{v}_i, \boldsymbol{\gamma}_i)). \quad (1)$$

If the agent's preferences depended only on  $x_i$  and  $G$ , the individual would

be called purely altruistic regarding the public good (Bergstrom et al. 1986). In this case, he would only care about the level provided in society but not how or by whom the good is provided. Thus,  $G$  is the argument representing *altruistic motivation*. Note that the simple formulation at hand does not distinguish whether the agent draws satisfaction over  $G$  due to his wish to consume the public good himself or due to his care about the consumption possibilities of others. However, due to the public nature of the good this distinction is superfluous. For the rest of this paper, we will call satisfaction from an increase of  $G$ , ceteris paribus, *altruism*<sup>2</sup>.

Likewise, the third argument in  $U_i$  represents satisfaction from the contribution by oneself. This has often been ascribed to a ‘warm glow’ of giving (Andreoni 1990), a term that is sometimes ambiguously defined in the literature. In this paper and in accordance with the Andreoni’s theoretical framework, ‘warm glow’ will denote utility that is (1) derived from the personal act of contributing and (2) increasing, ceteris paribus, in the size of contribution. Note that in most of our experimental design this may not only capture some affective feeling good from doing good but also some motivations due to more complex moral reasoning which also exclusively regards the own contribution. Since the latter should be regarded another category of motives (Brekke et al. 2003), further distinction is regarded of interest and explored in one treatment of our experiment.

An additional source of utility is image motivation. The image reward,  $I(\cdot)$ , depends on  $i$ ’s vector of contributions,  $\mathbf{y}_i$ , which is  $(M \times 1)$  for  $M$  contribution technologies. The image reward also depends on the prices of contribution,  $\mathbf{p}$ , the visibility of  $i$ ’s contribution via the  $j$ th technology,  $v_{ij} \in [0, 1]$ , and a vector of valuations of the social responses by others,  $\boldsymbol{\gamma}_i$ . Drawing from Benabou and Tirole (2006), a possible formulation for image motivation in

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<sup>2</sup>A more elaborate formulation of altruism would be based on the utilities of others (c.p. Nyborg and Rege 2003)

this impure public good setup is

$$I(\mathbf{y}_i, \mathbf{p}; \mathbf{v}_i, \boldsymbol{\gamma}_i) = h \left\{ v_{i1} \left[ \gamma_i^G E_{-i1} (u_{G,i} | y_{i1}, p_1) - \gamma_i^g E_{-i1} (u_{g,i} | y_{i1}, p_1) \right], \right. \\ \left. \dots, v_{iM} \left[ \gamma_i^G E_{-iM} (u_{G,i} | y_{iM}, p_M) - \gamma_i^g E_{-iM} (u_{g,i} | y_{iM}, p_M) \right] \right\}. \quad (2)$$

Here,  $u_G$  and  $u_g$  denote the marginal valuation of agent  $i$  with respect to changes in the amount of public good and her private contribution, respectively. To other agents,  $u_{G,i}$  and  $u_{g,i}$  are random variables of which they form expectations  $\mathbf{E}_{-i}$  based on the observed contributions and prices. We assume that the way these expectations are formed is common knowledge and perfectly anticipated by the agent. Finally,  $\boldsymbol{\gamma}_i = (\gamma_i^G, \gamma_i^g)$  reflects  $i$ 's concern for being perceived as altruistic,  $\gamma_i^G$ , and her concern for being perceived as not interested into the private reward of giving,  $\gamma_i^g$ .

A special feature of our public good model is the offset character of contributions (Kotchen 2009). Assume that private consumption imposes a linear externality,  $-\delta x_i$ , on the public good. It follows that agent  $i$ 's *net contribution* is

$$g_i = \sum_{j=1}^M y_{ij} - \delta x_i \quad (3)$$

where  $y_{ij}$  denotes  $i$ 's *direct contribution* in terms of the public good via technology  $j$ , for example, carbon offsets. The overall level of public good is

$$G = G_{-i} + g_i \quad (4)$$

where  $G_{-i}$  are net contributions by others. Note that  $G_{-i}$  may include some initial level of public good provided in nature. Thus,  $i$ 's direct contributions to the public good may either partly offset, fully offset, or even outbalance the harm done by his or her consumption. In the second case, net contributions are exactly zero. Note that the agent will also positively affect  $G$  by cutting down on private consumption. In order to analyze the effects of the subjects' heterogeneous understanding of climate change, we will assume that the parameter  $\delta$  represents the agent's *perception* of the impact of

consumption rather than the true externality.

Let the agent be endowed with wealth  $w_i$  which she allocates between private consumption,  $x_i$ , and a vector of direct contributions to the public good,  $\mathbf{p}'\mathbf{y}$ . The price of one unit of direct contribution,  $p_j$ , represents some technology  $j$  that converts the numéraire into the public good. Thus, the agent maximizes utility

$$\begin{aligned} \max_{x_i, \mathbf{y}_i} U_i(x_i, G, g_i, I(\cdot)) \\ \text{s.t. } w_i &= x_i + \mathbf{p}'\mathbf{y}_i \\ g_i &= \sum_{j=1}^M y_{ij} - \delta x_i \\ G &= G_{-i} + g_i \\ x_i, \mathbf{y}_i, G &\geq 0. \end{aligned}$$

Denote the solutions to this problem as  $x_i^*(\mathbf{p}, \delta, w_i, G_{-i}; \cdot)$  and  $\mathbf{y}_i^*(\mathbf{p}, \delta, w_i, G_{-i}; \cdot)$ . Substituting in the constraints, indirect utility is

$$V_i(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) = V_i \left( w_i - \sum_{j=1}^M p_j y_{ij}^*, G_{-i} + \sum_{j=1}^M (1 + \delta p_j) y_{ij}^* - \delta w_i, \sum_{j=1}^M (1 + \delta p_j) y_{ij}^* - \delta w_i, I^* \right). \quad (5)$$

This will be our starting point when analyzing subjects' behavior in section 4.

### 3 Experimental Design and Procedures

The basic setup of our experiment is very simple and corresponds to the standard dichotomous choice question employed in the contingent valuation literature. Subjects were asked to choose between a randomized monetary payout between two and 100 Euro and a one ton reduction in CO<sub>2</sub> emissions.

