On the interrelation between the consumption of impure public goods and direct donations: Theory and empirical evidence

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Abstract

This paper provides theoretical and empirical insights on the extent to which the possibility of direct donations to a public good may substitute the individual consumption of impure public goods. Theoretically, we demonstrate an ambiguous impact of donations on the consumption pattern of private and impure public goods and derive conditions under which substitution and complementary effects may occur. We then empirically test our predictions in the context of climate change mitigation using data from representative surveys among more than 2000 citizens in Germany and the U.S. Our empirical results indicate a rather complementary relationship between offsetting and other pro-environmental activities in both countries, although individuals substitute certain clean consumption alternatives by offsetting if they lay a sufficiently large weight on environmental preference or if offsetting is perceived to be relatively effective in providing the public good climate protection.

Keywords: impure public goods; direct donations to public goods; pro-environmental activities; carbon offsetting

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1. Introduction

The question what causes people to voluntarily provide public goods has received substantial interest in the recent literature (for summaries, e.g., List and Price, 2011; List, 2011). While much progress has been made on understanding the determinants of money or time donations, less attention has been given to another important mechanism of contributing to public goods: people may change consumption patterns and, for example, consume products which carry both direct consumption benefits as well as contributions to public goods. In this paper, we provide new theoretical and empirical insights on the interrelation between the consumption of such impure public goods and direct donations to public goods.

The guiding example for our research is the demand for voluntary carbon offsets and their impact on pro-environmental activities (e.g., Kotchen, 2009b). Voluntary carbon offsetting is being promoted to individuals, firms, and organizations as a promising way to reduce their carbon footprint and to help mitigating climate change. By investing in climate protection projects, they can compensate their carbon emissions originating from consumption activities, such as driving, flying, heating buildings, or electricity use. Instead of directly avoiding such emissions, which may be impossible or costly and time-consuming, investments in voluntary offsets may save costs and at the same time may enhance reputation or emotional well-being (e.g., Kollmuss et al., 2008; Kotchen, 2009a; MacKerron et al., 2009).

Such offsetting activities do, however, also face substantial criticism: first, paying others to compensate for own environmental "sins" may have a negative connotation (e.g., Kotchen, 2009a).[1] Second, the procedure may encourage a larger consumption of polluting goods and activities and thereby lead to even higher greenhouse gas emission levels rather than reducing them.[2] That is, the environmental impact of the purchase of voluntary offsets may be ambiguous if offsetting substitutes other pro-environmental activities.

In his general model of pro-environmental consumption, Kotchen (2005) is the first to account for the availability of substitutes for green products and the impact of consumer preferences for the private and the public characteristic. He also analyzes the effects of the possibility of purchasing offsets and shows that free-riding in large economies is reduced due to their

[1] Some critics even compare the concept of voluntary offsetting to the old practice of buying indulgences from the Catholic Church (e.g., Kotchen, 2009b; Lange and Ziegler, 2012).

[2] The potential of adverse environmental effects from offsetting is comparable to a rebound effect which may, for example, result from energy-efficiency improvements and lead to behavioral responses (e.g., Frondel, 2004). Such side effects have the potential to decrease or even reverse the intended impact of environmental policies and have to be taken into account by policy makers and regulators (e.g., Gans and Groves, 2012).

presence (Kotchen, 2009b). In the context of green-electricity consumption[3], Kotchen and Moore (2008) find a complementary relationship between participation in green-electricity programs and energy saving efforts for non-conservationists, while conservationists do not change their energy consumption after participating in green-energy programs. But households purchasing a minimum amount of green electricity increase their electricity consumption indicating a substitution effect which does not occur for households purchasing higher amounts of green electricity (Jacobsen et al., 2012). Similarly, Harding and Rapson (2014) find that signing up for a green-electricity program that offsets emissions from energy use increases energy consumption.

Lange and Ziegler (2012) show theoretically that offsets can be expected to reduce emission levels while not necessarily increasing the consumption of a polluting good in the context of vehicle purchases. Their empirical findings indicate that the purchase of offsets and voluntary mitigation activities by driving license owners in Germany and the U.S. are mainly driven by environmental preferences as well as a high awareness of the negative impacts of climate change and the perception of road traffic as being responsible for carbon emissions. Gans and Groves (2012) apply offsetting to a model of the electricity market and find that voluntary purchases of offsets are most likely to reduce emission levels. Chan and Kotchen (2014) enrich this discussion by generalizing the impure public good model. They argue that an increased contribution of a green good to environmental quality may increase its consumption and decrease direct donations if private and environmental characteristics enter individual utility as substitutes. The reverse result may hold if private and public characteristics are complements in generating individual utility. In this context, Blasch and Farsi (2014) empirically show that individuals with a low carbon footprint are more likely to offset their remaining carbon emissions, thereby indicating a complementary relationship between offsetting and other pro-environmental activities.

