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The willingness to offset CO_2 emissions from traveling: Findings from discrete choice experiments with different framings

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ABSTRACT

This paper explores the effects of framing a polluting activity in different contexts, i.e. different modes of transportation (bus versus plane) and different travel occasions (holiday versus professional training) on the individual willingness to pay (WTP) for carbon offsetting. For both types of framing, we also study additional contributions from the travel provider (i.e. matching). The empirical analyses with mixed logit and latent class logit models are based on data from discrete choice experiments with a representative sample of about 1000 individuals from Germany. The findings suggest substantial and systematic framing effects resulting from varying the mode of transportation, but not the travel occasion. Furthermore, the individual WTP is significantly higher across all four contexts when offsets are matched by the travel provider at a rate of 100%. In contrast, a lower matching rate of 33% is only relevant for one context, i.e. bus trips to a professional training. In addition, our results indicate that re-/afforestation projects are preferred to renewable energies projects or projects to improve energy efficiency. Likewise, projects carried out in a participant's region are preferred to projects implemented in European countries other than Germany or in developing countries. Finally, the WTP for offsets is found to be significantly higher for individuals with higher income, younger age, and stronger environmental and social preferences, as well as for individuals who believe that offsetting is effective in protecting the climate.

1. Introduction

The consumption of private households causes approximately 60% of global greenhouse gas (GHG) emissions (e.g. Ivanova et al., 2016) and is directly responsible for nearly 30% of total energy use (IEA, 2008). By lowering their energy use or using carbon-free energy sources, households can make a significant contribution to reducing the emissions of GHG and local pollutants. Actively reducing the emissions related to transport services is particularly challenging and may involve high opportunity costs (e.g. forgone overseas vacations, longer time to commute to work). As long as carbon-free substitutes (e.g. for kerosene) are not available, voluntary carbon offsetting (VCO) may be a viable means to compensate the emissions produced by transport services. VCO payments help to fund climate protection projects (e.g. developing renewable energies, improving energy efficiency, or re-/afforestation) and thereby mitigate the amount of carbon dioxide corresponding to the emissions caused by the original activity. This study empirically explores the factors that increase the willingness to pay (WTP) for offsetting activities to compensate the emissions caused by transport services.

The existing empirical literature[1] in this field identifies various factors, which influence the WTP for VCO. Ziegler et al. (2012) and Lu and Shon (2012) show that previous knowledge about and attitudes towards VCO affect the WTP of potential car buyers and air travelers. Likewise, Schwirplies and Ziegler (2016) find that individuals in Germany are still poorly informed and fairly uncertain about the use and effectiveness of VCO. Jacobsen (2011) shows that information and awareness campaigns can positively raise the demand for VCO, at least

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[1] An excellent overview of this literature can also been found in Blasch and Farsi (2014).

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in the short run, and Huber et al. (2018) identify a combination of social and institutional norms that can be beneficial. MacKerron et al. (2009) explore whether particular characteristics of offsetting projects have an effect on the WTP for VCO. Their findings suggest co-benefits such as "human development", "environmental protection and biodiversity", and "technology and market development" increase the WTP. "Environmental protection and biodiversity" is valued the highest at an additional WTP estimate of 15 British pounds (about 20 euros) per tCO_2e. Moreover, Blasch and Farsi (2014) find that individuals prefer offsetting projects in developing countries that are initiated by non-governmental organizations and certified by the government.

The existing literature also generates a wide range of WTP estimates for VCO. Brouwer et al. (2008) and Akter et al. (2009), for instance, interviewed flight passengers at Amsterdam Schiphol airport about their willingness to establish a voluntary "Carbon Travel Tax". Three quarters of their participants were generally willing to pay such a tax, and the average WTP estimate was around 25 euros per tCO_2e. Relying on a discrete choice experiment (DCE), MacKerron et al. (2009) analyzed the willingness of young and educated individuals from Great Britain to buy offsets from the voluntary carbon market in order to compensate their emissions from flights. They estimated an average marginal WTP per tCO_2e of 24 British pounds (about 32 euros). Similarly, Blasch and Farsi (2012) analyzed VCO for a broad set of consumption activities in Switzerland and estimated an average marginal WTP of up to 21 Swiss francs (about 17 euros) per tCO_2e. They found the highest WTP estimates of about 78 Swiss francs (about 64 euros) per tCO_2e for flights with a large impact on the environment. In comparison, the field experiments conducted in Germany by Diederich and Goeschl (2014) as well as Löschel et al. (2013) revealed a mean WTP between about six and 12 euros per tCO_2e, respectively. This range is lower than the values typically found in studies relying on stated preferences.

In this paper, we employ DCE on VCO for travel-related emissions to explore the effects of framing a polluting activity in different contexts, i.e. different modes of transportation (bus versus plane) and different travel occasions (holiday versus professional training). For both types of framing, we also study the effects of additional contributions from the travel provider (i.e. matching) on the individual WTP. The DCE were carried out with an online representative sample of 1000 individuals in Germany. These experiments add to the extant literature in various ways. First, we test for potential effects of framing the context. Previous studies have already revealed that the frame in which individuals are asked to make a contribution to public goods significantly influences their willingness to participate (e.g. Shogren et al., 2010; Cason and Raymond, 2011; Huber et al., 2018). While most of the existing studies on VCO deal with one specific frame and consumption context, Araña and León (2013) provide evidence of framing effects by asking individuals to offset carbon emissions in an opt-in or opt-out frame.

In our experiments, we randomly vary the framing in two dimensions. We assign our participants to an intrinsically and an extrinsically motivated travel occasion, i.e. holiday and professional training. Findings from the psychological literature on environmental behavior suggest that the moral obligation to engage in environmental behavior increases if personal responsibility is assumed for the relevant outcome of this behavior (e.g. Klöckner, 2013). This idea coincides with the assumptions in Brekke et al. (2003) that an individual has a socially responsible self-image, but that the perceived responsibility or duty to act in a pro-social way varies with the external situation (see also Brekke et al., 2010). We test this assumption with our framing since participants might feel a greater sense of personal responsibility for a polluting activity initiated by their own leisure pursuits than by a professional duty that also benefits their employer. In addition, we assign the participants to different modes of transportation, i.e. bus and plane. This framing enables us to directly compare the WTP for bus and plane trips, which have been analyzed in separate settings and experiments so far and thus cannot be directly linked or compared (e.g. Brouwer et al., 2008; Kesternich et al., 2016). We also add to the analyses in Blasch and Farsi (2014), who highlight that the willingness to offset carbon emissions depends on different consumption contexts such as space heating, plane trips, car rental, and hotel stays, and find a significantly higher willingness in high-emission contexts.

Second, we analyze the effect of additional contributions from the provider of the polluting activity (in the literature also referred to as matching grants). So far, the literature has examined different matching and rebate schemes for charitable giving that might also provide relevant insights into the funding of climate protection projects. Eckel and Grossman (2003) find that contributions to a charity are significantly higher with matching than with rebate subsidies. Meier (2007) shows that a matching rate of 50% leads to a significantly higher willingness to donate compared to no subsidies or a matching rate of 25%. Karlan and List (2007) provide further evidence that a 100% match significantly increases contributions, but higher rates (200% and 300%) have no additional impact. To our knowledge, the field experiment by Kesternich et al. (2016) is the only study analyzing the effect of matching schemes (33%, 100%, and 300%) on the willingness to compensate the carbon emissions caused by bus trips. In line with Karlan and List (2007), they show that the 100% matching scheme significantly increases the willingness to offset emissions compared to lower rates, while the higher rate leads to equivalent contributions.

Our DCE complement this literature by matching the participants' carbon offsets with 33% and 100% rates contributed by the travel provider. As discussed, we compare different consumption contexts, i.e. different modes of transportation and travel occasions. In contrast to previous studies, which only allow one specific context, we are thus able to examine possible differences in the effects of matching schemes across these contexts. Therefore, our empirical analysis offers a deeper understanding of previous field and stated preference experiments, particularly with respect to the effect of different matching rates.

The remainder of the paper is organized as follows: Section 2 discusses the survey administration and experimental design. Section 3 explains our econometric approach. Section 4 presents the empirical results. The concluding Section 5 summarizes the main findings and offers guidance for designing policies to foster the demand for VCO.

2. Survey and experimental design

2.1. Survey administration

The data for our empirical analyses stem from an online-representative web-based survey of a total of 1005 individuals in Germany. The survey was carried out in April 2014 by the market research company GfK SE (Gesellschaft für Konsumforschung). The participants were drawn from the GfK Online Panel using quota sampling to form a representative sample in terms of gender, age (between 18 and 90 years), and regional dispersion (at the level of federal states). The questionnaire was structured in several sections and collected information on personal beliefs about climate change and its consequences, individual travel behavior, experiences with VCO including a short explanation of VCO (e.g. with respect to different types of climate protection projects, i.e. compensation schemes), specific attitudes towards VCO and the environment, and socio-economic and socio-demographic characteristics. On average, completing the final survey took about 19 min.

Tables 1 and 2 provide a description and a summary of the characteristics reported by the sample participants. The age of the participants ranges between 18 and 90 with an average of 46.5 years. 50.7%

Table 1
Description of explanatory variables.