This concise experimental format was administered to a large sample via

the Internet using the infrastructure of our cooperation partner, YouGov<sup>®</sup>. The German section of the pollster maintains a panel of approximately 65,000 members. For the usual surveys conducted by YouGov<sup>®</sup>, members are invited via email and paid in “bonus points” which are convertible into cash as soon as a threshold of 50 Euro is reached. The experiment consisted of five treatments with sample sizes given in Table 3<sup>3</sup>. Numbers include only those participants who took part in the whole experiment and saw the final dismissing screen. Each sample was chosen according to YouGov<sup>®</sup>’s sampling practice aimed at being representative for the German population.

Table 1: Sample sizes for each treatment.

<b>Treatment</b>					<b>Total</b>
Baseline (& EUA)	‘Warm Glow’	Image	WGI	CER	
$n_1 = 2,188$	$n_2 = 546$	$n_3 = 546$	$n_4 = 543$	$n_6 = 545$	$n = 4,368$

One key feature of our experimental design was to employ emission certificates, predominantly EU emission allowances (EUAs), in order to facilitate real and preferably credible reductions in carbon emissions. EUAs are issued by EU member states according to the national allocation plans approved by the European Union under the EU Emission Trading System (EU-ETS). EUAs must be acquired<sup>4</sup> and submitted by those large EU installations included in the regulation to account for their yearly CO<sub>2</sub> emissions. In the current trading period (2008 to 2012), the system covers about half of the EU’s carbon dioxide emissions (European Union 2008). EUAs can be completely withdrawn (“deleted”) from the system by any trading account holder by a transfer to an official account dedicated to this purpose, in Germany account number DE-230-17-1. Deleting an EUA lowers the cap of the system and thus reduces emissions during the relevant trading period<sup>5</sup>.

<sup>3</sup>Since there was also a second stage that enables within subject comparisons not covered in this version of the paper, sample sizes are given for the independent observations of the first stage treatments only.

<sup>4</sup>While an increasing part of EUAs are auctioned, most of them are grandfathered to the installations. Note also that EUAs can, to a certain extent, be replaced by other types of certificates.

<sup>5</sup>This requires the cap of the system to be binding. Current prices of EUAs are around

In one treatment of our experiment, we employed another type of emission certificate: Certified Emission Reductions (CERs) created under the Clean Development Mechanism (CDM) of the Kyoto Protocol. CERs certify emission reductions from the implementation of a project in a developing and emerging country by comparing the effect of the project to the projected business-as-usual path. In particular, we employed Gold Standard (GS)–CERs. This independent standard, which is supported by a considerable number of NGOs such as the World Wide Fund and Greenpeace, certifies projects according to criteria of sustainable and environmentally friendly development as well as benefits for the local community in addition to the certified reductions according to the CDM. In our experiment, GS-CERs serve as an alternative reduction mechanism that is assumed to be equally credible but does not reduce emissions within the EU but in a developing country with the side benefits of sustainable development.

The Internet experiment ran from May 25th to June 2nd, 2010 and consisted of about 10 computer screens, depending on the treatment. Corresponding to the usual procedure, YouGov<sup>®</sup> panel members were invited via email. On the invitation screen (screen #1), the experiment was announced as two lotteries and some questions, both taking approximately ten minutes. Participation would give them the chance to win up to a prize worth up to a three-digit number in Euro. After the invitation screen, subjects were asked to indicate their nationality (or nationalities) and redirected to other surveys if they did not click “German”. Of 5,209 invited members 4,368 fully completed the experiment up to the dismissing screen. Median completion time was 5 minutes while average completion time was 1 hour 26 minutes due to a fraction of participants returning to the experiment after hours or days. Prior to the experiment we ran a set of pre-tests and a pilot experiment with 200 economics students at Heidelberg to test the online implementation and refine the set of texts and questions.

Centerpiece of the experimental design were the information and decision screens (screens #2 and #3) which presented the dichotomous choice

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15 Euro per ton. Note that banking and borrowing is allowed within but not between trading periods.

task. The information screen introduced the two possible prizes and briefly explained why the deletion of an EUA or the contribution to a GS-CDM project poses a reliable reduction of CO<sub>2</sub> emissions (Figures (1) and (2)). In the text we refrained from giving any details on the effects or causes of climate change. Thus, we made sure that subjects decided according to their preferences, beliefs, and knowledge brought “to the lab”, or in this case to the “framed field” (Harrison et al. 2004). The one exception to this was that we explicitly stated that CO<sub>2</sub> reductions have an identical effect on the climate no matter where they take place. Through this information we precluded subjects from expecting purely private benefits of a domestic reduction, e.g. with respect to the local climate or air pollution. Lastly, the text informed subjects that 100 winners would be randomly chosen out of approximately 5000 participants.

In all five treatments, the two prizes introduced on the information screen were money and a one ton reduction in CO<sub>2</sub> emissions. As to the former, we drew the opportunity cost of the reduction from a uniform distribution between two and one hundred Euro. The upper bound is to a certain extent guided by prior research (Goeschl and Perino 2009, Lee and Cameron 2008) and, apart from that, seemed a reasonable number to include many outliers. The lower bound was implemented above zero since there was no equivalent to a show-up fee. Numbers were drawn as even integers only. Subjects were informed that the cash prize would be paid out, as usual, in “bonus points” on their YouGov<sup>®</sup> account. For the reduction option, four treatments offered the deletion of an EUA as described above. One treatment offered a reduction that would take place in a developing country by contributing to a climate project that is especially environmentally friendly and benefits the local population by being a “Gold Standard” CER.

The decision screen of the dichotomous choice task (screen #3) differed in all treatments with respect to the procedural details for winners that were presented to the subjects. Figures (3) – (7) show the screen for all five treatments which will be discussed in more detail below. Beneath the procedural description subjects made their choice by clicking their preferred

prize. The two prizes were presented in randomized order<sup>6</sup>.

Subsequent to subjects' choices, we asked a set of follow-up questions on the following screens<sup>7</sup>. One question was designed to deal with the problem of "field price censoring" as discussed in section 5 and was asked only if subjects chose the cash prize. A control question for subjects' understanding of the warm glow related treatments was asked in these treatments. Several questions asked for the subjects' estimates of EUA as GS-CER prices and their availability to them outside the experiment. Another set of question was targeted at subjects' beliefs about their personal or future generations' benefits from today's emission reductions as well as their perceived personal contribution to climate change. Finally, we asked for several socioeconomic characteristics.

