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## Conference Paper

# The determinants of voluntary carbon offsetting: A micro-econometric analysis of individuals from Germany and the United States

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# **The determinants of voluntary carbon offsetting: A micro-econometric analysis of individuals from Germany and the United States**

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Preliminary version

February 2014

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# **The determinants of voluntary carbon offsetting: A micro-econometric analysis of individuals from Germany and the United States**

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## **Abstract**

This paper examines the determinants of voluntary individual carbon offsetting, i.e. the financial compensation of emissions from energy use. In contrast to former studies in this field, we particularly consider a comprehensive set of factors that are discussed in the context of voluntary contributions to public goods, such as psychological motives or social norms. The empirical analysis is based on unique data from representative surveys among more than 2000 citizens from Germany and the United States. These data reveal a higher extent of the past purchase of carbon offsets in the United States. In both countries, our micro-econometric analysis with discrete choice models indicates a strong positive correlation between the perceived contribution of this offsetting mechanism to climate protection and both actual carbon offsetting in the past and the planned purchase of carbon offsets in the future. In Germany, psychological motives such as the feeling of warm glow play an additional important role, while in the United States social motives such as expectations from the society are of a high relevance. Interestingly, a high environmental preference (measured by the membership in an environmental organization and the identification with green politics) is significantly correlated with already purchased carbon offsets in the United States, but not in Germany. These results suggest that not only the whole society in Germany has a lower average acceptance of carbon offsetting, but also that environmentally conscious people in this country obviously did not consider carbon offsetting as a measure to avoid further anthropogenic global warming so far.

**Keywords:** climate change; climate protection; carbon offsetting; discrete choice models

**JEL:** Q54, Q58

## 1. Introduction

Climate change is predominantly considered to be existent and anthropogenic and poses a multi-faceted challenge for the societies due to its strong impacts on the natural environment and human lives. In order to avoid further anthropogenic global warming, drastic reductions of greenhouse gas emissions, especially carbon emissions, from energy conversion and use are needed. Instead of directly reducing carbon emissions, an increasingly popular approach is targeted at voluntary engagements in global carbon markets, i.e. voluntary carbon offsetting. This offsetting mechanism refers mainly to the financial compensation of carbon emissions from everyday energy use such as in the case of driving, flying, or heating buildings. The voluntary carbon offsets are generated in specific projects like investments in renewable energies, energy efficiency, or even afforestation. In general, the global market for voluntary carbon offsets is open to individuals, organizations, and corporations.

In 2011, the share of the voluntary carbon market relative to the overall carbon market was almost negligible with 87 MtCO<sub>2e</sub> compared to 10281 MtCO<sub>2e</sub> and \$569 million compared to \$176020 million (e.g., Kossoy and Guigon, 2012), respectively. In 2012, the purchases of voluntary carbon offsets increased by four percent to 101 MtCO<sub>2e</sub>. By December 2013, the Carbon Catalog, which is the biggest online register of offsetting providers, listed 141 providers and overall 641 projects worldwide. Since 2008, the amount of projects nearly doubled (e.g., Kotchen, 2009; Carbon Catalog, 2013). More than half (52.9%) of the projects listed are concerned with renewable energies, followed by afforestation projects (20.4%), projects aiming at the substitution of certain materials or fuels (10.9%), energy-efficiency projects (6.7%), projects aiming at the reduction of methane (6.4%), and projects in the transportation sector (0.5%) (e.g., Carbon Catalog, 2013).

Overall, the share of the purchase of voluntary carbon offsets by individual citizens is still relatively low at 1,9% (1.4 MtCO<sub>2e</sub>) in 2012 (e.g., Peters-Stanley and Yin, 2013). On the one hand, this might be attributed to a lower acceptance of offsetting, since a fundamental point of criticism concerns the concept of paying others to compensate for one's own environmental sins (e.g., Kotchen, 2009). On the other hand, various barriers like the asymmetric availability of information on the offsetting market and relatively high transaction costs for the acquisition of information make the engagement in offsetting more difficult compared to other climate-friendly activities (e.g., Blasch and Farsi, 2013). Therefore, third parties are supposed to find remedy by setting standards and certifications, such as the Voluntary Carbon Standard and the Gold Standard (e.g., Conte and Kotchen, 2009; Kotchen, 2009). Albeit purchases of voluntary

carbon offsets by individuals only account for a fraction of total purchases, the household consumption is responsible for a significant share of global carbon emissions (e.g., Hertwich and Peters, 2009). This highlights the enormous potential of household decisions relating to the purchase of voluntary carbon offsets.

Researchers conducted numerous empirical studies and experiments to investigate the decisions of individuals for or against the purchase of voluntary carbon offsets and, in particular, their willingness-to-pay (WTP). Brouwer et al. (2008), for instance, interviewed flight passengers at Amsterdam Schiphol airport about their willingness to establish a voluntary “Carbon Travel Tax”. Overall, three quarters of the participants are generally willing to pay for such a tax, whereat the average WTP was found to be around 25 Euro per tCO<sub>2</sub>e (0.6 Euro per 100 kilometers). Thereupon, Akter et al. (2009) investigated the same data set and showed that the higher the proposed tax the lower was the respondents’ stated willingness to actually pay the tax. MacKerron et al. (2009) analyzed the flight behavior and willingness to buy voluntary carbon offsets of young and educated people from Great Britain and showed that the average WTP per tCO<sub>2</sub>e was £24. Additionally, Diederich and Goeschl (2012) as well as Löschel et al. (2013) conducted experimental studies in Germany and determined an average willingness to pay of 6.30 and 11.89 Euros per tCO<sub>2</sub>e, respectively, which is considerably lower than values assessed by questionnaire-based studies. In contrast to these studies, Blasch and Farsi (2013) analyzed the demand for voluntary carbon offsets for a diversity of consumption activities of more than 1000 Swiss citizens and observed the highest WTP per tCO<sub>2</sub>e in situations that have a huge impact on the environment, e.g., flights with 78 CHF per tCO<sub>2</sub>e, whereas the WTP of average respondents range from 1 to 21 CHF.