Offsetting and other pro-environmental activities form different channels through which an individual may voluntarily contribute to climate protection. They differ in their monetary costs, but also along other dimensions, e.g. time. The literature on charitable giving which investigates giving along different dimensions, e.g. money vs. time donations, can therefore provide relevant insights:[4] donations of time and money were theoretically predicted to be

[3] Participation in green-electricity programs is comparable to donations for climate protection if consumers pay a price premium for using the cleaner alternative.

[4] While offsetting may be associated with money donations, choosing other (costly) pro-environmental activities may change the perceived quality of a private consumption good or may be more time consuming (e.g., car trav-

perfect substitutes (e.g., Duncan, 1999), while empirical studies reveal complementary interdependences between cash donations and volunteer labor (e.g., Brown and Lankford, 1992; Mellström and Johannesson, 2008). Furthermore, offsetting puts a price tag on voluntary carbon reductions which may potentially crowd out intrinsically motivated pro-environmental action (compare, e.g., Gneezy and Rustichini, 2000; Brekke et al., 2003; Bénabou and Tirole, 2006; Falk and Kosfeld, 2006). A related literature on moral-licensing and self-balancing also predicts that pro-environmental activities give individuals a license to choose polluting consumption alternatives in the future and that previous dirty consumption may lead to compensatory measures in order to improve self-image and regain a balanced moral account (e.g., Clot et al., 2014; Croson and Treich, 2014). Recent theoretical, empirical, and experimental work shows that self-image and moral balance are important factors explaining individual decision making (e.g., Stringham, 2011; Ploner and Regner, 2013; Tiefenbeck et al., 2013). Greenberg (2014) discusses prosocial behaviors in light of complementary or substitutionary relations between underlying social norms.

In this paper, we investigate under which conditions direct donations to public goods and the consumption of impure public goods may be substitutes or complements. We both contribute to the theoretical literature on private provisions of public goods and provide empirical evidence by conducting a cross-country analysis. In Section 2, we explicitly model the consumption patterns of private and impure public goods (clean vs. dirty products) in the presence of direct donations (offsets). We show theoretically that complementarities between offsetting and using cleaner options to satisfy private consumption needs can only be expected when offsets are not too effective in generating the public good. When they become highly effective, full substitution away from the cleaner option is predicted as long as the cleaner option is more expensive than the dirty alternative. That is, individuals revert to using more dirty instead of cleaner consumption options due to the availability of effective offsetting. As such, the impact of offsetting on the consumption patterns is potentially ambiguous.

Based on this theoretical modeling, in Sections 3 and 4 we examine the impact of individual purchases of carbon offsets on the likelihood to choose cleaner consumption alternatives.[5] While prior research in this context has focused on green electricity (e.g., Kotchen and Moore, 2008; Jacobsen et al., 2012), we consider a wider range of seven pro-environmental activities which can be taken by individuals in order to reduce greenhouse gas emissions. We

el vs. public transport). Individuals also need time for changing habits in order to save energy at home or for finding adequate alternatives in order to reduce the consumption of meat or dairy products.

[5] This approach differs from the one pursued in the aforementioned study of Blasch and Farsi (2014) who use environmentally conscious behavior as a determinant for the demand of carbon offsets.

analyze the effect of offsetting purchases on pro-environmental activities and include several interactions of offsetting with financial advantages of the pro-environmental activity, the perceived effectiveness of offsetting and the pro-environmental activity in providing climate protection, as well as with environmental preferences and warm glow motives.[6] Using data from unique representative surveys among overall more than 2000 citizens in Germany and the U.S.,[7] we demonstrate that without considering these interactions, offsetting seems to be rather complementary to other pro-environmental activities in both countries, although individuals substitute certain clean consumption alternatives by offsetting if they lay a sufficiently large weight on environmental preference or if offsetting is perceived to be relatively effective in providing the public good climate protection.

The final Section 5 summarizes our theoretical and empirical findings and draws some important conclusions.

2. Theoretical Predictions

We formulate a model in the tradition of Kotchen (2005, 2009b) to capture an individual's demand for private consumption and a public good. The utility function of individual i is given by

$$u_i(z_i, x_i, y_i)$$

where z_i denotes the consumption of a numeraire (money), x_i is the consumption of a private characteristic (e.g., the private consumption of driving a car) and y_i denotes the individual's contribution to a public good.[8] Here, $u_i(z_i, x_i, y_i)$ is an increasing and quasi-concave utility function.

Individuals can spend income w_i on the numeraire z_i, a private good g_i^d, interpreted as a dirty good "d", and an impure public good g_i^c, the clean(er) alternative "c", whose consumption

[6] In contrast to the pro-environmental activities in this paper, an accompanying study (Schwirplies and Ziegler, 2015) investigates how (mainly psychological) motivational factors like social approval, identity, or signaling affect the willingness to use offsetting or to pay a price premium for goods and services that are better for the climate. That is, rather than considering impure public goods, i.e. clean consumption options which also carry private consumption benefits, two alternatives in contributing to climate protection are compared that provide no additional co-benefits

[7] The U.S. and Germany as the largest economy in the European Union (EU) were particularly chosen as both are large emitters and are supposed to play a key role in future international climate policy.