## 4 Treatment Design and Analysis

We employed four treatments to identify effects from altruistic, image related, and 'warm glow' related motives on the willingness to contribute (WTC) to greenhouse gas reductions. In these treatments, GS-CERs were neither mentioned nor employed. One additional treatment measured the effect from offering a GS-CER instead of an EUA.

Before we discuss design and analysis of the five treatments we briefly develop the random utility framework to analyze the dichotomous choice of the subjects. We do so for the model developed in section 2 while the approach for utility that is simply linear in all of its argument follows the same logic (Hanemann 1984, Haab and McConnell 2002). Introducing a stochastic component to (5) which reflects unobserved preferences and assuming utility to be additively separable in deterministic and stochastic preferences gives

$$V_i(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) + \epsilon_i. \quad (6)$$

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<sup>6</sup>Technical constraints precluded randomization of order on the information screen.

<sup>7</sup>Between the first lottery and the sets of follow-up questions, there was a second lottery to allow for within-sample comparisons. This data is not included in this version of the paper but only the independent observations of the first lottery.

In particular, let

$$V_i^Y(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) + \epsilon_i^Y \quad (7)$$

be the utility in state  $Y$  with  $Y = 0$  when the cash prize is chosen and  $Y = 1$  when the emission reduction is chosen. It follows that

$$\Pr(Y = 1) = \Pr(V_i^1(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) + \epsilon_i^1 \geq V_i^0(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) + \epsilon_i^0) \quad (8)$$

is the probability that the subject chooses the emission reduction. Define a single random term  $\epsilon_i \equiv \epsilon_i^0 - \epsilon_i^1$  and denote  $F_\epsilon$  the cumulative distribution function of  $\epsilon_i$ . We can then reformulate (8) as

$$\Pr(Y = 1) = F_\epsilon(V_i^1(\mathbf{p}, \delta, w_i, G_{-i}; \cdot) - V_i^0(\mathbf{p}, \delta, w_i, G_{-i}; \cdot)). \quad (9)$$

For the parametric analysis, we must assume a functional form for the utility function at this point. Let the deterministic part,  $V_i^Y$ , be linear in the arguments specified in section 2. Also, assume marginal utility of income and other parameters of the arguments to be constant between the two states. Then from (5),

$$\begin{aligned} V_i^Y(\cdot) &= \beta_x \left( w_i - \sum_{j=1}^M p_j y_{ij}^{Y*} \right) \\ &+ \beta_G \left( G_{-i} + \sum_{j=1}^M (1 + \delta p_j) y_{ij}^{Y*} - \delta w_i \right) \\ &+ \beta_g \left( \sum_{j=1}^M (1 + \delta p_j) y_{ij}^{Y*} - \delta w_i \right) + \beta_I I^{Y*} \end{aligned} \quad (10)$$

where  $y_{ij}^{Y*}$  denotes equilibrium direct contribution in state  $Y$ . W.l.o.g. let contribution technology 1 be the emission reduction within the experiment and technologies  $2, \dots, M$  be all other technologies available to the subject outside the experiment. Hence,  $y_{i1}^{0*} = 0$  and  $y_{i1}^{1*} = 1$ . Combining (9) and

(10) gives

$$\begin{aligned} \Pr(Y = 1) = F_\epsilon & \left[ \beta_x \sum_{j=2}^M p_j (y_{ij}^{0*} - y_{ij}^{1*}) - \beta_x p_1 \right. \\ & + (\beta_G + \beta_g) \left( \sum_{j=2}^M (1 + \delta p_j) (y_{ij}^{1*} - y_{ij}^{0*}) + (1 + \delta p_1) \right) \\ & \left. + \beta_I (I^{1*} - I^{0*}) \right] \end{aligned} \quad (11)$$

This looks somewhat messy but interpretation is straightforward. Note that deviations from a simple linear specification directly suitable for probit or logit estimation arise either from equilibrium effects,  $|y_{ij}^{1*} - y_{ij}^{0*}|$  for  $j = 2, \dots, M$ , or from the externality,  $\delta$ . Note also that income-related variables<sup>8</sup>  $w_i$  and  $G_{-i}$  drop out of (11). An example illustrates the effects: Assume for a moment  $\delta = 0$ . Let there be a technology 2 which is a perfect substitute to technology 1. Assume that technology 1 offered in the experiment is cheaper. Last, assume that visibility is zero with both technologies,  $(I^{1*} - I^{0*}) = 0$ . Then equilibrium demand for technologies 3,  $\dots$ ,  $M$  will be the same in both states. The second and third term in (11) will hence be zero since perfect substitution of one ton takes place. What remains will be the gain in utility from the cheaper price,  $\beta_x(p_2 - p_1)$ . This illustrates that the complications with respect to  $|y_{ij}^{1*} - y_{ij}^{0*}|$  are equilibrium cross price effects that are often overlooked in this type of analysis (Lusk and Hudson 2004).

To make (11) better operational though, and since we will deal with field price censoring in our experimental design, we will assume that substitutions will not play a major role and are negligible. Then (11) becomes

$$\Pr(Y = 1) = F_\epsilon \left[ (\beta_G + \beta_g) + (\beta_G + \beta_g)\delta p_1 + \beta_I (I^{1*} - I^{0*}) - \beta_x p_1 \right] \quad (12)$$

which may be developed further and estimated using maximum likelihood estimation.

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<sup>8</sup>To be exact,  $w_i$  includes the amount of the cash prize offered which is the endowment of the subject. Since this varies from subject to subject, income effects are assumed to be negligible.

Interpretation of (12) is more obvious. The first term represents an utility increase from a one ton increase in the amount of the public good due to (1) altruistic benefits from the resulting public rise in emission reductions or climate protection and (2) ‘warm glow’ related motivation. The second term reflects additional utility through a reduced externality. That is, an increase of one ton in  $G$  implies opportunity costs of  $p_1$  in terms of the numéraire. Thus, the externality on  $G$  is reduced by  $\delta p_1$ . The second term increases in  $p_1$  since a higher price of the emission reduction means that more harmful consumption has to be given up. The third term is the utility change due to the change in image reward between the two states. The last term weights the loss of  $p_1$  in terms of the numéraire (Euro) with the agent’s valuation of money showing her monetary opportunity costs in terms of utility.

**Baseline treatment.** Our baseline treatment most closely corresponded to the situation that is likely to be found in the real world. In particular, subjects’ choices whether to contribute to emission reductions or not were private information, and abatement was directly affected by their decisions. As shown in Figure (3), instructions informed the subjects that winners would be notified via email and that the deletion of the EUA, if they chose this prize, would be verifiable on a web page at Heidelberg University via a web link embedded in the notification email. Through this mode of prize issuance we minimized the visibility of the contribution and thus, of any private gains of showing off.