Amongst others, MacKerron et al. (2009) highlighted the influence properties of a specific project (especially co-benefits like “human development”, “environmental protection and biodiversity” as well as “technology and market development”) might have on the willingness to offset. The authors showed that all of the specified co-benefits have a significantly positive impact on the willingness to offset and ranked environmental protection and biodiversity highest with £15 per tCO<sub>2</sub>e. Additionally, Blasch and Farsi (2013) carved out the positive relationship between the willingness to purchase voluntary carbon offsets and factors like project location, initiator of the project, and certification by the government. Furthermore, the results of this study suggest that offsetting projects in developing countries initiated by non-governmental organizations and certified by the government were preferred (Blasch and Farsi, 2013). Knowledge about carbon offsetting represents a further considerable factor influencing

the demand for voluntary carbon offsets. Ziegler et al. (2012) emphasize the importance of previous knowledge about offsetting by analyzing data from the vehicle market in Germany and the United States. Additionally, Jacobsen (2011) examined the impact of the awareness and knowledge of climate change and showed that information and awareness campaigns positively influence the demand for carbon offsets, at least in the short term. Moreover, the frame in which voluntary carbon offsets are offered during the booking process might significantly influence the decision of individuals to compensate their carbon emissions (e.g., Araña and León, 2013).

We contribute to this literature by econometrically analyzing data from a unique representative survey among more than 2000 citizens from Germany and the United States and taking into account a variety of motives for the engagement in offsetting discussed in the context of voluntary contributions to climate protection. The main objective of this paper is to carve out the determinants of the past purchase of voluntary carbon offsets and the stated willingness to offset the own carbon emissions in the future. In this respect, we especially consider motives like a feeling of warm glow, social approval, feeling responsible for climate protection, or the awareness of the free-rider phenomenon, which, if at all, were mostly considered separately in the previous literature. By applying common discrete choice models, we demonstrate that the determinants differ significantly in the two countries. While perceived effectiveness of carbon offsetting, a feeling of warm glow, and feeling responsible for climate protection influence the stated willingness to engage in carbon offsetting in the future as well as the probability to plan offsetting in the future, although not yet taken, in both countries, the awareness of the free-rider phenomenon has a negative effect only in Germany and social norms are of particular importance only in the United States.

The remainder of the paper is organized as follows: Section 2 develops the hypotheses for our empirical analysis. Section 3 presents the data and the variables in our micro-econometric analysis. Section 4 discusses the estimation results and the final Section 5 draws some conclusions.

## **2. Background and hypotheses**

Since global emissions of all sources determine the concentration of greenhouse gases in the atmosphere, contributing to climate protection and, thus, carbon offsetting is inherently a public good problem (e.g., IPCC, 2001). No individual can be excluded from the benefits, i.e. a lower risk of climate change, and enjoying those benefits by one party does not affect the lev-

el of enjoyment of those benefits by others. But a voluntary contribution to carbon offsetting is not necessary to reap its benefits. In the scientific literature this phenomenon is referred to as the free-rider phenomenon, which intensifies as the number of people who benefit from carbon offsetting gets higher, while the effect of the own contribution remains relatively or even negligibly low (e.g., Stiglitz, 2000). According to the standard economic theory, individuals will not contribute due to this social dilemma (e.g., Holländer, 1990). This leads to the first hypothesis that is examined in our empirical analysis:

*Hypothesis 1: Individuals with a higher awareness of the free-rider problem are less likely to engage in voluntary carbon offsetting.*

Nonetheless, experiments and empirical studies show that, contrary to expectations, individuals do not solely behave selfish, but engage in carbon offsetting to a non-negligible extent (e.g., Akter et al., 2009; Nakamura and Kato, 2013; Araghi et al., 2014). Potential explanations for this phenomenon are additional benefits, which derive from the climate-friendly activity, e.g., in terms of preferences of environmental quality, a good feeling, gains in identity, or social approval. In this respect, voluntary carbon offsetting can be regarded as an impure public good (e.g., Kotchen, 2005).

Besides individual preferences for environmental quality, the concept of impure altruism or “warm glow” (e.g., Andreoni, 1989, 1990) may be an important approach to explain individual contributions to carbon offsetting. Warm glow can be described as a good feeling, which is experienced through the sole act of giving and can be regarded as the private component of the impure public good. While for purely altruistic individuals the needs of others are of crucial importance, impure altruism is motivated by egoism (e.g., Andreoni, 1989, 1990). In the context of individual climate protection activities, Clark et al. (2003) asked 261 participants of a green electricity program in the United States to rank five motives in order of their importance for participating. Warm-glow altruism (i.e. responding “yes” to the statement “I take satisfaction in participating in this program, regardless of its environmental effects.”) was ranked as least important. In contrast, Menges et al. (2005) conducted an experiment among 200 participants from two German cities concerning their willingness to pay for green electricity and found evidence for impure altruistic behavior. Moreover, numerous experiments and studies underpin the relevance of warm glow with regard to charitable giving and donations (e.g., Crumpler and Grossman, 2008; Konow, 2010). Thus, the following hypothesis is examined in our empirical analysis:

*Hypothesis 2: Individuals who associate their contribution with a good feeling (warm glow) are more likely to engage in voluntary carbon offsetting.*

Another important motive to explain individual contributions to carbon offsetting may be the identity of a person, which influences her behavior. Akerlof and Kranton (2000) describe identity as the internalization of the behavioral rules belonging to a certain social category. Choosing activities, which are not compliant with these rules, leads to a loss in identity accompanied by a loss in utility for the individual and others belonging to this social category (e.g., Akerlof and Kranton, 2000). According to the authors, in-group norms have the potential to solve the free-rider problem. Kotchen and Moore (2008), for instance, used the membership in an environmental organization to classify households as conservationists and showed that this group consumes almost 10% less conventional electricity and is more likely to participate in green-electricity programs. Hence, the following hypothesis is examined in our empirical analysis:

*Hypothesis 3: Individuals who possess an environmentally conscious identity are more likely to engage in voluntary carbon offsetting.*