Variable	Description
High contribution of offsetting	1 if the participant chose the categories "rather effective" or "very effective" on a five-point scale in response to the question "How effective do you consider carbon offsetting in protecting the climate?", 0 otherwise
At least one donation in past 3 years	1 if participant answered "yes" to the question "Have you made donations in the past three years that you paid for yourself?", 0 otherwise
Identifying with green politics	1 if the participant chose the categories "somewhat agree" or "agree" on a five-point scale indicating his/her agreement with the statement "I identify myself with green politics", 0 otherwise
Identifying with social politics	1 if the participant chose the categories "somewhat agree" or "agree" on a five-point scale indicating his/her agreement with the statement "I identify myself with social politics", 0 otherwise
Religious	1 if the participant answered "rather strongly" or "very strongly" to the question "How religious do you consider yourself?", 0 otherwise
Age	Age of the participant in years
Female	1 if the participant is a woman, 0 otherwise
Number of children	Number of the participant's own children
Highly educated	1 if the participant received a higher secondary school qualification ("Abitur") or higher, 0 otherwise
High individual income	1 if the individual monthly net income of the participant is above the median category "1500 to < 2000 euros", 0 otherwise
North, East, West, South	1 if the participant lives in a Northern, Eastern, Western, or Southern federal state of Germany, 0 otherwise

of the participants are qualified to pursue a degree in higher education (i.e. have the school leaving certificate "Abitur" in Germany), 27.3% indicated an individual income of > 2000 euros per month,[2] and the participants have 1.1 own children on average.[3,4]

2.2. Experimental design

The main component of the survey was the experimental part, for which we designed four DCE. The experiments started with a brief introduction of the (hypothetical) choice situation. The participants were asked to imagine they were booking a short trip of two to five days. They must bear the costs for this trip themselves. They received information about the amount of carbon emissions produced due to this trip, and were asked to decide whether they want to offset these emissions. The framing of the four experiments varied with the mode of transportation (long-distance bus versus plane) and the reason for the trip (holiday versus professional training). Table 3 provides an overview of the resulting four contexts. The amount of carbon emissions produced by a trip is calculated based on the emission intensity of the relevant mode of transportation and the assumed distance.[5] Each participant was randomly assigned to two of the four contexts without any restrictions. A participant might be assigned to the holiday trip by bus and the trip to a professional training by bus, the holiday trip by bus and by plane, the professional training by bus and by plane, or the trip to a professional training by plane and the holiday trip by bus. The two experiments were always presented in random order.

The frames of the choice situation were introduced as follows:

(i) Holiday trip by bus: You travel by bus to reach a large city about 250 km away from your hometown. The bus ticket costs 20 euros. The reason for the journey is a vacation. Outward and return trips cause about 20 kg of carbon emissions. (N = 503 participants)
(ii) Trip to professional training by bus: You travel by bus to reach a large city about 250 km away from your hometown. The bus ticket costs 20 euros. The reason for the journey is a professional training. Outward and return trips cause about 20 kg of carbon emissions. (N = 501 participants)
(iii) Holiday trip by plane: You travel by plane to reach a large city about 1000 km away from your hometown. The plane ticket costs 250 euros. The reason for the journey is a vacation. Outward and return trips cause about 700 kg of carbon emissions. (N = 503 participants)
(iv) Trip to professional training by plane: You travel by plane to reach a large city about 1000 km away from your hometown. The plane ticket costs 250 euros. The reason for the journey is a professional training. Outward and return trips cause about 700 kg of carbon emissions. (N = 503 participants)

Each experiment consisted of six choice sets with three offsetting alternatives and one opt-out option (see Fig. 1), resulting in > 3000 observations from approximately 500 participants per experiment. The three offsetting alternatives were described by four attributes: (1) price in euros per tCO_2e, (2) place of compensation, (3) compensation scheme (i.e. type of climate protection project), and (4) contribution from the provider. Table 4 summarizes these attributes and the corresponding attribute levels. Instead of the underlying price per tCO_2e (which varies between €10 and €50 in our DCE), the participants were confronted with the actual price of the compensation.[6] "Contribution from the provider" resulted (except for attribute level "none") in an additional amount of carbon offsets financed by the travel provider. In line with former studies (e.g. Karlan and List, 2007; Kesternich et al., 2016), we considered matching rates which increased the amount of carbon offsets by 33% or by 100%.

Typically, the validity of DCE may suffer from the hypothetical nature of the decisions made by participants. We tried to address this potential hypothetical bias in two ways. First, we used cheap talk scripts, which have been proven to reduce or even eliminate this hypothetical bias (e.g. Cummings and Taylor, 1999; List, 2001; Aadland and Caplan, 2006). In this respect, we explicitly highlighted the importance of participants making a decision as they would in a real booking situation and taking account of their personal financial situation. Second, we included the opt-out option to make the choice situation more realistic. Whenever participants decided to choose this opt-out option, we received no information about the relative attractiveness of the three offsetting alternatives offered. However, it is plausible to assume that some participants are generally not willing to pay for carbon offsetting in reality (in line with the approach in Adamowicz et al., 2011) and not including an opt-out option would most likely lead to strongly biased results.

The experimental design was developed using the Sawtooth Software and employed the complete enumeration method. This design strategy assured minimal overlap of choice sets and achieved an

[2] The sample median is in the interval of 1500 to < 2000 euros and 22% of the participants responded "don't know/no answer" to the income question.
[3] In our sample, single-person households are underrepresented and individuals with a higher educational level are overrepresented compared to the general population in Germany (e.g. https://www.destatis.de/DE/Startseite.html).
[4] All values refer to the inclusion of the category "don't know/no answer", respectively.
[5] The amount of carbon emissions associated with the respective trips was estimated from information provided by offsetting providers (e.g., "Klima ohne Grenzen") for comparable trips within Germany (bus) or within Europe (plane).
[6] This leads to compensation prices ranging from €0.2 (for a price of €10 per tCO_2e) to €1 (for a price of €50 per tCO_2e) for bus trips, and from €7 (for a price of €10 per tCO_2e) to €35 (for a price of €50 per tCO_2e) for plane trips.

Table 2
Frequencies (in %) for the attitudes and socio-demographic profile of the participants.

Characteristic and description	Whole sample (N = 1005)	Restricted sample excluding "always-offsetters"[a] (N = 519)
High contribution of offsetting		
Rather effective, very effective	47.9	37.2
Very ineffective, rather ineffective, neither nor	44.8	51.3
Don't know/no answer	7.4	11.5
At least one donation in past 3 years		
Yes	51.2	44.1
No	45.3	52.2
Don't know/no answer	3.5	3.7
Identifying with green politics		
Somewhat agree, agree	35.8	27.4
Disagree, somewhat disagree, neither nor	60.5	68.8
Don't know/no answer	3.7	3.8
Identifying with social politics		
Somewhat agree, agree	77.1	72.1
Disagree, somewhat disagree, neither nor	20.3	25.6
Don't know/no answer	2.6	2.3
Religious		
Very strongly, rather strongly	13.6	11.0
Very weakly, rather weakly, neither nor	81.4	83.4
Don't know/no answer	5.0	5.6
Age		
18–20	9.4	7.9
21–30	12.8	12.1
31–40	16.2	16.0
41–50	18.6	18.1
51–60	14.4	13.9
61–99	28.6	32.0
Female		
Women	51.5	53.4
Men	48.5	46.6
Number of children		
0	42.1	40.9
1	18.0	17.9
2	28.2	29.1
3 or more	11.7	12.1
Highly educated		
Yes	50.7	47.2
No	49.2	52.8
Don't know/no answer	0.1	0
Individual monthly net income		
< 500 euro	11.6	11.9
500 to < 1000 euros	14.2	15.6
1000 to < 1500 euros	11.8	11.4
1500 to < 2000 euros	13.0	13.3
2000 to < 3000 euros	16.8	14.1
3000 to < 4500 euros	7.1	7.3
4500 euros or more	3.4	3.1
Don't know/no answer	22.0	23.3
Regions		
North	18.0	17.9
South	27.6	29.0
West	19.7	17.5
East	34.7	35.6

[a] "Always-offsetters" are participants who never chose the opt-out option throughout the 12 choices they made in two experiments.

efficiency of approximately 98%.

3. Econometric approach

The basis for our econometric analysis is the individual choice (for each of the four DCE, respectively) among the four mutually exclusive alternatives (i.e. the three offsetting alternatives and the opt-out option) in each choice set as discussed above. The hypothetical utility of participant i (i = 1, …,N) from VCO alternative j (j = 1, …,4) in choice set m (m = 1, …,6) is:

$$U_{ijm} = \beta_i' x_{ijm} + \varepsilon_{ijm}$$

The latent variables U_{ijm} thus depend on the vectors $x_{ijm} = (x_{ijm1}, \ldots, x_{ijm8})'$ for the variables of the four attributes and an alternative-specific constant (ASC) for the opt-out option. The ASC reflects the change in utility if emissions are not compensated and captures all effects that cannot be explained by the attributes. $\beta_i = (\beta_{i1}, \ldots, \beta_{i8})'$ is the unknown parameter vector and the error terms ε_{ijm} summarize all unobserved factors. According to the random utility maximization theory (e.g. McFadden, 1974), participant i chooses category j in choice set m if the utility of alternative j is the largest of all utilities. With $\beta_i = \beta$ ($\forall i$), the choice probability is (e.g. Rolfe et al., 2000):

$$P_{ijm} = P(U_{ijm} > U_{ij'm}; \forall\, j' \neq j) = P(\beta_i' x_{ijm} + \varepsilon_{ijm} > \beta_i' x_{ij'm} + \varepsilon_{ij'm}; \forall\, j' \neq j)$$

The assumption of independently and standard (type 1) extreme value distributed error terms ε_{ijm} (e.g. Louviere et al., 2000) leads to the common multinomial or (with only alternative-specific attributes) to the conditional logit model, which both rely on the so-called independence of irrelevant alternatives (IIA) property.