Since image effects drop out, (12) becomes

$$\Pr(Y = 1) = F_\epsilon [(\beta_G + \beta_g) + (\beta_G + \beta_g)\delta p_1 - \beta_x p_1] . \quad (13)$$

**Image treatment.** The aim of the image treatment was to boost visibility of the winners’ contributions. We decided not to achieve this by issuing confirming certificates, an option sometimes found in the literature. We believe that receivers of a certificate, both electronic and in hard copy, are quite likely to derive utility from the certificate *per se* even if they do not

show it to others<sup>9</sup>. Thus, this option seems inappropriate to dissect the pure image effect which requires an increase in only the visibility of the pro-social action. Consequently, we opted for (1) publishing winners' names on a section of YouGov<sup>®</sup>'s website dedicated to this purpose and moreover (2) indicating in instructions that the subject will be personally contacted by a staff member via email to arrange deletion of the EUA (and ask for the consent to publish the name) if he or she wins. The latter stands in contrast to the unpersonal aggregate deletion procedure announced in the baseline treatment and should increase visibility of the subject's action if he chooses the pro-social act. In order to account for the more sensible environment of the internet, subjects were informed that their names would be published only with first name, the first letter of the surname, and city and only with the subject's consent.

If image motivation is expressed as in eq. (2), then

$$dI = \sum_{j=1}^M \left\{ v_{ij} \left[ \gamma_i^G \frac{\partial E_{-ij}(u_{G,i}|y_{ij}, p_j)}{\partial y_{ij}} - \gamma_i^g \frac{\partial E_{-ij}(u_{g,i}|y_{ij}, p_j)}{\partial y_{ij}} \right] dy_{ij} \right\} \quad (14)$$

comprises of two effects: the change in others' posterior expectation of  $i$ 's altruism and the change in their posterior expectation of  $i$ 's interest in personal reward from giving. Both effects should be expected to be positive from an increase of giving (Benabou and Tirole 2006). Hence the net effect is unclear ex ante.

Having image effects will have  $(I^{1*} - I^{0*}) \neq 0$  in (12). Thus the difference in the intercept between (12) and (13) will reflect the valuation of the image effect. However, while the marginal utility  $\beta_I$  is assumed to be constant for small changes in  $\mathbf{y}_i$ , along with the other valuation from the baseline treatment, (14) clearly is not<sup>10</sup>. In particular, the size of the image effect (14) is likely to depend on  $\mathbf{p}$ . To make analysis easier, we 'wash out' these

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<sup>9</sup>This utility appears thus to be rather a boost in some 'warm glow' related motivation than image.

<sup>10</sup>An interesting feature of this model is that the second order effects with respect to  $G_i$  should be expected to have opposite signs. This may be used to differentiate image motivation further into its components.

second order effects by concealing the price a winning contributor has faced. Thus, instructions noted that the alternative cash prize of a winner would not be made public and that other participants may face different trade-offs.

In this way the image effect may be estimated by the difference between WTC of the image treatment and WTC of the baseline treatment.

**‘Warm glow’ treatment.** Differentiating ‘warm glow’ from altruism and other motives is not a straightforward task. Several experiments have attempted to do so. Examples can be found in Palfrey and Prisbrey (1997), Goeree et al. (2002), Crumpler and Grossman (2008), and, at an early stage, in Andreoni (1993). Most of the experimental designs induce variations in both the individual opportunity cost of contributions and the marginal value of the public good to separate between altruism and ‘warm glow’. While this technique is possible in lab experiments with artificial public goods the marginal value of climate change abatement is fixed in our case. We thus decided to develop a variant of a design by Crumpler and Grossman (2008).

These authors used a rather direct approach to dissect ‘warm glow’. Subjects selected a charity from a list of ten and were informed that the charity would receive \$10 from the experimenter. Subjects were endowed with \$10 afterwards and asked to indicate how much of their endowment they would like to keep for themselves and how much they want to pass to the charity they had selected. The design then mimicked a complete crowding out. Instructions stated that “The amount contributed by the proctor to your selected charity WILL be reduced by however much you pass to your selected charity. *Your selected charity will receive neither more nor less than \$10.*” (Crumpler and Grossman 2008, p.1014). Having made sure that subjects understood the procedure, the authors find a stable average contribution rate of around 20% among 150 subjects. The strongest limitation of this design probably is that it does not preclude an experimenter demand effect or a desire to give to the experimenter.

In our slightly different procedure, subjects were informed on the decision screen that:

“A certain fixed amount of emission allowances will definitely

be bought and deleted in this lottery. The emission allowance offered to you is part of these. In other words, no matter how you decide: the number of allowances to be deleted will not be altered. However, you have the opportunity to personally contribute to this emission reduction. You do this by foregoing the cash payout and choosing the emission reduction instead.”

Since the identity of the experimenters were much less clear in our field setting than in Crumpler and Grossman (2008) the problems of Crumpler and Grossman (2008) were mitigated somewhat. First, an experimenter demand effect could not be induced by personal interaction. Second, it was less clear whose financial burden would be reduced from contributing.

In terms of our model, the procedure of this treatment means a complete crowd out of the subject’s contribution. Formally, let there be some  $\Delta_j$  included in  $G_{-i}$  which takes on the value  $-1$  if the winner  $i$  chose the EUA and  $0$  if not. (12) becomes

$$\Pr(Y = 1) = F_\epsilon [\beta_g + \beta_g \delta p_1 - \beta_x p_1] . \quad (15)$$

**‘Warm glow’ + image treatment (WGI).** This treatment completes the two factor between subjects design part of our experiment. Thus, we add publicity to the barebone willingness to contribute in the ‘warm glow’ treatment. The experimental instructions exactly combine both treatments. Subjects were informed that, first, their choice of an EUA would have no additional effect on emission reductions and, second, winning contributors’ names would be made public with the winner’s consent. In the instructions, it was made clear that information on whether the winner’s EUA was pre-bought or not would not be disclosed when publishing the name.