Similarly, Holländer (1990) defines social norms as being the object of others' positive emotions. By complying with social norms the individual seeks to get social approval and avoid disapproval (e.g., Nyborg and Rege, 2003). According to the sociological theory, a behavioral norm or code of conduct reflects the normative expectations of the group members regarding the behavior of others. As the group rewards or punishes positive as well as negative deviation, individuals adjust their behavior (e.g., Holländer, 1990; Nyborg and Rege, 2003). The higher the utility of the own contribution for others, the stronger is the experience of social appreciation (e.g., Nyborg and Rege, 2003). In addition, the social approval based on norm compliant behavior seems to be positively correlated with the share of the population that acts according to these norms (e.g., Rege, 2004). Therefore, norms of society should have a greater influence on individual behavior than behavioral rules of families and friends if these rules are contradictory. In this respect, Araghi et al. (2014) demonstrate that travelers are more likely to offset their emissions from air-traveling if the collective participation rate is high. These results suggest that there is in fact a preference for social approval and that revealing the contributions of other individuals has a significant impact on the behavior. Hence, the following hypothesis is examined in our empirical analysis:



*Hypothesis 4: Individuals who experience social pressure in terms of expectations of their social environment or the society are more likely to engage in voluntary carbon offsetting.*

Social behavior of individuals is also highly dependent on the social behavior of others. Amongst others, Holländer (1990) finds a positive correlation between the individual contribution and the contribution of others. The mere information that a huge quantity of other individuals contribute to a public good can significantly increase the average contribution rate (e.g., Frey and Meier, 2004; Blasch and Farsi, 2013). Frey and Meier (2004) observe in their field experiment that the higher the expectation about the average group behavior, the more likely is a voluntary donation to charitable funds, while Blasch and Farsi (2013) found offsetting to be strongly driven by adherence to social norms and expectations about the cooperation of others. Hence, the following hypothesis is examined in our empirical analysis:

*Hypothesis 5: Individuals are more likely to engage in voluntary carbon offsetting if their social environment (family, friends or colleagues) also makes a contribution to climate protection.*

In addition, Schwartz (1973) defines personal responsibility of an individual as the awareness of the consequences in a specific situation for the collectivity. At the same time, the individual is supposed to internalize personal norms concerning the certain activity and have controlling impact on the activity as well as on its results. The influence on individual behavior by social norms is therefore considerably stronger when the disposition to assume responsibility is higher (e.g., Schwartz, 1973). Akter et al. (2009), for instance, showed in their case study that the perceived individual responsibility for contributing to climate change has a significantly positive effect on the probability of actually paying the carbon travel tax. Moreover, Lange and Ziegler (2012) found a positive interrelation of the perceived responsibility of road traffic for carbon emissions and the probability of purchasing carbon offsets. Further studies also support the hypothesis that moral obligation leads to higher probability to engage in offsetting (e.g., Brouwer et al., 2008; Akter et al., 2009; Blasch and Farsi, 2013). Hence, the following hypothesis is examined in our empirical analysis:

*Hypothesis 6: Individuals who take on responsibility for climate protection are more likely to engage in voluntary carbon offsetting.*

Furthermore, the perceived effectiveness of carbon offsetting is supposed to be positively interrelated with the engagement in offsetting (e.g., Brouwer et al., 2008; Akter et al., 2009).

### 3. Data and variables

The data for our analyses stem from representative online surveys among a total of 1005 citizens in Germany and 1010 citizens in the United States aged 18 and older. The surveys were carried out in May and June 2013 by the market research company GfK SE (Gesellschaft für Konsumforschung) drawing the sample from the GfK Online Panel based on the official population statistics of the particular country. The questionnaire collected information about general personal assessments of climate change, specific attitudes towards international climate policy and negotiations, as well as individual engagement in climate-friendly activities and carbon offsetting. In order to measure the attitudes and beliefs, we asked the respondents to specify their level of agreement with particular statements on a symmetric scale with five ordered response levels (i.e. “very weakly”, “rather weakly”, “neither weakly nor strongly”, “rather strongly”, and “very strongly”). We discuss potential problems associated with this kind of scale in Schleich et al. (2013).

To draw meaningful conclusions, our micro-econometric analyses comprise a mix of two methodological approaches. In the first step, a binary discrete choice analysis is performed. In this respect, respondents were asked if they have already engaged in carbon offsetting in the past to compensate the carbon emissions they caused and if they would be prepared to engage in carbon offsetting in the future. Based on the binary structure of the response options, we construct two dummy variables (i.e. *past offsetting* and *planned future offsetting*) that take the value one if the respondent answered “yes” to the corresponding question. Since statistically significant parameter estimates with regard to *past offsetting* may not reflect a causal relationship with the associated explanatory, we refer to correlation rather than causality when discussing the results. Furthermore, we construct a combined variable (i.e. *past or future offsetting*), which reflects a general tendency to offset the own emissions and takes the value one if the respondent already engaged in offsetting in the past or stated to be willing to engage in the future.

Due to the binary structure of these dependent variables, we apply common univariate binary probit models to estimate the determinants of offsetting. To allow for the potential interdependencies between the decision on past and planned future offsetting, we check the robustness of our results by applying bivariate binary probit models. Besides parameter estimates, these models incorporate the estimation of correlation coefficients between the dependent dummy variables in the corresponding error terms of the underlying latent variables (Greene, 2012). For our models, these correlation coefficients are estimated to be 0.47 for Germany

and 0.63 for the United States (both statistically significant at the 1% level). These values can be interpreted as the conditional tetrachoric correlation and incorporate the joint determination of two dependent variables after the influence of the included explanatory variables is accounted for (Greene, 2012). The corresponding parameters in the univariate as well as the bivariate probit models are estimated via maximum likelihood method, correcting for heteroskedasticity (White, 1982). In addition, we discuss the estimates of the discrete probability effects for the variables with a significant effect.