The inclusion of an opt-out choice option, however, renders the IIA property implausible. We therefore apply more flexible mixed logit models (MLM, also referred to as random parameter logit models). MLM allow for taste heterogeneity across participants and are thus able to incorporate correlations between the choice alternatives by attaching a random component to the parameters β_{ik} (i = 1, …,N) for the k = 1, …,8 variables of the attributes (including the ASC for the opt-out option) assuming that some β_{ik} are normally distributed (e.g. Revelt and Train, 1998; Hensher and Greene, 2003). Following Hole (2007), the probability of the observed sequence of choices across all six choice sets for participant i is then:

$$P_i(\theta) = \int \prod_{m=1}^{6} \frac{e^{\beta' x_{ij_{im}m}}}{\sum_{r=1}^{4} e^{\beta' x_{irc}}} \varphi(\beta) d\beta$$

Here, j_{im} is the alternative chosen by participant i in choice set m, $\varphi(\beta)$ is the joint density function of some independently normally distributed parameters in $\beta_i = (\beta_{i1}, \ldots, \beta_{i8})'$ with expectation b and variance covariance matrix W, and θ is the vector of all expected values in b and variances or standard deviations in W. The vector x_{ijimm} includes the price attribute as a quantitative variable, two dummy variables of the other three attributes with three categories, respectively, as well as the ASC.[7] Overall, seven random parameters $\beta_2, \ldots, \beta_8$ are considered for the ASC of the opt-out option and the variables of the three discrete attributes, whereas the price parameter β_1 is fixed. This is common practice as we use the estimated parameters of the price attribute for the WTP estimation (e.g. Valck et al., 2014). The probabilities $P_i(\theta)$, which are characterized by multiple integrals, are approximated by simulation methods using 1000 Halton draws. The parameters are therefore estimated by the simulated maximum likelihood method. In sum, this leads to the estimation of seven means and seven standard deviations of the random parameters and the estimation of the fixed price parameter. On the basis of these estimated parameters, the average WTP for all variables with random parameters can be estimated (k = 2, …,8):

[7] As a robustness check, we also estimated nested logit models with the three offsetting options in one nest and the opt-out option in another. This model approach does not yield qualitatively different results to those from the MLM. To save space, we do not discuss the results of the estimated nested logit model, but will make them available upon request.

Table 3
Overview of DCE.

Travel occasion	Holiday	Professional training
Means of transportation (travel distance, carbon emissions)		
Bus (250 km, 20 kg)	(i) Holiday trip by bus	(ii) Trip to professional training by bus
Plane (1000 km, 700 kg)	(iii) Holiday trip by plane	(iv) Trip to professional training by plane

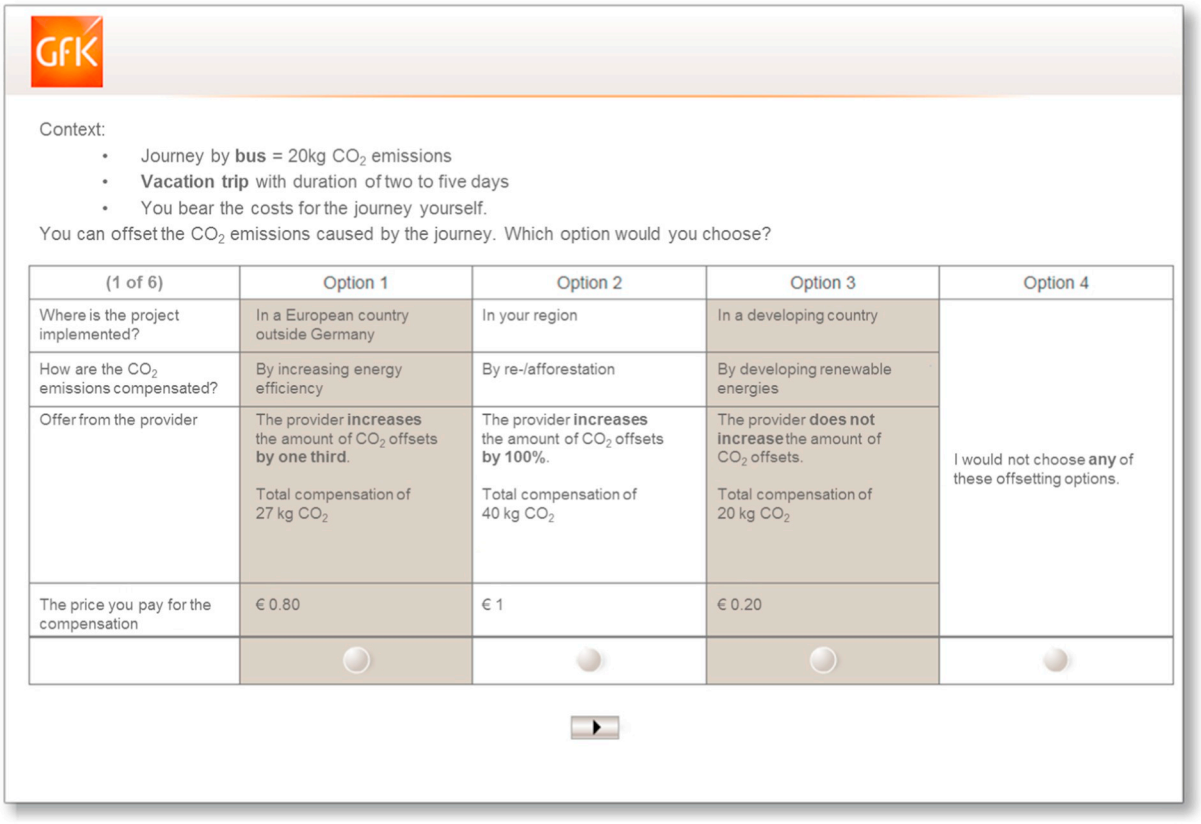

Fig. 1. Translated screenshot of one original DCE.

Table 4
Attributes and attribute levels in the DCE.

Attributes	Attribute levels
Price (in euros) per tCO_2e	10, 20, 30, 40, 50
Place of compensation	In your region, in a European country outside Germany, in a developing country
Compensation scheme	Re-/afforestation, developing renewable energies, improve energy efficiency
Contribution from the provider	None, 33%, 100%

$$\widehat{WTP} = -\frac{\widehat{E}(\widehat{\beta}_k)}{\widehat{\beta}_1}.$$

For the ASC, the WTP can be interpreted as the marginal value of not compensating emissions. For each attribute level, the WTP is the marginal value of moving away from the base alternative of the variables of the three discrete attributes (i.e. in a developing country for the place of compensation, re-/afforestation for the compensation scheme, no contribution from the provider).

In addition to the previous specification, we also consider MLM that include interaction terms of the ASC for the opt-out option and the respondents' characteristics. This allows investigating the factors related with the choice of the opt-out option. The corresponding parameters are assumed to be fixed.

As a second estimation approach, we consider latent class logit models (LCLM), which, in contrast to MLM, rely on discrete parameter variations (e.g. Greene and Hensher, 2003). LCLM assume that individuals are implicitly sorted into a set of Q classes and are therefore particularly attractive for our case. Some individuals are not willing to compensate CO_2 emissions in general and thus exhibit a higher probability of choosing the opt-out option regardless of the attribute levels. These individuals might, for example, doubt that anthropogenic climate change exists, not believe they are responsible for climate change, or that climate change cannot be effectively mitigated by climate protection activities. In this case, heterogeneity across individuals is better reflected as discrete and should lead to preference classes with heterogeneity in the parameter for the opt-out option. Accordingly, we estimate the LCLM with two classes:

Class 1: Participants with a higher probability of choosing the opt-out option i.e. $\beta^{ASC} \geq 0$ (non-offsetters).

Class 2: Participants with a lower probability of choosing the opt-out option, i.e. $\beta^{ASC} < 0$ (offsetters).

Individuals in class 1 might also exhibit higher sensitivity to the price attribute because the price in the opt-out option is always zero. One might be concerned about the amount of attention paid to the price by participants (i.e. that the price attribute is disregarded), especially in the bus experiments due to the modest absolute compensation costs here ranging between 0.20 and 1 euro. Although this might be true, there is, however, no reason to believe that these participants will pay

more attention to the low price when faced with real offsetting decisions in the field.

In the LCLM, $\beta_q = (\beta_{q1}, \ldots, \beta_{q8})'$ is the class-specific vector of parameters in class q. The probability of the observed sequence of choices across all six choice sets for participant i is:

$$P_i = \sum_{q=1}^{Q} H_{iq} P_{iq}(\beta_q)$$

The joint conditional probability of the observed sequence of choices across all six choice sets is given by:

$$P_{iq}(\beta_q) = \prod_{m=1}^{6} \frac{e^{\beta_q' x_{ijm}}}{\sum_{k=1}^{4} e^{\beta_q' x_{ikm}}}$$

Assuming that the membership in a class q depends on a vector $z_i = (z_{i1}, \ldots, z_{il})'$ of l individual characteristics with the unknown parameter vector $\gamma_q = (\gamma_{q1}, \ldots, \gamma_{ql})'$, the probability that participant i belongs to class q is:

$$H_{iq} = \frac{e^{\gamma_q' z_i}}{\sum_{q'=1}^{Q} e^{\gamma_{q'}' z_i}}$$

In line with Train (2008), we use the Expectation-Maximization (EM) algorithm in the maximum likelihood method to estimate the parameters to guarantee numerical stability and convergence of the log-likelihood function to a local maximum. Based on the results for each class, we estimate the average WTP for the ASC and the variables of the three discrete attributes if the price parameter is significantly different to zero.