(12) becomes

$$\Pr(Y = 1) = F_\epsilon [\beta_g + \beta_I(I^{1*} - I^{0*}) + \beta_g \delta p_1 - \beta_x p_1] . \quad (16)$$

**CER treatment.** The two abatement technologies, EUA and GS-CER explicitly differed along two dimensions: region of abatement and region of

investment. We expected both to give rise to specific moral considerations. While the former suggests a polluter-pays motivation in favor of EU abatement the latter points to the CDM project due to its by-product of developmental assistance. Interestingly, both motivations can be found in anecdotal evidence. For example, Carbon Retirement, a commercial, UK based service for deleting EUAs, advertises with the feature of domestic abatement for moral reasons. On the contrary, the Kyoto Protocol emphasizes the developmental aspect of its CDM mechanism.

W.l.o.g. let the GS-CER be technology 2 while the EUA remains technology 1. Allowing for an technology-specific intercept  $\alpha = \alpha_2 - \alpha_1$  the equivalent to (11) would be

$$\Pr(Y = 1) = F_\epsilon \left[ \alpha + \beta_x \sum_{j=2}^M p_j (y_{ij}^{0*} - y_{ij}^{1*}) + p_2 - \beta_x p_1 + (\beta_G + \beta_g) \left( \sum_{j=2}^M (1 + \delta p_j) (y_{ij}^{1*} - y_{ij}^{0*}) - (1 + \delta p_2) + (1 + \delta p_1) \right) \right] \quad (17)$$

Disregarding cross-price effects gives

$$\Pr(Y = 1) = F_\epsilon [\alpha + (\beta_G + \beta_g) \delta (p_2 - p_1) + \beta_x (p_2 - p_1)] \quad (18)$$

## 5 Results

### 5.1 Summary statistics

Socioeconomic characteristics of our sample are listed in Tables (2) to (5). Deviations from German population data can be identified, especially for the case of the number of children, in YouGov<sup>®</sup>'s sample. Results should therefore not be generalized to be representative. Nevertheless, the sample is large with sufficient variation.

Table 2: Number of males and females in the sample.

<b>Sex</b>	<b>Freq.</b>	<b>Percent</b>
Male	2,306	52.79
Female	2,062	47.21
Total	4,368	100.00

Table 3: Distribution of age and the number of kids below 18 living in the household.

<b>Variable</b>	<b>Mean</b>	<b>25% q.</b>	<b>Median</b>	<b>75% q.</b>	<b>Min</b>	<b>Max</b>	<b>n</b>
age	45.42	33	46	56	18	89	4359
numkids	.44	0	0	1	0	19	4368

Table 4: Highest level of education stated by subjects.

<b>Education</b>	<b>Freq.</b>	<b>Percent</b>	<b>Cum.</b>
Left school without graduating	8	0.19	0.19
Still in schooling	63	1.46	1.64
Graduated at special school for disabled persons	7	0.16	1.80
Elementary secondary school	675	15.61	17.42
Graduated “Polytechnical School” of the GDR	272	6.29	23.71
Highschool (to 10th grade)	1,222	28.27	51.98
Advanced Technical College Entrance Qualif.	367	8.49	60.47
A-levels (Abitur, 12th or 13th grade)	683	15.80	76.27
Advanced Technical College (FH)	412	9.53	85.80
University B.A. or Masters	553	12.79	98.59
Ph.D.	61	1.41	100.00
Total (45 obs. missing)	4,323	100.00	

<b>Household income</b>	<b>Freq.</b>	<b>Percent</b>	<b>Cum.</b>
Income < EUR 500	128	3.51	3.51
EUR 500 $\leq$ income < EUR 1.000	385	10.55	14.06
EUR 1.000 $\leq$ income < EUR 1.500	553	15.16	29.22
EUR 1.500 $\leq$ income < EUR 2.000	536	14.69	43.91
EUR 2.000 $\leq$ income < EUR 2.500	562	15.41	59.32
EUR 2.500 $\leq$ income < EUR 3.000	518	14.20	73.52
EUR 3.000 $\leq$ income < EUR 3.500	332	9.10	82.62
EUR 3.500 $\leq$ income < EUR 4.000	224	6.14	88.76
EUR 4.000 $\leq$ income < EUR 4.500	194	5.32	94.08
EUR 4.500 $\leq$ income < EUR 5.000	22	0.60	94.68
EUR 5.000 $\leq$ income < EUR 10.000	167	4.58	99.26
Income $\geq$ EUR 10.000	27	0.74	100.00
Total (720 obs. missing)	3,648	100.00	

Table 5: Net income in the subject's household.

## 5.2 Willingness-to-pay (willingness to contribute)

In estimating willingness to contribute (henceforth also called (voluntary) willingness-to-pay (WTP)) from a binary dependent variable parametric maximum likelihood estimation is a standard approach in valuation literature. Most commonly, utility is assumed to be linear in all covariates and the random error of the utility difference between both choices to be distributed normal or logistic with mean zero. This leads to the standard probit or logit estimation which we will also employ as the starting point in this section<sup>11</sup>.

One challenge to deal with in this field valuation exercise is field price censoring (Harrison et al. 2004). In short, rational choice theory predicts that a subject's answer will be censored if the subject thinks that an equally good field substitute is available for less than his or her opportunity costs. To deal with field price censoring we included a question asking for the reason why they chose the cash prize if they had done so. Subjects could check that they did not want to pass on the cash prize given their options, or that they assume to be able to abate one ton of CO<sub>2</sub> for less money, or provide a free text reason. If the answer(s) to this questions suggested that

<sup>11</sup>More elaborate maximum likelihood estimation of the model developed earlier is left for a future version of this text.

a subject was, in principle, willing to forgo the amount offered but did not do so because he or she assumed that they could abate one ton of CO<sub>2</sub> for less than this contribution decision was recoded to a choice in favor of the reduction. By this technique, 882 lottery choices were recoded of which 23 were due to reasons stated in free text. Using other follow-up questions asking for price estimates for EUAs and CERs as well as their availability to the subjects, we tested whether recoded decisions appear to be consistent with the answers to the other questions. In the pilot experiment, consistency checks well supported recoding. We used the same procedure for the field data but have not run the checks yet.

Another important step in cleaning the data for estimation was to exclude subjects who indicated doubt in the instrument used for achieving emission reductions. This included either doubt in the success of the lottery itself or the reduction from deleting EUAs or buying CERs.