It should be noted that the basic alternatives of the binary dependent variables *past offsetting* and *planned future offsetting* are very heterogeneous, since they contain respondents with a tendency to offset their carbon emissions as well as respondents who never engaged in offsetting yet and are not willing to offset in the future. Therefore, a binary probit analysis cannot carve out the determinants of specific combinations of the respondents' past and planned future offsetting activities. On this account, in the second step of our analyses multinomial discrete choice models are applied by constructing suitable mutually exclusive alternatives, i.e. *offsetting neither already taken, nor planned in the future* (base category), *offsetting not yet taken, but planned in the future*, and *offsetting already taken and planned in the future*. This specification further enables the analysis of the factors affecting behavioral changes, i.e. *offsetting not yet taken, but planned in the future*. If we assume the stochastic component in our model to be independently and identically distributed with Type I extreme value density functions, we obtain the common multinomial logit model. The simple structure of the probabilities of the realization of an alternative allows applying maximum likelihood method.

To test the effect of a higher awareness of the free-rider problem according to hypothesis 1, respondents were asked to agree to the statement "Others who don't make a contribution to climate protection themselves would benefit from my contribution". The corresponding binary explanatory variable *awareness of free-rider problem* takes the value one if the respondent agrees rather strongly or very strongly. With respect to hypothesis 2, we construct another dummy variable *warm glow*, which takes the value one if the respondent agrees rather strongly or very strongly to the statement "It makes me feel good to contribute to climate protection". The next three groups of explanatory variables are concerned with the social norms that influence the behavior of the respondent. To carve out the impact of an environmentally conscious identity according to hypothesis 3, we construct two dummy variables which indicate a raised awareness for environmental and climate change issues. The variable *member of environmental organization* takes the value one if the respondent is a member of a group or organ-

ization that engages in the preservation and protection of the environment and nature and *identifying with green politics* takes the value one if the respondent agrees rather strongly or very strongly to the statement “I identify myself closest with green politics”. Additionally, we control for the influence of the expectations of the environment and of the society according to hypothesis 4 by including two dummy variables *expectation of social environment* and *expectation of society*, which take the value one, if the respondent agrees rather strongly or very strongly to the statements “My family, friends or colleagues expect me to contribute to climate protection” and “Society expects me to contribute to climate protection”, respectively. Moreover, in order to test hypothesis 5, another dummy variable *contribution of social environment* takes the value one, if the respondent agrees rather weakly or very weakly to the statement “My family, friends or colleagues do not contribute to climate protection”. Finally, we test hypothesis 6 by including a dummy variable *feeling responsible for climate protection*, which takes the value one if the respondent agrees rather strongly or very strongly to the statement “I feel responsible for making a contribution to climate protection”. Since the efficiency of an activity to protect the climate might play an important role, we construct the dummy variable *high contribution*, which indicates that the respondent believes that carbon offsetting contributes rather a lot or a lot to climate protection.

In addition, we control for several socio-demographic characteristics of the respondents, namely the variable *age of the respondent* (in years), the gender dummy variable *female* that takes the value one if the respondent is a woman, the variable *number of own children*, the variable *household size*, which indicates the number of people living in the household of the respondent, the dummy variable living with a partner for the marital status of the respondent, and the dummy variable *highly educated* if the respondent received the general qualification for university entrance. Additionally, the dummy variable *high household income* takes the value one if the monthly net income of the household (the underlying question was based on several income intervals) amounts to at least 3000 Euros (i.e. about 4120 US-Dollar at the exchange rate applicable in December 2013), and 4000 US-Dollars, respectively, and, thus, exceeds the corresponding median income interval of the country sample. Finally, to control for regional heterogeneity, the set of explanatory variables includes the regional dummy *west* for people living in Western Germany as well as the dummies *west*, *midwest*, *northeast*, and *south*, which indicate that the respondent lives in the corresponding region of the United States. For both countries, Tables 1 and 2 report several descriptive statistics (i.e. mean, standard deviation, minimum, maximum) of the full samples.

To draw reliable conclusions for the total population, we employed specific weights for our statistical analyses, which were calculated by the survey institute to ensure offline representativeness of the results. For this reason, the unweighted values in Tables 1 and 2 differ from the shares reported in Section 4.

#### **4. Empirical results**

In Germany, 7.37% of the population already engaged in carbon offsetting, while 32.28% stated to be willing to offset their emissions in the future after receiving information about the procedure of voluntary carbon offsetting. Among those who already engaged in carbon offsetting 34.62% compensated emissions caused by flying, 11.33% emissions caused by staying in hotels or guest houses, 23.62% emissions caused by car journeys (including car rentals), 19.94% emissions caused by logistics (mail order), 48.16% emissions caused by energy consumption at home, and 5.17% all their emissions within a certain period of time. 37.48% received their carbon offsets directly (e.g., when booking a flight), 13.01% booked them via a provider of compensatory measures (e.g., atmosfair, myclimate), and 12.50% compensated by direct payments to a climate protection project. In Germany, the age of individuals who already engaged in carbon offsetting ranges from 19 to 68 years with a mean value of 44 years. Additionally, 46.51% are female, 65.54% received the general qualification for university entrance, 82.45% live in Western Germany, 28.24% are single and 63.86% live together with a partner.

In the United States, 12.37% of the respondents already engaged in carbon offsetting, while 31.86% stated to be willing to offset their emissions in the future. Among those who already engaged in carbon offsetting 35.66% compensated emissions caused by flying, 30.18% emissions caused by staying in hotels or guest houses, 56.11% emissions caused by car journeys (including car rentals), 25.72% emissions caused by logistics (mail order), 45.03% emissions caused by energy consumption at home, and 16.75% offset all their emissions within a certain period of time. 38.39% booked the carbon offsets directly (e.g., when booking a flight), 45.47% booked them via a provider of compensatory measures (e.g., greenmountain.com), and 25.93% directly paid to a climate protection project. In the United States, the age of individuals who already engaged in carbon offsetting ranges from 19 to 81 years with a mean value of 39 years. Furthermore, 32.08% are female, 76.07% received the general qualification for university entrance, 33.81% are single and 55.62% live together with a partner. 21.99% of

the people who already engaged in carbon offsetting live in the western part of the United States, 19.14% in the Midwest, 26.64% in the Northeast, and 32.23% in the South.