4. Results

Tables 5 to 11 report the estimation results in the MLM and the LCLM with two classes. As discussed, class 1 in the LCLM refers to participants with a higher probability of choosing the opt-out option regardless of the attribute levels. In most cases, these exhibit a higher estimated sensitivity to the price attribute (as the price for the opt-out option is zero). Class 2 comprises participants with a significantly higher probability of choosing one of the offsetting options, i.e. it comprises the offsetters. Since the latter are of greater interest to policy makers and offsetting providers, our discussion of preferences and estimated WTP focuses on the results for these offsetters. For all estimations, we also contrast the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) of the MLM and the LCLM. According to these measures of fit, the MLM is superior in all cases. Yet, the estimation results in the MLM and class 2 of the LCLM are very similar.[8] Therefore, our discussion of results focuses on the MLM and only refers to the LCLM if it provides additional insights.

4.1. Framing effects

We first discuss the effects of framing by comparing the frequencies of choosing the opt-out option in the four DCE (see Fig. 2). In experiments (i) and (ii) (i.e. bus trips), the opt-out option was chosen in 26.4% and 26.0% of the cases.[9] These shares are significantly ($p < 0.01$) higher for experiments (iii) and (iv) (i.e. trips by plane) with 35.7% and 38.1% of the choices, respectively.[10] Thus, framing appears to be relevant. Moreover, there is a slightly significant difference for plane trips but not for bus trips when choosing the opt-out option between holiday trips and trips to a professional training ($p < 0.1$). We can only speculate that the price differences for bus trips were not large enough to result in differences between travel occasions. Furthermore, trips with long-distance buses were still relatively rare at the time of our study in Germany, especially for business trips. Participants responded more strongly to the plane trip framing than the bus trip framing, possibly, because this was the more realistic scenario for long-distance trips.

Table 5 reveals that for plane trips the WTP estimates for the opt-out option in the MLM are much lower than those for bus trips, even though plane trips are more emission-intensive. In particular, the estimated WTP is about 250 euros per tCO_2e for holiday trips by bus and about 335 euros for trips to professional trainings by bus.[11] The estimated WTP are significantly lower when trips are conducted by plane, i.e. about 40 euros for holiday trips or trips to professional trainings.

This finding is contrary to results in earlier studies,[12] but in line with the so called “low-cost hypothesis” from the social science literature. Many empirical studies exploring the impact of pro-environmental preferences on the adoption of energy-efficient technologies rely on (stated) environmental attitudes. These attitudes have been found to be positively correlated with the adoption of inexpensive measures like light bulbs (e.g. Di Maria et al., 2010; Mills and Schleich, 2014), but appear less relevant for predicting more expensive investments like thermal retrofits (e.g. Whitmarsh, 2009; Ramos et al., 2016). This finding suggests a trade-off between financial and environmental concerns. In a similar way, the “low-cost hypothesis” implies that individuals prefer to placate their environmental conscience with low-cost measures, which may in reality have little impact on environmental quality (e.g. Diekmann and Preisendörfer, 1998, 2003; Whitmarsh, 2009).

The parameter estimates for the attributes also reveal some (rather unsystematic) differences with regard to the reason for travel. For example, in the bus experiments, participants exhibit a significantly lower willingness to offset emissions from holiday trips (but not from trips for professional trainings) if the offsetting option involves the development of renewable energies (compared to re-/afforestation). A contribution by the provider of one third of the offsetting amount significantly increases the willingness to offset emissions from bus trips to a professional training (but not from holiday trips). For the plane trips, the willingness to offset emissions from trips to a professional training (but not from holiday trips) is significantly lower if the offsetting project is carried out in a European country outside Germany or involves the development of renewable energies.

4.2. Effects of provider contributions

Our second main interest refers to how contributions from the travel provider influence the WTP for VCO. In the MLM, contributions at a rate of 100% significantly enhance the willingness to offset emissions in all four experiments, i.e. for all modes of transportation and travel occasions. The findings in the LCLM (see Tables 6 and 7) suggest that

[8] Please note that we decided not to estimate the LCLM with the statistically optimal number of classes, but chose an approach with two classes driven by our hypotheses as discussed in Section 3. The statistically optimal number of classes for the two bus experiments is six (holiday trips: BIC = 5553 and AIC = 5606, trips to professional training: BIC = 5442 and AIC = 5495). For holiday trips by plane, five classes would be statistically optimal (BIC = 5390, AIC = 5434), and seven classes for trips to professional training by plane (BIC: 4694, AIC: 4756).

[9] The difference between the means is not statistically significant ($p = 0.77$).

[10] These differences are also reflected by the shares of participants in class 2 (offsetters) across the experiments, which further suggest that framing effects do matter (see Table 6).

[11] A significantly negative (positive) parameter estimate of the ASC reflects a utility loss (gain) from choosing the opt-out option, which cannot be explained by the included attributes. These results are largely unchanged by excluding participants who never undertook the respective type of travels (private or business travels).

[12] Blasch and Farsi (2014), for example, find higher WTP estimates for emission-intensive contexts.

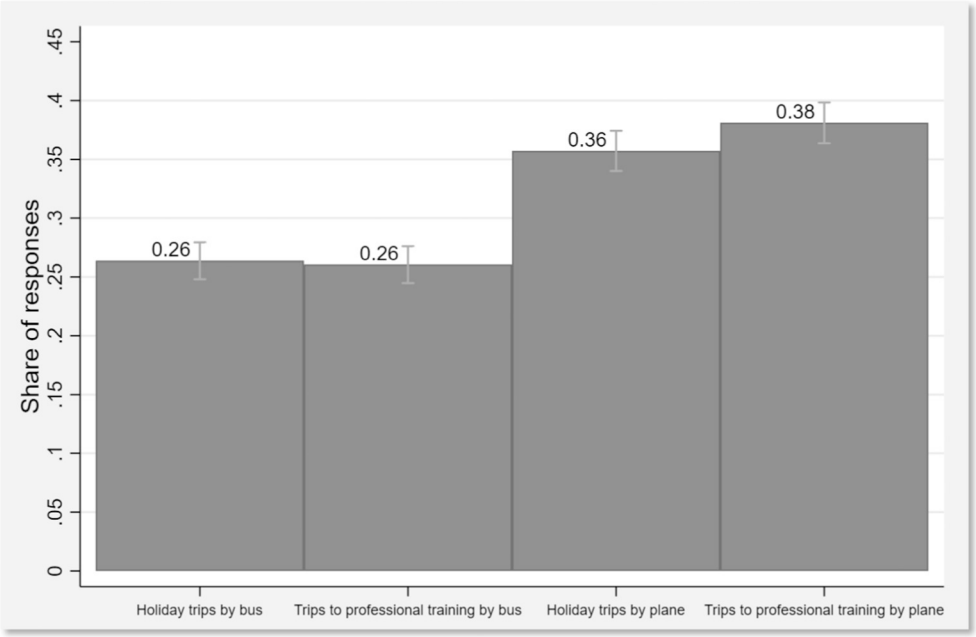

Fig. 2. Shares (95% confidence intervals) of choices for the opt-out option.

Table 5
Simulated ML (with 1000 Halton draws) and WTP estimates (in euros per tCO_2e) in the MLM.

Variables	Holiday trips by bus			Trips to professional training by bus			Holiday trips by plane			Trips to professional training by plane		
	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP
Price (in euros) per tCO_2e	−0.02*** (−7.13)			−0.02*** (−7.81)			−0.06*** (−18.89)			−0.05*** (−16.20)		
ASC for opt-out option	−4.22*** (−4.43)	9.69*** (9.00)	−250.30*** (65.40)	−6.27*** (−6.99)	12.98*** (7.92)	−334.83*** (61.23)	−2.26*** (−5.73)	6.84*** (11.81)	−40.38*** (6.97)	−1.85*** (−5.09)	6.84*** (11.80)	−39.34*** (7.65)
Place of compensation (base: in developing country)												
In your region	0.90*** (8.49)	1.53*** (12.24)	53.58*** (9.38)	0.98*** (8.57)	1.70*** (13.45)	52.17*** (8.65)	0.58*** (6.02)	1.20*** (10.88)	10.40*** (1.74)	0.55*** (5.28)	1.40*** (11.37)	11.65*** (2.24)
In European country outside Germany	−0.34*** (−3.90)	0.64*** (4.57)	−20.09*** (5.76)	−0.24*** (−2.65)	−0.81*** (−5.67)	−12.79** (5.08)	0.03 (0.35)	−0.63*** (−4.64)	0.53 (1.50)	−0.17** (−1.98)	−0.69*** (−5.16)	−3.66** (1.84)
Compensation scheme (base: re-/afforestation)												
Developing renewable energies	−0.24*** (−2.87)	0.82*** (7.11)	−14.03*** (5.17)	−0.11 (−1.43)	0.65*** (5.48)	−5.94 (4.19)	−0.08 (−1.04)	−0.51*** (−3.88)	−1.41 (1.35)	−0.23*** (−2.89)	−0.66*** (−5.72)	−4.99*** (1.73)
Improve energy efficiency	−0.51*** (−6.21)	0.59*** (4.30)	−30.03*** (6.18)	−0.46*** (−5.31)	0.75*** (6.27)	−24.40*** (5.38)	−0.38*** (−4.80)	−0.29 (−1.19)	−6.80*** (1.39)	−0.52*** (−6.13)	0.59*** (4.19)	−10.99*** (1.80)
Contribution from provider (base: none)												
33%	0.06 (0.83)	−0.31 (−1.60)	3.72 (4.49)	0.30*** (4.08)	0.05 (0.22)	16.15*** (4.37)	0.10 (1.40)	−0.20 (−0.62)	1.87 (1.34)	0.06 (0.72)	−0.32 (−1.50)	1.17 (1.64)
100%	0.74*** (7.02)	1.49*** (12.39)	43.92*** (8.54)	0.78*** (7.53)	1.37*** (11.89)	41.56*** (7.44)	0.53*** (5.65)	1.12*** (10.36)	9.50*** (1.69)	0.26*** (2.78)	−1.09*** (−9.85)	5.60*** (2.03)
AIC	5537.2			5304.2			5456.1			5537.4		
BIC	5648.2			5415.1			5567.1			5648.4		
Number of participants	503			501			503			503		