We begin with estimates for the baseline treatment only. Tables 6 and 7 show Probit and Logit coefficient estimates, respectively, from regressing the choice of the prize on a set of covariates. The choice is one if the subject decided in favor of the emission reduction. From the theoretical considerations, the independent variables included, first and foremost, the variable *cashprize* denoting the opportunity cost of the subject's choice. The variables *benefits* and *nextgenben* denote the extent to which the subject believes that she will personally benefit from the positive effects of today's emission reductions and the extent she believes future generations will, respectively. This reflects, to some extent, subject's perceptions on the private benefits of the global public good they have the opportunity to donate to. Both variables are categorical and coded with one for a sure "no" up to 4 for a sure "yes". The variable *contributor* is dichotomous and one if the subject indicated that she feels to have contributed to climate change through her personal lifestyle. This variable is included to proxy for, in a simple dichotomous manner, Kotchen's  $\delta$  parameter. Besides these variables derived from theoretical considerations, we included a vector of socioeconomic characteristics not explicitly stated in section 4.

Some variables are insignificant although one would expect them to have

Table 6: Probit estimation for the comprehensive simple linear specification and WTP computation

<b>Variable</b>	<b>Coefficient</b>	<b>(Std. Err.)</b>	<b>Weighted coef.</b>
cashprize	-0.004**	(0.001)	-1
benefits	-0.069	(0.055)	(0)
nextgenben	0.175**	(0.057)	47,678
contributor	0.261**	(0.051)	71,009
sex	-0.058	(0.083)	(0)
age	0.004	(0.003)	(0)
numkids	-0.152**	(0.052)	-41,342
educ	0.070**	(0.019)	19,159
income	0.019	(0.017)	(0)
Intercept	-1.810**	(0.248)	-492,598
Est. WTP:			-69,304
N	1139		
Log-likelihood	-698.666		
$\chi^2_{(9)}$	106.479		
Significance levels : † : 10% * : 5% ** : 1%			

Table 7: Logit estimation for the comprehensive specification

<b>Variable</b>	<b>Coefficient</b>	<b>(Std. Err.)</b>
cashprize	-0.006**	(0.002)
benefits	-0.111	(0.090)
nextgenben	0.291**	(0.095)
contributor	0.432**	(0.084)
sex	-0.091	(0.137)
age	0.006	(0.005)
numkids	-0.250**	(0.087)
educ	0.117**	(0.032)
income	0.032	(0.027)
Intercept	-2.996**	(0.417)
N	1139	
Log-likelihood	-698.513	
$\chi^2_{(9)}$	106.785	
Significance levels : † : 10% * : 5% ** : 1%		

an effect. The believe to personally benefit from emission reductions does not have significant influence which strengthens the notion of a public good contribution. Nevertheless, if one believes an impact on future generations we find a positive impact. The same is true for perceived personal contribution to climate change. The fact that a greater number of children reduces the probability of choosing the emission reduction is counterintuitive, though. One possible explanation might be that money constraints are larger for this group. This could be further examined using the income variable. Higher education increases contributions as one would expect. The size of household income has no significant effect.

Different willingness-to-pay measures can, in principle, be computed from these numbers. The standard approach is to compute the amount the average subject were willing to pay for choosing the emission reduction to be indifferent to the state without the opportunity cost. For that, we assume a constant marginal utility of money and use the estimate on cashprize to weight the remaining coefficients. Resulting numbers are marginal effects that can be directly interpreted in Euro terms. Coefficients weighted by the money coefficient are presented in the fourth column in Table 6. We can interpret these numbers as Euro changes in WTP if the variable changes by one unit, or category, or from zero to one, depending on the type of variable. To get expected overall WTP, we compute the crossproduct of the weighted marginals and the variable means (see 5.2). For Table 6 as well as for all other estimates, WTP for the average subject turns out to be negative and thus, must be set to zero on average. Note that for these results we have not yet dealt with truncated distributions of WTP which should alter these figures.

Table 9 shows a reduced specification including only the variables significant in the comprehensive specification. WTP derived from this estimates the same way as above does not change much.

Table 10 presents a probit estimate using the full sample and including dummies for the four treatments that differ from the baseline treatment. Estimated differences are insignificant between treatments in the given between-subject design. In fact, this is not too unexpected since it is well es-

Table 8: Summary statistics of covariates.

Variable	Obs	Mean	Std. Dev.	Min	Max
benefits	3864	2.342391	.9907698	1	4
nextgenben	3917	2.867245	.9792233	1	4
contributor	3875	2.740645	.9519087	1	4
sex	4368	.4720696	.4992764	0	1
age	4359	45.42418	14.7595	18	89
numkids	4368	.444826	.8704369	0	19
educ	4323	5.82142	2.069262	0	10
income	3648	5.170504	2.51161	1	12

Table 9: Probit estimation for a reduced model

Variable	Coefficient	(Std. Err.)
cashprize	-0.003*	(0.001)
nextgenben	0.135**	(0.043)
contributor	0.254**	(0.045)
numkids	-0.125**	(0.045)
educ	0.087**	(0.017)
Intercept	-1.727**	(0.177)
	Est.WTP:	-64,52
N		1384
Log-likelihood		-851.949
$\chi^2_{(5)}$		126.285
Significance levels : † : 10% * : 5% ** : 1%		

established that WTP elicitation from individuals has an arbitrary component (Ariely et al. 2003). Nevertheless the insignificant estimates point to the fact that differences in WTP are unlikely to be very large. In line with the so-called “coherent arbitrariness principle” we expect within-subject comparisons, made possible by the second lottery in the experiment, to shed more light on the differences in treatments.

Table 10: Probit estimation for the complete sample

Variable	Coefficient	(Std. Err.)
cashprize	-0.003**	(0.001)
wg1	0.107	(0.077)
image1	0.036	(0.078)
wg11	0.117	(0.077)
cer1	0.064	(0.078)
benefits	-0.001	(0.035)
nextgenben	0.175**	(0.038)
contributor	0.211**	(0.033)
sex	-0.035	(0.053)
age	0.005**	(0.002)
numkids	-0.110**	(0.033)
educ	0.065**	(0.013)
income	0.010	(0.011)
Intercept	-1.904**	(0.164)
	Est. WTP:	-93,06
N	2668	
Log-likelihood	-1662.285	
$\chi^2_{(13)}$	238.883	
Significance levels : † : 10% * : 5% ** : 1%		

## 6 Conclusion

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## Appendix



Figure 1: Information screen for treatments Baseline, ‘Warm Glow’, Image, and WGL.