Tables 3 and 4 report the parameter estimates in the univariate binary probit models for the determinants of offsetting for Germany and the United States. While the first column refers to *past or future offsetting* and, thus, the general tendency to offset the own emissions, the second and third column report the estimation results of the determinants of *past offsetting* and *planned future offsetting* in the two countries, respectively. In both countries, the perception of a *high contribution* of carbon offsetting to climate protection is of paramount importance for the engagement in offsetting, since all of the parameter estimates are significantly positive at least at the 5% level. These findings are confirmed by the estimation results in the bivariate binary probit models reported in Tables 5 and 6. The estimates of average probabilities at minimum and maximum values of explanatory variables with a statistically significant effect, reported in Tables 7 to 10, show that the estimated average probability of *planned future offsetting* increases by 36.6 percentage points from 38.6% at the minimum level of *high contribution* to 75.2% at the maximum level in Germany, but by only 7.4 percentage points in the United States.

With respect to our first hypothesis, the *awareness of the free-rider problem* significantly decreases the general tendency to offset the own emissions (*past or future offsetting*) as well as the willingness to engage in offsetting in the future in Germany. In the United States, in contrast, we find a significantly positive interrelation of the *awareness of the free-rider problem* and the general tendency to offset the own emissions (*past or future offsetting*). This finding might be an indicator that the engagement in offsetting is motivated by purely altruistic reasons, instead of being negatively affected by the awareness of the free-rider phenomenon. Altogether, our first hypothesis can be confirmed for Germany, but not for the United States.

The feeling of *warm glow* according to hypothesis 2 has a significantly positive effect on the future willingness to engage in carbon offsetting in Germany. By allowing for correlations between *past offsetting* and *planned future offsetting* in the corresponding error terms, the parameter estimate for past offsetting in the bivariate binary probit model gets also significantly positive at the 1% level. According to the estimated average probability, the willingness of German respondents to engage in offsetting increases by 18.5 percentage points from 48.9% at the minimum level of *warm glow* to 67.4% at the maximum level. In the United States, the decision to engage in offsetting is not influenced by impurely altruistic motives,

i.e. none of the parameter estimates in the univariate and bivariate binary probit models is significantly different from zero.

The effect of an environmentally conscious identity according to hypothesis 3 also differs in the two countries. In Germany, only the general tendency to offset the own emissions (*past or future offsetting*) is significantly positively interrelated with *identifying with green politics*, while the other parameter estimates for *member of environmental organization* and *identifying with green politics* are not significantly different from zero. In the United States, in contrast, being a *member of an environmental organization* is positively interrelated with the engagement in offsetting, since the parameter estimates are significantly different from zero at least at the 1% level for the three dependent variables, and *identifying with green politics* is significantly positively correlated with the past engagement in offsetting. These findings again conform with the estimation results in the bivariate binary models and suggest that an environmentally conscious identity has a strong effect on the engagement in offsetting in the United States, while offsetting is not the preferred measure to reduce carbon emissions for German citizens with an increase in environmental awareness. In other words, German citizens with an environmentally conscious identity do not differ from other individuals with respect to their decisions to engage in offsetting.

With regard to hypotheses 4 to 5, social norms also seem to play a more important role in the United States. In Germany, *expectation of society* is even negatively correlated with the past engagement in carbon offsetting. In the United States, the *expectation of society* is significantly positively correlated with *past offsetting* and significantly increases the probability of *planned future offsetting*, while the *contribution of social environment* is positively correlated with *past offsetting*. In contrast, the parameter estimates for *expectation of social environment* are not significantly different from zero. The magnitude of the effect of *expectation of society* is most noteworthy in the United States as the stated willingness to engage in offsetting in the future increases by 21.8 percentage points if society expects the respondent to contribute to climate protection. These results also indicate that social norms are of greater relevance for compensating carbon emission than behavioral rules of the social environment as discussed in section 2. Thus, our findings partly confirm hypotheses 4 and 5 for citizens from the United States.

Our final hypothesis 6 can be clearly confirmed, as *feeling responsible for climate protection* has a significantly positive impact on *planned future offsetting* and is also significantly positively correlated with the general tendency to offset the own emissions (*past or future offset-*

ting) in both countries. Most remarkably, the estimated average probability of *feeling responsible for climate protection* increases the willingness to engage in carbon offsetting of German respondents by 22.8 percentage points and of US respondents by 24.9 percentage points. Our estimation results concerning hypotheses 4 to 6 again are robust with regard to the parameter estimates in the bivariate binary probit models.

Since our indicators might be highly correlated, we additionally conducted several Wald tests to carve out joint impacts. The results of these tests show that the indicators for an environmentally conscious identity (i.e. *member of environmental organization* and *identifying with green politics*) have a common effect (statistically significant at the 1% level) on both dependent variables in the United States statistically significant at the 1% level, but not in Germany. In the United States, the three indicators for social norms (i.e. *expectation of social environment*, *expectation of society* and *contribution of social environment*) also have a common impact on the willingness to engage in offsetting in the future statistically significant at the 5% level, which emphasizes the important role of these indicators in this country.

In contrast, the socio-economic characteristics are of minor importance. In Germany, no robust effect on the general tendency to offset the own emissions (*past or future offsetting*) and on *planned future offsetting* can be detected. With regard to *past offsetting*, *highly educated* exhibits a positive correlation, which is robust in the univariate and bivariate models. In the United States, *age of the respondent* is significantly negatively correlated with *past offsetting* and the general tendency to offset the own emissions (i.e. *past or future offsetting*). Additionally, living in the Northeast of the United States is positively interrelated with *past offsetting* and respondents living in the Midwest of the United States are less likely to engage in carbon offsetting in the future compared to respondents living in the South (base category). The group of socio-economic characteristics has (on the basis of the results from corresponding Wald tests) a joint significant correlation on *past offsetting* in both countries, statistically significant at least at the 10% level.