Notes: Standard errors are in parentheses. * (**, ***) means that the parameter estimate is different to zero at the 10% (5%, 1%) significance level.

this result is driven by the class of offsetters (class 2). For the non-offsetters (class 1), the effects of provider contributions are always insignificant. The WTP estimates in the MLM (see Table 5) are about 44 and 42 euros per tCO_2e for holiday trips and trips to professional training by bus as well as about 10 and 6 euros for the corresponding trips by plane. Contributions by travel providers at a rate of one third significantly increase the estimated WTP only for bus trips to a professional training by about 16 euros. This result suggests that the effect of small matching rates varies by context. Our results for holiday trips by bus and plane are in line with those obtained by Kesternich et al. (2016) in a field experiment for bus trips in Germany. More specifically, Kesternich et al. (2016) find that a 100% matching scheme (but not a

Table 6
ML estimates in the LCLM with two classes.

Variables	Holiday trips by bus		Trips to professional training by bus		Holiday trips by plane		Trips to professional training by plane	
	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
Price (in euros) per tCO_2e	0.00	−0.01***	−0.07***	−0.01***	−0.09***	−0.04***	−0.14***	−0.03***
	(0.02)	(0.00)	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
ASC for opt-out option	5.75***	−1.81***	2.44***	−2.29***	1.51***	−2.37***	0.48	−2.46***
	(0.78)	(0.13)	(0.58)	(0.16)	(0.37)	(0.15)	(0.31)	(0.16)
Place of compensation (base: in developing country)								
In your region	1.18	0.67***	0.50	0.74***	1.01***	0.51***	1.00***	0.46***
	(0.78)	(0.05)	(0.43)	(0.05)	(0.30)	(0.06)	(0.23)	(0.06)
In European country outside Germany	0.87	−0.22***	−0.06	−0.15**	0.48	0.04	0.31	−0.13*
	(0.83)	(0.06)	(0.48)	(0.06)	(0.32)	(0.07)	(0.26)	(0.07)
Compensation scheme (base: re-/afforestation)								
Developing renewable energies	0.32	−0.11**	−0.09	−0.05	−0.21	−0.03	−0.06	−0.14**
	(0.51)	(0.05)	(0.40)	(0.05)	(0.24)	(0.06)	(0.20)	(0.06)
Improve energy efficiency	−1.28	−0.30***	−0.94*	−0.24***	−0.85***	−0.23***	−0.61***	−0.33***
	(0.86)	(0.06)	(0.54)	(0.06)	(0.32)	(0.06)	(0.23)	(0.06)
Contribution from provider (base: none)								
33%	0.03	0.05	−0.10	0.24***	−0.04	0.09	−0.16	0.06
	(0.67)	(0.06)	(0.45)	(0.06)	(0.29)	(0.07)	(0.22)	(0.07)
100%	0.68	0.60***	0.24	0.64***	−0.05	0.55***	−0.08	0.32***
	(0.59)	(0.05)	(0.41)	(0.06)	(0.28)	(0.06)	(0.21)	(0.06)
Constant		1.20***	−1.09***			0.61***	−0.38***	
		(0.11)	(0.10)			(0.10)	(0.10)	
AIC	6026.6		5762.3		5782.5		5817.5	
BIC	6152.4		5888.0		5908.3		5943.3	
Number of participants	503		501		503		503	
Class share	23.1%	76.9%	25.2%	74.8%	35.3%	64.7%	40.5%	59.5%

Notes: Class 1: higher probability of choosing the opt-out option regardless of the attribute levels; class 2: lower probability of choosing the opt-out option (offsetters). Standard errors are in parentheses. * (**, ***) means that the WTP is different to zero at the 10% (5%, 1%) significance level.

Table 7
WTP estimates (in euros per tCO2e) in the LCLM according to Table 6.

Variables	Holiday trips by bus	Trips to professional training by bus		Holiday trips by plane		Trips to professional training by plane	
	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
ASC for opt-out option	−159.85***	35.51**	−200.78***	16.75***	−58.45***	3.52	−92.94***
	(22.97)	(15.21)	(30.29)	(5.95)	(4.25)	(2.47)	(8.86)
Place of compensation (base: in developing country)							
In your region	59.50***	7.72	65.20***	11.20***	12.61***	7.38***	17.22***
	(10.15)	(6.58)	(10.95)	(3.80)	(1.62)	(1.83)	(2.60)
In European country outside Germany	−19.44***	−0.87	−13.14**	5.32	1.00	2.28	−4.80*
	(6.31)	(7.11)	(5.93)	(3.62)	(1.65)	(1.88)	(2.58)
Compensation scheme (base: re-/afforestation)							
Developing renewable energies	−9.94**	−1.27	−4.17	−2.32	−0.78	−0.43	−5.37**
	(5.00)	(5.79)	(4.79)	(2.73)	(1.50)	(1.47)	(2.31)
Improve energy efficiency	−26.67***	−13.67*	−21.18***	−9.43**	−5.61***	−4.46**	−12.34***
	(6.49)	(7.76)	(5.94)	(3.90)	(1.59)	(1.74)	(2.54)
Contribution from provider (base: none)							
33%	4.86	−1.39	20.79***	−0.39	2.15	−1.15	Feb 36
	(5.39)	(6.66)	(6.14)	(3.19)	(1.65)	(1.62)	(2.46)
100%	53.36***	3.48	55.94***	−0.55	13.45***	−0.57	12.20***
	(9.55)	(6.00)	(9.90)	(3.12)	(1.62)	(1.58)	(2.54)
Number of participants	503	501		503		503	
Class share	76.9%	25.2%	74.8%	35.3%	64.7%	40.5%	59.5%

Notes: Class 1: higher probability of choosing the opt-out option regardless of the attribute levels; class 2: lower probability of choosing the opt-out option (offsetters). Standard errors are in parentheses. * (**, ***) means that the WTP is different to zero at the 10% (5%, 1%) significance level. Because the parameter of the price attribute is not significantly different from zero for holiday trips by bus for class 1, the WTP was not estimated for this class.

33% matching scheme) significantly increases the share of passengers who offset their carbon emissions. In addition, we show that the WTP for the 100% matching scheme is significantly higher for bus trips.

4.3. Effects of further attributes

Our findings confirm the expected negative effects of the price attribute in all four experiments in the MLM (see Table 5). The estimated

Table 8
Simulated ML estimates (with 1000 Halton draws) in the MLM including interactions of the ASC with individual characteristics.

Variables	Trips by bus			Trips by plane		
	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP
High contribution of offsetting						
1	−5.83***			−3.37***		
	(0.72)			(0.59)		
Don't know/no answer	2.88**			2.87***		
	(1.19)			(0.98)		
At least one donation in past 3 years						
1	−3.48***			−1.69**		
	(0.57)			(0.68)		
Don't know/no answer	−1.11			−0.43		
	(1.25)			(1.23)		
Identifying with green politics						
1	−3.97***			−2.79***		
	(0.59)			(0.60)		
Don't know/no answer	−1.32			−0.78		
	(1.74)			(0.97)		
Identifying with social politics						
1	−4.21***			−1.86***		
	(0.82)			(0.57)		
Don't know/no answer	−2.43			−3.31**		
	(2.28)			(1.54)		
Religious						
1	−2.00***			−1.40		
	(0.68)			(1.07)		
Don't know/no answer	1.25			−0.64		
	(2.28)			(0.81)		
Age	0.06***			0.05**		
	(0.02)			(0.02)		
Female	2.03***			0.98		
	(0.66)			(0.67)		
Number of own children	0.11			0.13		
	(0.22)			(0.25)		
Highly educated	0.68			−0.01		
	(0.61)			(0.60)		
High individual income						
1	−0.28			−1.37**		
	(0.67)			(0.67)		
Don't know/no answer	0.83			0.66		
	(0.73)			(0.70)		
North	2.01**			0.04		
	(0.98)			(0.86)		
East	1.55*			0.32		
	(0.82)			(0.78)		
West	−0.00			0.08		
	(0.80)			(0.61)		
Price (in euros) per tCO_2e	−0.02***			−0.05***		
	(0.00)			(0.00)		
ASC for opt-out option	−0.80	8.40***	−44.09	0.06	5.71***	1.16
	(1.22)	(0.64)	(66.62)	(1.08)	(0.38)	(20.88)
Place of compensation (base: in developing country)						
In your region	0.97***	1.69***	53.24***	0.56***	1.32***	10.93***
	(0.09)	(0.09)	(6.50)	(0.07)	(0.08)	(1.47)
In European country outside Germany	−0.28***	−0.74***	−15.59***	−0.06	−0.67***	−1.19
	(0.06)	(0.09)	(3.78)	(0.06)	(0.10)	(1.19)
Compensation scheme (base: re-/afforestation)						
Developing renewable energies	−0.17***	0.79***	−9.58***	−0.15***	0.58***	−2.84***
	(0.06)	(0.07)	(3.35)	(0.06)	(0.09)	(1.08)
Improve energy efficiency	−0.48***	0.68***	−26.32***	−0.45***	0.52***	−8.76***
	(0.06)	(0.08)	(3.99)	(0.06)	(0.10)	(1.13)
Contribution from travel provider (base: none)						
33%	0.18***	−0.29**	10.02***	0.07	0.38***	1.30
	(0.05)	(0.13)	(3.07)	(0.06)	(0.11)	(1.07)
100%	0.76***	1.44***	41.59***	0.39***	−1.07***	7.55***
	(0.08)	(0.08)	(5.57)	(0.07)	(0.08)	(1.35)
AIC	10,431.66			10,599.53		
BIC	10,706.68			10,874.61		
Number of participants	1003			1005		