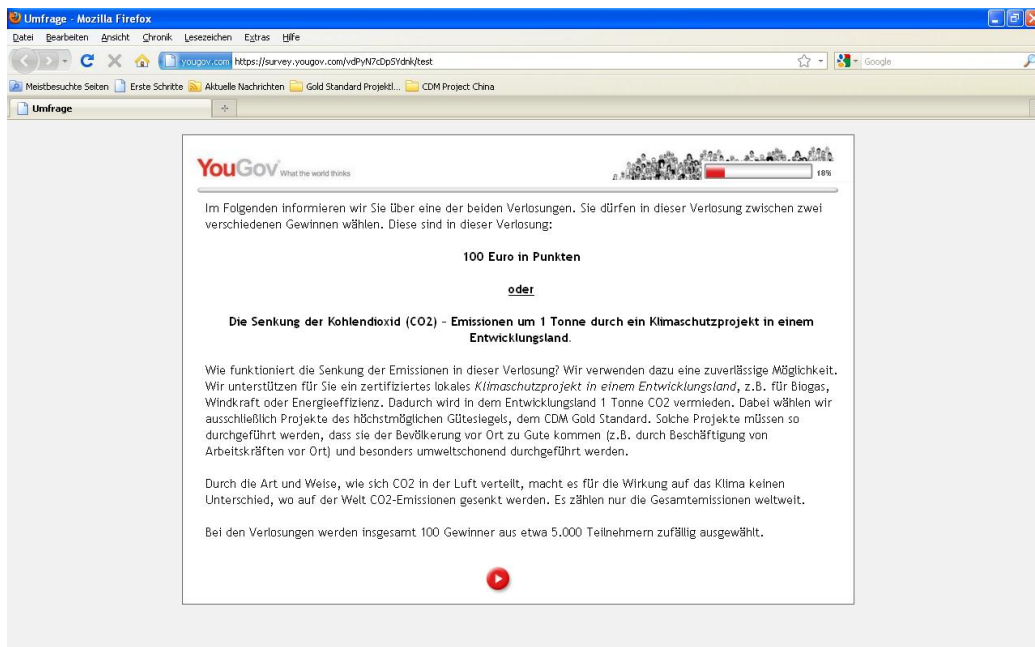


Figure 2: Information screen for CER treatment.

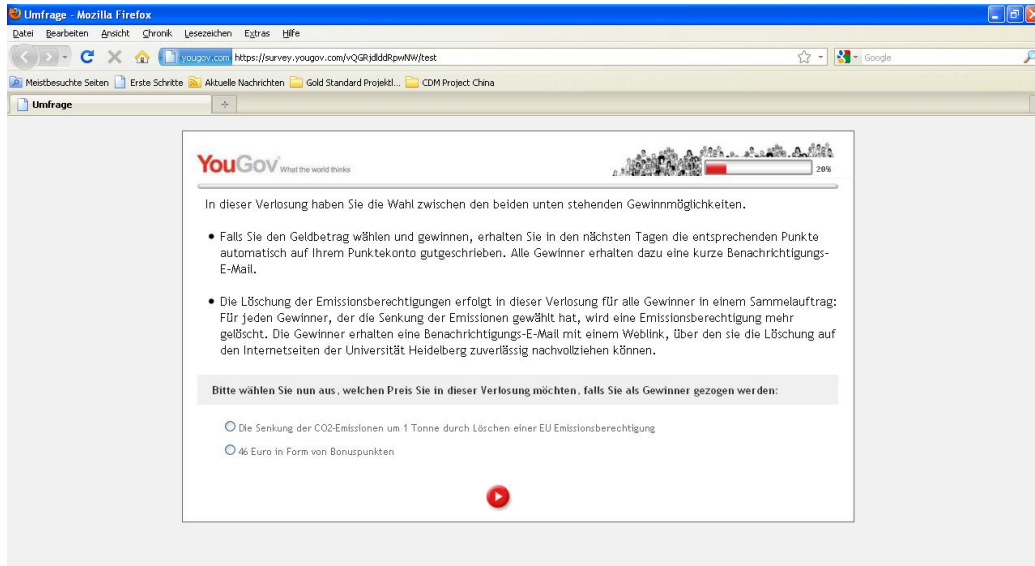


Figure 3: Decision screen for Baseline treatment.

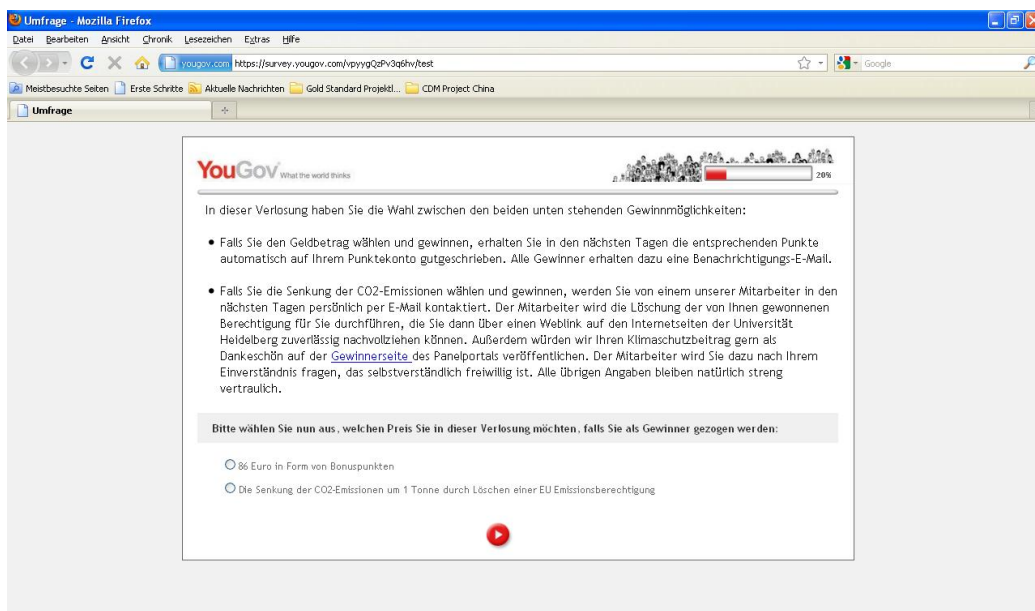


Figure 4: Decision screen for Image treatment.