Tables 11 and 12 report the estimation results in the multinomial logit models. For the interpretation of these results, it must be noted that *offsetting neither already taken, nor planned in the future* (first column) is the base category, so that the results in the second and third column have to be interpreted in relation to this category. In Germany, the parameter estimates of *offsetting not yet taken, but planned in the future* suggest that the perception of a *high contribution* of offsetting to climate protection, a feeling of *warm glow*, *feeling responsible for climate protection* and being *female* are associated with a significantly higher probability of this



behavioral change with regard to the future engagement in offsetting. In contrast, German respondents who are *aware of the free-rider problem* or are *highly educated* are significantly less likely to plan offsetting in the future, although not yet taken, compared to the base category and, thus, are significantly less likely to undertake this behavioral change. German respondents who perceive a *high contribution* of offsetting to climate protection and get a feeling of *warm glow* are also significantly more likely to be in the third category, i.e. *offsetting already taken and planned in the future*. In the United States, the probability of being in the category *offsetting not yet taken, but planned in the future* and, thus, conducting a behavioral change, is significantly positively affected by the perception of a *high contribution*, being a *member of an environmental organization*, the *expectation of society*, the *contribution of social environment*, and *feeling responsible for climate protection*, but also negatively influenced by a *high household income* as well as living in the *Midwest* or the *Northeast*. US respondents who perceive a *high contribution*, are a *member of an environmental organization*, *identify with green politics*, and experience a great *expectation of society* or expect a higher *contribution of their environment* are significantly more likely to be in the third category, i.e. *offsetting already taken and planned in the future*, compared to the base category.

## **5. First conclusion**

In order to limit the dangerous impacts of anthropogenic climate change, our empirical analysis implies that in both Germany and the United States voluntary carbon offsetting seems to be a promising complement for directly reducing carbon emissions. According to our microeconomic analysis based on unique data from a representative survey among more than 2000 citizens from Germany and the United States, a feeling of warm glow and responsibility for climate protection play significant roles for the stated willingness to engage in carbon offsetting in the future as well as for the propensity to plan offsetting in the future, although not yet taken, in both countries. Besides these factors, the awareness of the free-rider phenomenon decreases the probability of future offsetting as well as behavioral changes (i.e. planning to offset in the future, although not yet taken) in Germany, while social norms and an environmentally conscious identity are of particular importance for future offsetting and behavioral changes (i.e. planning to offset in the future, although not yet taken) in the United States. Our findings also suggest that the belief in the effectiveness of carbon offsetting is the factor with the highest relevance, since it positively influences past and planned future offsetting as

well as behavioral changes (i.e. planning to offset in the future, although not yet taken) in both countries.

These estimation results can be used by policy makers as well as providers of carbon offsets in order to increase the extent of individual carbon offsetting. One possible policy direction is an appropriate regulation of the carbon offsetting market (e.g., by corresponding certificates) so that the confidence of individuals in the effectiveness of this market can be increased. Voluntary carbon offsetting can also be regarded as an appropriate opportunity to raise public consciousness about climate change and its consequences. In this respect, public policy may also have the potential to strengthen social norms concerning voluntary climate-friendly activities.

While our analyses focus on differences between citizens in Germany and the United States, future research might explore the determinants of voluntary carbon offsetting in further countries or apply an experimental approach for an in-depth study of the propensity to offset the own carbon emissions. Future research could also explore the interrelation between voluntary carbon offsetting and further climate-friendly activities in a cross-country comparison. In this respect, a potential substitution effect is of particular interest.

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## Appendix

Table 1: Descriptive statistics (unweighted) of dependent and explanatory variables for overall 1,005 observations in Germany

Variables	Number of observations	Mean	Standard deviation	Minimum	Maximum
Past offsetting	788	0.11	0.31	0	1
Planned future offsetting	572	0.55	0.50	0	1
High contribution	892	0.54	0.50	0	1
Awareness of free-rider problem	907	0.38	0.49	0	1
Warm glow	963	0.56	0.50	0	1
Member of environmental organization	994	0.10	0.30	0	1
Identifying with green politics	938	0.30	0.46	0	1
Expectation of social environment	935	0.19	0.40	0	1
Expectation of society	944	0.32	0.47	0	1
Contribution of social environment	912	0.42	0.49	0	1
Feeling responsible for climate protection	965	0.54	0.50	0	1
Age of respondent	1,005	41.13	12.52	18	89
Female	1,005	0.49	0.50	0	1
Number of own children	1,005	0.95	1.12	0	5
Household size	1,005	2.50	1.25	1	14
Living with a partner	1,002	0.63	0.48	0	1
Highly educated	1,000	0.55	0.50	0	1
High household income	822	0.41	0.49	0	1
West	1,005	0.79	0.41	0	1

Table 2: Descriptive statistics (unweighted) of dependent and explanatory variables for overall 1,010 observations in the United States

Variables	Number of observations	Mean	Standard deviation	Minimum	Maximum
Past offsetting	750	0.14	0.35	0	1
Planned future offsetting	549	0.57	0.50	0	1
High contribution	778	0.49	0.50	0	1
Awareness of free-rider problem	912	0.41	0.49	0	1
Warm glow	947	0.54	0.50	0	1
Member of environmental organization	974	0.13	0.33	0	1
Identifying with green politics	907	0.21	0.41	0	1
Expectation of social environment	896	0.26	0.44	0	1
Expectation of society	916	0.44	0.50	0	1
Contribution of social environment	872	0.24	0.43	0	1
Feeling responsible for climate protection	944	0.49	0.50	0	1
Age of respondent	1,010	48.51	14.46	18	85
Female	1,010	0.53	0.50	0	1
Number of own children	1,010	1.32	1.39	0	8
Household size	1,010	2.51	1.28	1	10
Living with a partner	1,006	0.62	0.49	0	1
Highly educated	1,006	0.68	0.47	0	1
High household income	864	0.37	0.48	0	1
West	1,010	0.22	0.41	0	1
Midwest	1,010	0.23	0.42	0	1
Northeast	1,010	0.20	0.40	0	1
South	1,010	0.35	0.48	0	1

Table 3: ML estimates (z-statistics) of parameters in the univariate binary probit model in Germany