Notes: Standard errors are in parentheses. * (**, ***) means that the parameter estimate is different to zero at the 10% (5%, 1%) significance level.

Table 9
ML and WTP estimates (in euros per tCO_2e) in the LCLM with two classes including individual characteristics that explain class membership.

Variables	Trips by bus				Trips by plane			
	Class 1		Class 2		Class 1		Class 2	
	Mean	WTP	Mean	WTP	Mean	WTP	Mean	WTP
High contribution of offsetting								
1	−1.23***				−1.26***			
	(0.21)				(0.18)			
Don't know/no answer	0.18				0.59*			
	(0.33)				(0.33)			
At least one donation in past 3 years								
1	−0.97***				−0.48***			
	(0.20)				(0.18)			
Don't know/no answer	−0.42				−0.23			
	(0.51)				(0.46)			
Identifying with green politics								
1	−1.11***				−0.84***			
	(0.23)				(0.18)			
Don't know/no answer	0.13				0.65			
	(0.61)				(0.52)			
Identifying with social politics								
1	−0.81***				−0.63***			
	(0.21)				(0.20)			
Don't know/no answer	−0.63				−1.91**			
	(0.72)				(0.75)			
Religious								
1	−0.26				−0.12			
	(0.33)				(0.27)			
Don't know/no answer	0.23				0.25			
	(0.40)				(0.38)			
Age	0.02***				0.02***			
	(0.01)				(0.01)			
Female	0.27				0.12			
	(0.20)				(0.18)			
Number of own children	0.05				0.01			
	(0.08)				(0.07)			
Highly educated	−0.01				−0.08			
	(0.19)				(0.17)			
High individual income								
1	−0.10				−0.45**			
	(0.24)				(0.22)			
Don't know/no answer	0.33				0.05			
	(0.23)				(0.21)			
North	0.29				0.20			
	(0.28)				(0.25)			
East	0.34				0.56**			
	(0.27)				(0.24)			
West	−0.16				0.35			
	(0.24)				(0.21)			
Price (in euros) per tCO_2e	−0.03***		−0.01***		−0.10***		−0.03***	
	(0.01)		(0.00)		(0.01)		(0.00)	
ASC for opt-out option	3.28***	111.11***	−2.12***	−188.06***	1.08***	10.91***	−2.52***	−76.64***
	(0.29)	(39.26)	(0.11)	(20.46)	(0.32)	(4.02)	(0.16)	(7.26)
Place of compensation (base: in developing country)								
In your region	0.84***	28.47***	0.70***	62.40***	0.98***	9.98***	0.47***	14.35***
	(0.30)	(10.94)	(0.04)	(7.60)	(0.18)	(2.26)	(0.04)	(1.51)
In European country outside Germany	−0.22	−7.52	−0.18***	−15.88***	0.46**	4.64**	−0.05	−1.66
	(0.35)	(12.67)	(0.04)	(4.35)	(0.18)	(1.94)	(0.05)	(1.46)
Compensation scheme (base: re-/afforestation)								
Developing renewable energies	−0.10	−3.39	−0.08**	−7.10**	−0.05	−0.53	−0.09**	−2.76**
	(0.26)	(8.89)	(0.04)	(3.48)	(0.14)	(1.39)	(0.04)	(1.32)
Improve energy efficiency	−0.16	−5.47	−0.28***	−25.20***	−0.55***	−5.56***	−0.28***	−8.48***
	(0.27)	(9.49)	(0.04)	(4.54)	(0.16)	(1.74)	(0.05)	(1.43)
Contribution from travel provider (base: none)								
33%	−0.07	−2.53	0.15***	13.23***	0.03	0.28	0.07	1.98
	(0.27)	(9.37)	(0.04)	(4.07)	(0.16)	(1.57)	(0.05)	(1.43)
100%	0.47*	15.76*	0.62***	55.06***	0.02	0.24	0.44***	13.27***
	(0.25)	(9.25)	(0.04)	(7.03)	(0.16)	(1.62)	(0.04)	(1.51)
Constant	−0.69*				0.12			
	(0.39)				(0.34)			

(*continued on next page*)

Table 9 (*continued*)

Variables	Trips by bus				Trips by plane			
	Class 1		Class 2		Class 1		Class 2	
	Mean	WTP	Mean	WTP	Mean	WTP	Mean	WTP
AIC	11,621.42				11,432.87			
BIC	11,912.62				11,724.14			
Number of participants	1003				1005			
Class share	24.6%		75.4%		39.3%		60.7%	

Notes: Class 1: higher probability of choosing the opt-out option regardless of the attribute levels, class 2: lower probability of choosing the opt-out option (offsetters). Standard errors are in parentheses. * (**, ***) means that the parameter estimate is different to zero at the 10% (5%, 1%) significance level.

price parameters for bus trips are smaller (in absolute terms) than for plane trips. This suggests a lower attention or a smaller response to changes in the price of the offsetting option and results in the higher WTP estimates for offsetting emissions from bus trips compared to plane trips as discussed above.

For the place of compensation, we find that projects implemented in the participant's region significantly increase the willingness to offset emissions in all four DCE, but the WTP does not appear to differ by travel occasion. For bus trips, the estimated WTP is approximately 53 euros per tCO_2e higher than for projects carried out in developing countries (which is the base for this attribute). The corresponding WTP estimates for plane trips range around 11 euros. Compensations implemented in a European country outside Germany have a significantly negative impact on the probability that participants will choose an offsetting option (with the exception of holiday trips by plane). Such offsetting projects reduce the estimated WTP by about 20 euros per tCO_2e for holiday trips by bus, by about 13 euros for trips to a professional training by bus, and by about 4 euros for trips to a professional training by plane.

Re-/afforestation (which is the base level) seems to be the most popular compensation scheme. In all four experiments, we find significantly negative parameter estimates for projects to improve energy efficiency. For bus trips, the difference in the estimated WTP for offsetting projects ranges between about 24 and 30 euros. For trips by plane, the difference ranges between about 7 and 11 euros. The parameter estimates for projects involving the development of renewable energies are also significantly negative for holiday trips by bus and professional training trips by plane. The estimated difference in the WTP amounts to about 14 and 5 euros per tCO_2e, respectively.

4.4. Characteristics of offsetters

The results presented in Section 4.1 suggest that differences between travel occasions are rather small and unsystematic. Therefore, we now pool the data of the bus and the plane trips at the level of travel occasions, allowing for more robust and more efficient parameter estimates and facilitating the interpretation of the relevant characteristics of offsetters. To do so, we construct several explanatory variables that reflect participants' preferences and beliefs (such as identifying with green and social politics, being religious, or believing that carbon offsetting is effective in protecting the climate) as well as their socio-demographic backgrounds.[13] Table 1 provides a description of these variables.[14]

Table 8 reports the results in the MLM including interactions of the ASC for the opt-out option with these explanatory variables. On this basis, we discuss the characteristics of participants who are less likely to choose the opt-out option. In general, the results for the attributes demonstrate that the findings from Sections 4.1 to 4.3 are quite robust when we pool the data for holidays and professional training. In addition, our WTP estimates are, except for the opt-out option, robust to pooling the data and including the characteristics of the participants.

The parameter estimates for participants who are more likely to offset emissions from traveling (referred to as “offsetters” in the following) refer to the negative values of the estimated parameters of the interaction terms (of the characteristics with the ASC) reported in Table 8. The offsetters are therefore significantly more likely to believe that carbon offsetting makes a high contribution to climate protection and less uncertain about this contribution (less likely to answer “don't know/no answer”). In addition, the offsetters are also significantly more likely to donate to charitable purposes and to identify themselves with green or social politics. The likelihood of being an offsetter also decreases significantly with age. In the bus experiments, women as well as participants from the Northern and the Eastern federal states are significantly less likely to be offsetters, whereas participants identifying themselves as religious are significantly more likely to be offsetters. In the plane experiments, being an offsetter is significantly positively related with income. In addition to the individual characteristics mentioned in footnote 13 (marital status, employment status, profession, and travel frequency), the number of own children and the level of education seem to be poor predictors of being an offsetter.