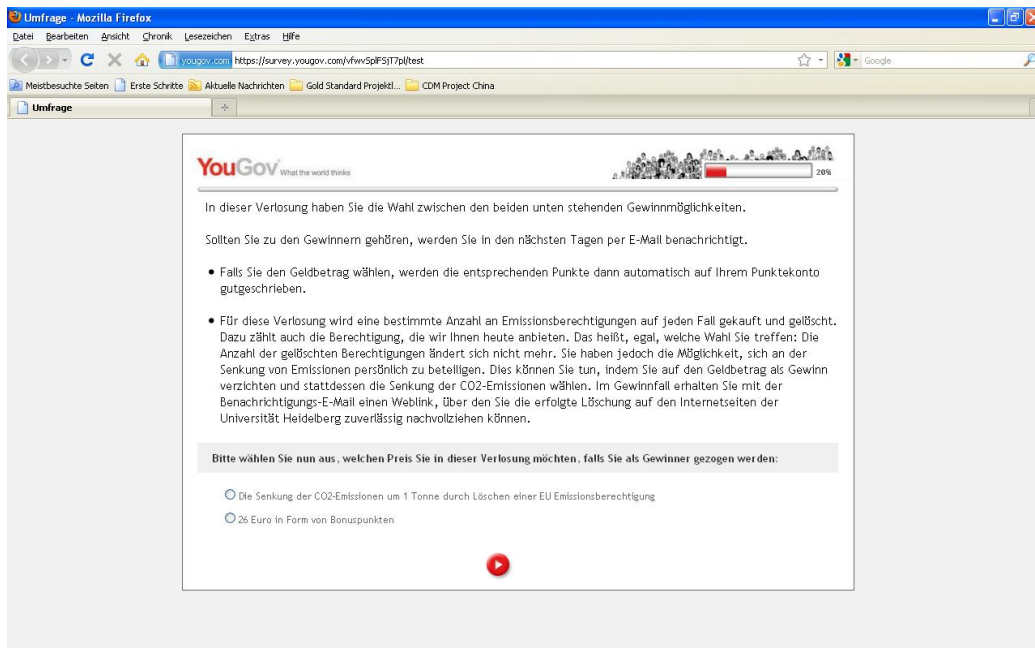


Figure 5: Decision screen for 'Warm glow' treatment.

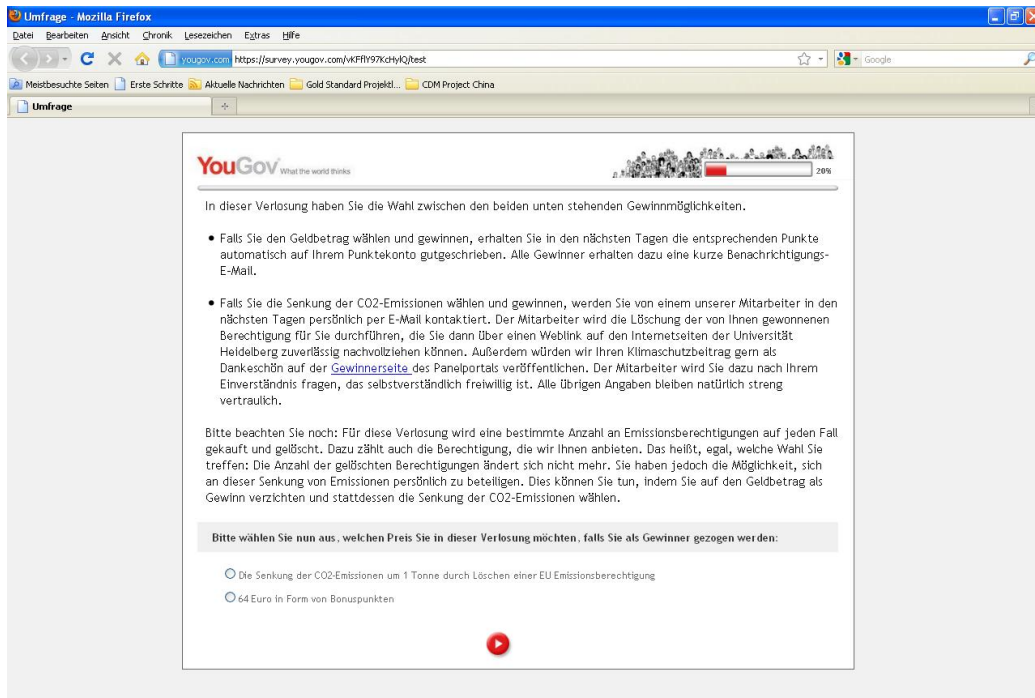


Figure 6: Decision screen for WGI treatment.

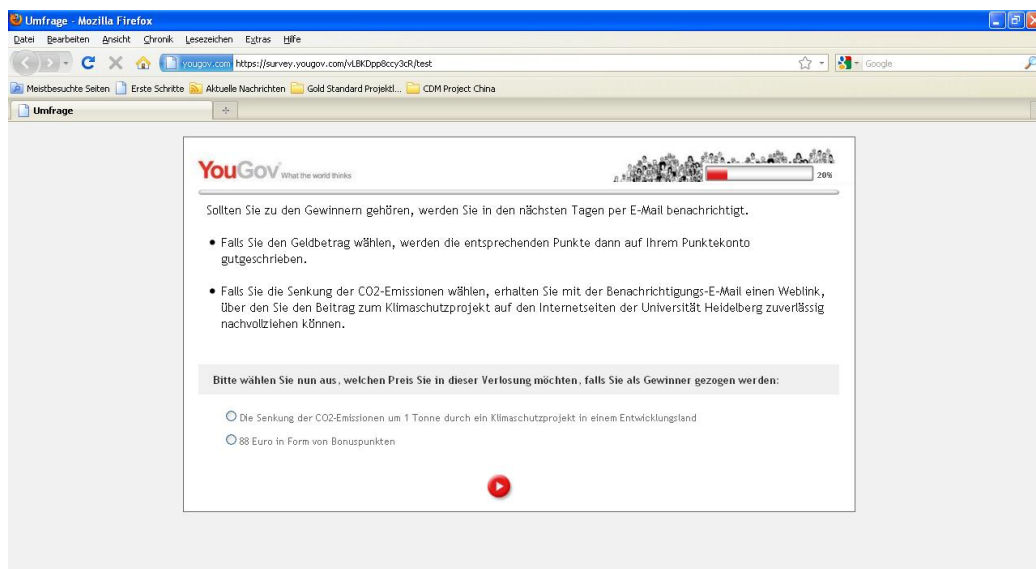


Figure 7: Decision screen for CER treatment.