Explanatory Variables	Dependent variable: past offsetting	Dependent variable: planned future off- setting	Dependent variable: past or future offset- ting
High contribution	0.38** (2.26)	1.20*** (7.19)	0.74*** (5.14)
Awareness of free-rider problem	0.05 (0.29)	-0.45** (-2.43)	-0.31** (-2.10)
Warm glow	0.33 (1.52)	0.67*** (3.16)	0.26 (1.39)
Member of environmental organization	0.06 (0.23)	0.10 (0.35)	0.14 (0.57)
Identifying with green politics	-0.01 (-0.08)	-0.02 (-0.13)	0.30* (1.91)
Expectation environment	0.21 (1.06)	-0.04 (-0.20)	0.00 (0.02)
Expectation society	-0.42** (-2.45)	0.15 (0.75)	0.22 (1.38)
Contribution of social environment	0.16 (0.89)	-0.07 (-0.38)	0.02 (0.13)
Feeling responsible for climate protection	0.07 (0.32)	0.81*** (3.59)	0.50*** (2.72)
Age of respondent	-0.00 (-0.30)	0.00 (0.44)	-0.00 (-0.48)
Female	-0.13 (-0.75)	0.38** (2.10)	0.07 (0.47)
Number of own children	-0.16* (-1.81)	0.04 (0.33)	-0.07 (-0.86)
Household size	0.13 (1.50)	-0.11 (-1.25)	0.01 (0.16)
Living with a partner	0.08 (0.37)	0.14 (0.71)	0.01 (0.08)
Highly educated	0.39** (1.96)	-0.05 (-0.26)	-0.02 (-0.14)
High household income	0.14 (0.72)	-0.02 (-0.08)	-0.08 (-0.49)
West	-0.09 (-0.43)	-0.09 (-0.49)	-0.16 (-1.04)
Constant	-2.14*** (-4.56)	-1.13** (-2.28)	-0.86** (-2.36)
Observations	546	415	594

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 4: ML estimates (z-statistics) of parameters in the univariate binary probit model in the United States

Explanatory Variables	Dependent variable: past offsetting	Dependent variable: planned future off- setting	Dependent variable: past or future offset- ting
High contribution	0.58*** (2.78)	0.61*** (3.27)	0.69*** (4.56)
Awareness of free-rider problem	0.29 (1.45)	0.15 (0.69)	0.46*** (2.72)
Warm glow	-0.14 (-0.57)	0.22 (0.90)	0.03 (0.15)
Member of environmental organization	0.59*** (2.88)	0.68*** (2.67)	0.52*** (2.69)
Identifying with green politics	0.61*** (2.91)	-0.16 (-0.74)	0.12 (0.63)
Expectation environment	-0.03 (-0.14)	-0.17 (-0.79)	-0.02 (-0.09)
Expectation society	0.32* (1.73)	0.31* (1.66)	0.23 (1.47)
Contribution of social environment	0.37* (1.82)	0.32 (1.58)	0.23 (1.34)
Feeling responsible for climate protection	-0.04 (-0.14)	0.90*** (3.56)	0.64*** (3.18)
Age of respondent	-0.02*** (-3.09)	0.01 (0.87)	-0.02*** (-3.13)
Female	-0.34* (-1.94)	0.08 (0.44)	-0.18 (-1.20)
Number of own children	-0.05 (-0.56)	-0.03 (-0.45)	0.02 (0.38)
Household size	0.02 (0.23)	0.11 (1.46)	0.00 (0.06)
Living with a partner	0.34* (1.67)	0.11 (0.57)	0.11 (0.73)
Highly educated	-0.19 (-0.91)	0.11 (0.58)	0.19 (1.18)
High household income	0.25 (1.35)	-0.17 (-0.98)	-0.01 (-0.06)
West	0.16 (0.69)	0.19 (0.85)	0.31 (1.60)
Midwest	0.23 (0.99)	-0.37* (-1.84)	-0.11 (-0.64)
Northeast	0.51** (2.18)	-0.12 (-0.48)	0.11 (0.55)
Constant	-1.06** (-2.43)	-1.57*** (-3.78)	-0.79** (-2.26)
Observations	500	397	536

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.



Table 5: ML estimates (z-statistics) of parameters in the bivariate binary probit model in Germany

Explanatory Variables	Dependent variable: past offsetting	Dependent variable: planned future offsetting
High contribution	0.86*** (4.06)	1.22*** (7.21)
Awareness of free-rider problem	0.03 (0.13)	-0.45** (-2.47)
Warm glow	0.74*** (2.93)	0.79*** (3.74)
Member of environmental organization	0.21 (0.74)	0.28 (0.89)
Identifying with green politics	-0.06 (-0.26)	0.03 (0.16)
Expectation environment	0.23 (1.03)	0.07 (0.29)
Expectation society	-0.42* (-1.95)	0.11 (0.59)
Contribution of social environment	-0.02 (-0.10)	0.05 (0.28)
Feeling responsible for climate protection	-0.19 (-0.77)	0.69*** (3.15)
Age of respondent	-0.00 (-0.35)	0.00 (0.21)
Female	-0.06 (-0.27)	0.25 (1.48)
Number of own children	-0.08 (-0.84)	-0.00 (-0.02)
Household size	0.07 (0.58)	-0.06 (-0.61)
Living with a partner	0.05 (0.22)	0.10 (0.52)
Highly educated	0.42* (1.76)	-0.15 (-0.80)
High household income	0.39* (1.70)	-0.18 (-0.84)
West	-0.11 (-0.41)	-0.23 (-1.28)
Constant	-2.42*** (-4.28)	-1.11** (-2.35)
Observations	367	367

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 6: ML estimates (z-statistics) of parameters in the bivariate binary probit model in the United States