The estimation results from the LCLM including individual characteristics that explain class membership in Table 9 (empty columns indicate the reference class in this analysis) provide insights for respondents who belong to the class of offsetters (class 2). About three quarters of the participants are characterized as offsetters in the bus experiments and about 61% in the plane experiments. Overall, the LCLM estimation results for class 2 confirm the findings from the MLM.

4.5. Analysis excluding “always-offsetters”

The findings discussed in Sections 4.1 to 4.3 suggest that the estimated WTP for the project attributes are substantially higher than the observed market prices for offsetting one ton of CO_2e. We therefore now exclude participants who never chose the opt-out option in the 12 choices they made in two experiments, regardless of the attribute levels. This group involves about 50% of the participants in the bus experiments (49.3% for holiday trips, 53.7% for trips to professional training) and approximately 45% in the plane experiments (45.1% for holiday trips, 45.3% for trips to professional training). Never choosing to opt-out is actually quite unrealistic given the relatively small share of about 11% of the participants in our sample who reported that they had compensated emissions in the past three years. Always-offsetters show a

[13] We also tested additional individual characteristics such as marital status, employment status and profession, or travel frequency of the participant, but none of these variables seemed significant in characterizing the offsetters.

[14] Since excluding observations with missing values has significant effects on the estimation results, we additionally included six dummy variables: for missing data with regard to the high contribution of offsetting, identifying with green and social politics, at least one donation in the past three years, religious, and high individual income. This allows using (almost) all observations.

Table 10
Simulated ML (with 1000 Halton draws) and WTP estimates (in euros per tCO_2e) with a restricted sample excluding "always-offsetters" in the MLM.

Variables	Trips by bus			Trips by plane		
	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP
High contribution of offsetting						
1	−2.47***			−1.66***		
	(0.62)			(0.34)		
Don't know/no answer	−0.42			0.50		
	(1.04)			(0.58)		
At least one donation in past 3 years						
1	−2.20***			−0.52		
	(0.57)			(0.33)		
Don't know/no answer	−1.49			−0.72		
	(1.74)			(0.78)		
Identifying with green politics						
1	−2.04***			−1.27***		
	(0.57)			(0.34)		
Don't know/no answer	−2.35			−0.17		
	(2.46)			(1.06)		
Identifying with social politics						
1	−1.44**			−0.85**		
	(0.63)			(0.38)		
Don't know/no answer	2.15			−0.68		
	(2.98)			(1.56)		
Religious						
1	−0.55			−0.64		
	(0.83)			(0.50)		
Don't know/no answer	1.44			−0.68		
	(1.33)			(0.67)		
Age	0.04**			0.02		
	(0.02)			(0.01)		
Female	0.50			−0.03		
	(0.59)			(0.33)		
Number of children	0.35			0.10		
	(0.23)			(0.14)		
Highly educated	0.24			−0.37		
	(0.61)			(0.33)		
High individual income						
1	0.07			−0.58		
	(0.74)			(0.41)		
Don't know/no answer	1.50**			0.30		
	(0.74)			(0.40)		
North	2.17**			0.79		
	(0.85)			(0.50)		
East	1.25			0.31		
	(0.79)			(0.45)		
West	1.10			0.37		
	(0.77)			(0.39)		
Price (in euros) per tCO_2e	−0.03***			−0.08***		
	(0.00)			(0.00)		
ASC for opt-out option	0.75	5.26***	25.79	2.45***	2.70***	31.29***
	(1.09)	(0.45)	(38.06)	(0.66)	(0.18)	(8.71)
Place of compensation (base: in developing country)						
In your region	0.94***	1.59***	32.58***	0.62***	1.05***	7.94***
	(0.13)	(0.15)	(5.42)	(0.12)	(0.12)	(1.54)
In European country outside Germany	−0.24**	0.44**	−8.33**	0.15	−0.22	Jan 94
	(0.10)	(0.23)	(3.58)	(0.10)	(0.34)	(1.29)
Compensation scheme (base: re-/afforestation)						
Developing renewable energies	−0.26***	0.49***	−8.90***	0.02	0.32*	0.23
	(0.09)	(0.16)	(3.23)	(0.09)	(0.18)	(1.20)
Improve energy efficiency	−0.59***	0.78***	−20.52***	−0.40***	0.36*	−5.12***
	(0.11)	(0.14)	(4.14)	(0.10)	(0.21)	(1.32)
Contribution from provider (base: none)						
33%	0.12	−0.15	4.22	0.03	0.03	0.43
	(0.09)	(0.32)	(3.15)	(0.09)	(0.29)	(1.17)

(*continued on next page*)

Table 10 (*continued*)

Variables	Trips by bus			Trips by plane		
	Mean	Standard deviation	WTP	Mean	Standard deviation	WTP
100%	0.49***	1.14***	16.93***	0.18*	0.37*	2.31*
	(0.12)	(0.13)	(4.29)	(0.10)	(0.19)	(1.25)
AIC	4465.2			4551.7		
BIC	4715.7			4806.3		
Number of participants	487			551		

Notes: The MLM include interactions of the ASC with individual characteristics. Standard errors are in parentheses. * (**, ***) means that the parameter estimate is different to zero at the 10% (5%, 1%) significance level.

low sensitivity to changes in the price attribute, which might drive the high WTP estimates.[15]

The results for this restricted sample in the MLM (see Table 10) suggest that, similar to the results for the unrestricted sample (see Table 8), being an offsetter correlates positively with the belief that carbon offsetting makes a high contribution to climate protection and with identifying oneself with green and social politics. Similarly, for the restricted sample, offsetters in the bus experiments are significantly more likely to have made at least one donation in the past three years, to be younger, to live not in the North of Germany and to have reported their income in the survey. In contrast to the findings for the unrestricted sample, the parameter for the ASC is significantly positive for plane trips in the restricted sample. This reflects the higher relative share of non-offsetters in the sample without the “always-offsetters”.

In the LCLM and for trips by plane, we additionally find that the offsetters have a significantly higher preference for projects in European countries outside Germany than for projects in developing countries, but their preferences for re-/afforestation projects do not differ significantly from those involving the development of renewable energies (see Table 11). A 33% contribution from the provider has no significant effect on the willingness to offset emissions for bus trips or plane trips in the MLM and the LCLM.

In general and similar to the unrestricted sample, the findings in Tables 10 and 11 suggest that the WTP estimates are qualitatively quite similar for the MLM and class 2 in the LCLM. However, the levels of the WTP estimates are substantially lower when excluding the “always-offsetters”. In the MLM, for example, a 100% contribution from the provider increases the estimated WTP for the restricted sample by about 17 euros per tCO_2e for bus trips compared to about 42 euros for the unrestricted sample and by about 2 euros per tCO_2e for plane trips compared to about 8 euros for the unrestricted sample. Similarly, for the restricted sample, a project in the participant's region is worth an additional approximately estimated 33 euros for bus trips and 8 euros for plane trips. The latter value is very similar to the about 11 euros for plane trips in the unrestricted sample.

5. Summary and conclusions

The climate protection activities of individuals play an important role in limiting the negative impacts of anthropogenic climate change. This paper focuses on VCO and examines potential drivers and the individuals' WTP in the case of travel-related CO_2 emissions. In particular, we explore whether the WTP for VCO differs in different contexts, i.e. different modes of transportation (bus versus plane) and reasons for travel (holiday versus professional training). For both types of framings, we study the effects of additional contributions from the travel provider (i.e. matching). Our empirical analyses rely on data from four DCE (and thus four contexts) collected via a representative online survey among a total of about 1000 individuals from Germany. We apply MLM and as a robustness check LCLM with 2 classes (non-offsetters and offsetters) to analyze the relevant determinants of offsetting projects and the characteristics of individuals who are more likely to offset travel-related emissions. In general, our results from the two models are widely consistent.

Our findings reveal only small and rather unsystematic differences between travel occasions, while the willingness to offset emissions and the WTP estimates differ significantly between the transportation modes. This result suggests that the perceived responsibility to offset varies with external factors (see also Brekke et al., 2010). The willingness to offset the emissions produced by bus trips (about 74% of the choices) is significantly higher than for trips by plane (about 63% of the choices). In contrast to Blasch and Farsi (2014), we find a much higher estimated WTP for offsetting emissions produced by bus trips, i.e. the less emission-intensive mode of transportation. Rather than the effect of the mode of transportation per se, this finding may be explained by the low overall costs of offsetting for bus trips, reflecting the diminishing marginal utility per unit of carbon offsets, which is in line with the “low-cost hypothesis”.

This finding offers guidance for policies aiming to enhance the demand for VCO in transportation. First, offering high-cost VCO may only result in a small market of individuals with strong environmental preferences (and high income). Thus, to increase the demand for VCO for trips by planes, the transport providers could directly subsidize VCO (rather than use the funds to match the carbon reduction). Second, low-cost VCO could be offered and promoted (or be made the default option with the possibility to opt out) for trips employing public transportation (i.e. trains, trams, and buses). In this case, the individual's effect on carbon emissions may be rather small, but the accumulated effect of a substantial uptake is much larger. Our findings further indicate the potentially high social acceptance of such measures.

A 33% matching rate of contributions by travel providers significantly increases the estimated WTP only for bus trips to a professional training. In contrast, for all four contexts, the participants show a significantly higher WTP if their compensations are matched by the travel provider under a 100% matching rate scheme. This finding is in line with existing studies relying on revealed preferences (e.g. Karlan and List, 2007; Kesternich et al., 2016). Previous studies also indicate that individuals are more willing to contribute to charities and public goods if others are also willing to participate (‘conditional cooperation’) (e.g. Fischbacher and Gächter, 2010; Khadjavi and Lange, 2013). Therefore, our finding might be attributed to specific individual fairness preferences. If the participants perceive the travel provider as (co-)responsible for the produced emissions, the 100% matching rate may be interpreted as a positive signal that providers are willing to share the offsetting burden equally. In addition, the participants may be more willing to compensate their carbon emissions due to the higher effectiveness of their compensation contribution under a 100% matching rate. For these reasons, providers aiming to substantially enhance the take-up of VCO should offer a 100% matching rate rather than a lower

[15] Comparing the descriptive statistics in Table 2 suggests that the restricted sample is very similar in terms of socio-demographic and socio-economic characteristics, but differs in the participants' beliefs and attitudes.

Table 11
ML and WTP estimates (in euros per tCO_2e) with a restricted sample excluding "always-offsetters" in the LCLM with two classes.

Variables	Trips by bus				Trips by plane			
	Class 1		Class 2		Class 1		Class 2	
	Mean	WTP	Mean	WTP	Mean	WTP	Mean	WTP
High contribution of offsetting								
1	−1.06***				−1.05***			
	(0.26)				(0.24)			
Don't know/no answer	−0.43				0.08			
	(0.37)				(0.37)			
At least one donation in past 3 years								
1	−0.97***				−0.22			
	(0.25)				(0.23)			
Don't know/no answer	−1.01				−0.39			
	(0.67)				(0.57)			
Identifying with green politics								
1	−1.03***				−0.97***			
	(0.28)				(0.25)			
Don't know/no answer	0.13				0.02			
	(0.79)				(0.70)			
Identifying with social politics								
1	−0.63**				−0.52**			
	(0.26)				(0.26)			
Don't know/no answer	0.14				−0.52			
	(1.00)				(0.94)			
Religious								
1	−0.37				−0.43			
	(0.40)				(0.38)			
Don't know/no answer	0.57				−0.40			
	(0.49)				(0.48)			
Age	0.02***				0.01*			
	(0.01)				(0.01)			
Female	0.29				0.11			
	(0.24)				(0.23)			
Number of children	0.01				−0.02			
	(0.09)				(0.09)			
Highly educated	0.12				−0.16			
	(0.24)				(0.23)			
High individual income								
1	0.09				−0.32			
	(0.31)				(0.29)			
Don't know/no answer	0.54*				0.26			
	(0.29)				(0.28)			
North	0.46				0.51			
	(0.35)				(0.33)			
East	0.13				0.17			
	(0.33)				(0.32)			
West	0.05				0.22			
	(0.30)				(0.27)			
Price (in euros) per tCO_2e	−0.03**		−0.02***		−0.10***		−0.07***	
	(0.02)		(0.00)		(0.03)		(0.00)	
ASC for opt-out option	3.83***	118.07*	−0.80***	−37.19***	2.23***	23.03**	−0.89***	−13.00***
	(0.50)	(66.59)	(0.13)	(5.53)	(0.51)	(11.22)	(0.13)	(1.76)
Place of compensation (base: in developing country)								
In your region	0.47	14.63	0.89***	41.52***	0.78	8.07	0.71***	10.44***
	(0.55)	(17.06)	(0.07)	(5.35)	(0.81)	(7.54)	(0.09)	(1.35)
In European country outside Germany	−0.04	−1.19	−0.16*	−7.70*	−1.18	−12.20	0.20**	2.91**
	(0.68)	(21.00)	(0.09)	(4.10)	(1.17)	(14.11)	(0.09)	(1.44)
Compensation scheme (base: re-/afforestation)								
Developing renewable energies	−0.49	−15.12	−0.15**	−6.87**	−0.40	−4.18	0.06	0.89
	(0.42)	(14.44)	(0.07)	(3.39)	(0.50)	(5.47)	(0.08)	(1.23)
Improve energy efficiency	−0.93*	−28.75	−0.33***	−15.26***	−1.21	−12.53	−0.27***	−3.98***
	(0.50)	(21.04)	(0.07)	(3.79)	(0.84)	(9.34)	(0.09)	(1.40)
Contribution from provider (base: none)								
33%	0.09	2.79	0.11	525	−0.57	−5.89	0.07	5.01
	(0.70)	(21.29)	(0.08)	(3.69)	(0.60)	(6.31)	(0.09)	(1.31)
100%	0.84	25.94	0.50***	23.29***	−0.10	−1.03	0.21**	3.02**
	(0.62)	(19.64)	(0.07)	(4.17)	(0.54)	(5.54)	(0.09)	(1.30)
Constant	−0.09				0.66			
	(0.46)				(0.42)			

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Table 11 (*continued*)

Variables	Trips by bus				Trips by plane			
	Class 1		Class 2		Class 1		Class 2	
	Mean	WTP	Mean	WTP	Mean	WTP	Mean	WTP
AIC	4750.5				4589.9			
BIC	5015.7				4589.9			
Number of participants	487				551			
Class share	45.5%		54.5%		53.1%		46.9%	

Notes: The LCLM include individual characteristics that explain class membership, Class 1: higher probability of choosing the opt-out option regardless of the attribute levels, class 2: lower probability of choosing the opt-out option (offsetters). Standard errors are in parentheses. * (**, ***) means that the WTP is different from zero at the 10% (5%, 1%) significance level.

rate. The differences in the estimated effects of the various matching rates across the four DCE corroborate our general approach of allowing these effects to differ across contexts. However, further research on matching in varying contexts and frames is needed to fully understand the drivers behind these differences.

Our results further indicate that re-/afforestation projects are preferred to renewable energies projects or projects to improve energy efficiency. Likewise, projects carried out in the participants' region are preferred to schemes in European countries outside Germany or in developing countries. A potential explanation is that individuals expect additional benefits from such compensation activities or that they are more tangible. Projects in the participant's region might stimulate the regional economy and lower the emissions of local pollutants. Re-/afforestation measures may provide recreational services (e.g. Pittel and Rübbelke, 2008; Baranzini et al., 2018). In comparison, projects involving the development of renewable energies may have suffered from a negative image at the time of the survey. In particular, media coverage in Germany attributed high electricity costs to the strong diffusion of renewable energies in electricity generation. In addition, individuals may perceive the planting of trees as a more transparent, more trustworthy, and less abstract activity than investments in more abstract technologies to improve energy efficiency. Thus, promoting carbon offsetting through re-/afforestation projects in the region may be expected to enhance the demand for VCO more than other projects.

Our analyses further help to characterize individuals who are more likely to choose an offsetting option to compensate travel-related CO_2 emissions. These “offsetters” are mostly younger, more often male (only for bus trips), and with a higher income (only for plane trips). Offsetters also have significantly stronger environmental and social preferences, more often believe that carbon offsetting makes a high contribution to climate protection, and are significantly more certain about this contribution. These findings are largely in line with the determinants of an individual's willingness to engage in VCO found in Schwirplies and Ziegler (2016). We also observe some regional heterogeneity in our sample, indicating, in particular, that individuals from the Eastern part of Germany are significantly less willing to offset emissions. However, this finding is difficult to interpret as the socio-economic and geographic structure of Eastern Germany differs in several aspects from that of Western Germany in addition to having a different history. While it is therefore difficult to pinpoint the underlying reason for this difference, our observation emphasizes the relevance of contextual factors.

Thus, if promoting VCO targets individuals with the above mentioned socio-economic characteristics, this is likely to raise the demand for VCO. For example, placing ads in magazines for members of political parties may be an effective strategy to reach individuals with strong environmental preferences (notably members of the Green party) or social preferences (notably members of social-democratic or socialist parties). In addition, providing information about the effectiveness of VCO schemes is likely to push their uptake (e.g. Lu and Wang, 2018). In particular, such information could highlight the fact that the offsetting projects lead to emission reductions, which are additional to any that would occur in the absence of the project, and that these emission reductions are verified and certified by independent third parties. Providing information that some offsetting projects meet additional strict sustainability criteria, for example, certified via the Gold Standard, may appeal to individuals with strong environmental and social preferences.

About half of our participants never chose the opt-out option regardless of the variation in the attribute levels. This finding is rather surprising given the limited size of the voluntary carbon market and the small share of about 11% of our participants, who reported they had actually paid for carbon offsets in the past three years. Since these participants are insensitive to changes in the price attribute, they might drive the high average WTP estimates. Excluding this group of “always-offsetters” significantly decreases the WTP estimates to arguably more realistic values. Also, for bus trips, the class of offsetters now involves 27% of the whole sample who are sensitive to changes in the attributes, which is largely in line with the field experiment of Kesternich et al. (2016). For plane trips, the share of offsetters is only slightly smaller (about 25%). Contrasting these results to the share of offsetters present in our sample suggests a rather large potential for VCO. Increasing the actual use of VCO, however, probably requires the providers of the polluting activities, especially activities that produce low emissions, to inform their customers about the emissions produced by consuming these activities and to actively offer carbon offsets as part of the purchase process. Still, because transportation-related greenhouse gas emissions, especially from planes, continue to grow in Germany and most other countries, further research is needed to test and identify strategies that are successful in enhancing the demand for VCO.

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