Explanatory Variables	Dependent variable: past offsetting	Dependent variable: planned future offsetting
High contribution	0.66*** (2.81)	0.58*** (3.04)
Awareness of free-rider problem	0.28 (1.25)	-0.01 (-0.06)
Warm glow	-0.05 (-0.21)	0.36 (1.51)
Member of environmental organization	0.62*** (2.86)	0.60** (2.41)
Identifying with green politics	0.65*** (3.01)	0.06 (0.27)
Expectation environment	0.03 (0.16)	-0.19 (-0.81)
Expectation society	0.47** (2.32)	0.46** (2.43)
Contribution of social environment	0.28 (1.26)	0.51** (2.55)
Feeling responsible for climate protection	-0.28 (-0.98)	0.69*** (2.61)
Age of respondent	-0.02** (-1.99)	0.00 (0.65)
Female	-0.27 (-1.33)	-0.07 (-0.39)
Number of own children	-0.07 (-0.77)	-0.07 (-1.04)
Household size	-0.02 (-0.23)	0.11 (1.60)
Living with a partner	0.32 (1.42)	0.07 (0.33)
Highly educated	-0.02 (-0.07)	0.04 (0.19)
High household income	0.27 (1.33)	-0.09 (-0.55)
West	-0.02 (-0.07)	0.21 (0.93)
Midwest	0.18 (0.72)	-0.38* (-1.88)
Northeast	0.49* (1.90)	-0.13 (-0.49)
Constant	-1.33*** (-2.91)	-1.43*** (-3.60)
Observations	361	361

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 7: Estimates of average probabilities at minimum and maximum values of explanatory variables with a significant effect in the binary probit model in Germany, dependent variable “past offsetting”

Explanatory variables with significant effect	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
High contribution	0.054	0.116
Warm glow	0.064	0.109
Expectation society	0.110	0.065
Highly educated	0.059	0.113
Number of own children	0.124	0.026

Table 8: Estimates of average probabilities at minimum and maximum values of explanatory variables with a significant effect in the binary probit model in Germany, dependent variable “planned future offsetting”

Explanatory variables with significant effect	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
High contribution	0.386	0.752
Awareness of free-rider problem	0.630	0.520
Warm glow	0.489	0.674
Feeling responsible for climate protection	0.462	0.690
Female	0.545	0.645

Table 9: Estimates of average probabilities at minimum and maximum values of explanatory variables with a significant effect in the binary probit model in the United States, dependent variable “past offsetting”

Explanatory variables with significant effect	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
High contribution	0.112	0.285
Member of environmental organization	0.174	0.315
Identifying with green politics	0.158	0.310
Expectation society	0.167	0.236
Contribution of social environment	0.185	0.253
Age of respondent	0.279	0.113
Female	0.236	0.150
Living with a partner	0.195	0.211

Table 10: Estimates of average probabilities at minimum and maximum values of explanatory variables with a significant effect in the binary probit model in the United States, dependent variable “planned future offsetting”

Explanatory variables with significant effect	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
High contribution	0.632	0.706
Member of environmental organization	0.627	0.814
Expectation society	0.559	0.777
Feeling responsible for climate protection	0.522	0.771
Midwest	0.709	0.551

Table 11: ML estimates (z-statistics) of parameters in the multinomial logit model in Germany, base category: offsetting neither already taken, nor planned in the future

Explanatory Variables	Offsetting not yet taken, but planned in the future	Offsetting already taken and planned in the future
High contribution	2.22*** (6.95)	2.44*** (4.91)
Awareness of free-rider problem	-0.94*** (-2.63)	-0.34 (-0.74)
Warm glow	1.36*** (3.65)	1.90*** (3.26)
Member of environmental organization	0.75 (1.26)	0.46 (0.61)
Identifying with green politics	0.04 (0.10)	-0.06 (-0.12)
Expectation environment	0.28 (0.60)	0.27 (0.47)
Expectation society	0.41 (1.10)	-0.49 (-0.98)
Contribution of social environment	-0.23 (-0.68)	0.17 (0.33)
Feeling responsible for climate protection	1.36*** (3.23)	0.62 (1.08)
Age of respondent	-0.01 (-0.62)	0.01 (0.47)
Female	0.73** (2.25)	0.09 (0.19)
Number of own children	0.05 (0.23)	-0.15 (-0.68)
Household size	-0.11 (-0.63)	0.04 (0.17)
Living with a partner	0.37 (0.98)	0.04 (0.07)
Highly educated	-0.83** (-2.25)	0.61 (1.15)
High household income	-0.40 (-0.98)	0.37 (0.71)
West	-0.17 (-0.49)	-0.83 (-1.46)
Constant	-1.72** (-2.00)	-4.50*** (-3.64)
Observations	361	

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 12: ML estimates (z-statistics) of parameters in the multinomial logit model in the United States, base category: offsetting neither already taken, nor planned in the future

Explanatory Variables	Offsetting not yet taken, but planned in the future	Offsetting already taken and planned in the future
High contribution	1.07*** (2.90)	1.34*** (2.76)
Awareness of free-rider problem	0.11 (0.24)	0.19 (0.39)
Warm glow	0.69 (1.47)	0.32 (0.60)
Member of environmental organization	0.94* (1.87)	1.82*** (3.63)
Identifying with green politics	-0.37 (-0.77)	0.86* (1.71)
Expectation environment	-0.56 (-1.19)	-0.25 (-0.45)
Expectation society	0.84** (2.25)	1.40*** (3.31)
Contribution of social environment	0.70* (1.74)	0.95** (1.97)
Feeling responsible for climate protection	1.73*** (3.31)	0.50 (0.82)
Age of respondent	-0.00 (-0.11)	-0.01 (-0.84)
Female	0.15 (0.39)	-0.54 (-1.25)
Number of own children	-0.05 (-0.38)	-0.15 (-0.80)
Household size	0.05 (0.37)	0.10 (0.64)
Living with a partner	0.04 (0.10)	0.57 (1.20)
Highly educated	0.62 (1.51)	0.04 (0.08)
High household income	-0.70** (-1.97)	0.04 (0.10)
West	-0.12 (-0.26)	0.18 (0.31)
Midwest	-1.20*** (-2.60)	-0.38 (-0.68)
Northeast	-0.96* (-1.73)	0.39 (0.63)
Constant	-2.23*** (-2.90)	-3.07*** (-3.26)
Observations	355	

\* (\*\*, \*\*\*) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.