[8] In Kotchen (2009b), this is defined as a public good to which other individuals can also contribute, i.e. $Y = y_i + Y_{-i}$. Here, we concentrate on individual decision only, taking as given the behavior of other players. Our modeling approach therefore corresponds to a warm glow approach by Andreoni (1993) or the concept of moral licensing, as discussed in the introduction, where the individual's moral balance can be maintained through different channels: direct offsetting or the consumption of clean rather than dirty goods.

contributes to the public good at rate β_i^c and to the private characteristic at rate α_i^c, respectively.[9] Each dollar spent on direct donations g_i^ocontributes to the public good at rate β_i^o. Therefore:

$$x_i = \alpha_i^c g_i^c + g_i^d \qquad\qquad y_i = \beta_i^o g_i^o + \beta_i^c g_i^c \,.$$

Prices for all goods are normalized to one such that the budget constraint is given by

$$z_i + g_i^o + g_i^c + g_i^d \leq w_i.$$

While Kotchen (2005, 2009b) is concerned with the impact of introducing an impure public good on the level of the environment, we study how the option of direct donations, interpreted as offsetting option "o", affects the consumption of impure public goods. This is captured by varying the effectiveness parameter β_i^o, i.e. no donation possibilities correspond to $\beta_i^o = 0$, while direct donations could only be a reasonable option if $\beta_i^o > \beta_i{}^c$ since buying only impure public goods would otherwise dominate.

Modeling three consumption options, a private good, an impure public good, and direct donations to the public good, allows us to investigate the determinants of consumption patterns along two dimensions: (i) individuals may substitute some dirty consumption for cleaner alternatives. (ii) they may purchase offsets in order to directly contribute to the public good. We explore how the availability of offsets and an increased effectiveness β_i^o of their use[10] change the consumption patterns for the clean and dirty alternatives.

In order to derive optimal demand, it is helpful to first solve the following cost minimization problem

$$\min g_i^o + g_i^c + g_i^d \text{ such that } x_i \leq \alpha_i^c g_i^c + g_i^d \text{ and } y_i \leq \beta_i^o g_i^o + \beta_i^c g_i^c$$

We immediately obtain the following solution to this cost minimization problem depending on different cases for the effectiveness of the green good in generating private and public characteristics relative to the dirty good and offsetting, respectively:

(A.1) $\quad \alpha_i^c \geq 1, \beta_i^c > \beta_i^o$: $\quad g_i^c = \max\left\{\frac{x_i}{\alpha_i^c}, \frac{y_i}{\beta_i^c}\right\}, \quad g_i^d = 0, \quad g_i^o = 0.$

(A.2) $\quad \alpha_i^c \geq 1, \beta_i^c < \beta_i^o$: $\quad g_i^c = \frac{x_i}{\alpha_i^c}, \quad g_i^d = 0,$

$$g_i^o = \max\left\{0, \frac{\alpha_i^c y_i - \beta_i^c x_i}{\beta_i^o \alpha_i^c}\right\}.$$

[9] Alternatively, one could allow for a negative contribution from the dirty good and a less negative or positive contribution rate from the clean(er) alternative. This would not qualitatively change our results.

[10] An increase in the effectiveness of offsets could equivalently be modelled as a reduction in their price.

(B.1) $\alpha_i^c < 1, \beta_i^c > \beta_i^o$: $g_i^c = \frac{y_i}{\beta_i^c}$, $g_i^d = \max\left\{0, \frac{\beta_i^c x_i - \alpha_i^c y_i}{\beta_i^c}\right\}$,

$g_i^o = 0$

(B.2) $\alpha_i^c < 1, \beta_i^o(1-\alpha_i^c) - \beta_i^c < 0 < \beta_i^o - \beta_i^c$: $g_i^c = \min\left\{\frac{x_i}{\alpha_i^c}, \frac{y_i}{\beta_i^c}\right\}$,

$g_i^d = \max\left\{0, \frac{\beta_i^c x_i - \alpha_i^c y_i}{\beta_i^c}\right\}$, $g_i^o = \max\left\{0, \frac{\alpha_i^c y_i - \beta_i^c x_i}{\beta_i^o \alpha_i^c}\right\}$

(B.3) $\beta_i^o(1-\alpha_i^c) - \beta_i^c > 0$: $g_i^c = 0$, $g_i^d = x_i$, $g_i^o = \frac{y_i}{\beta_i^o}$

Note that cases (A.1) and (A.2) comprise a situation where $\alpha_i^c \geq 1$, i.e. where the clean consumption good is superior to the dirty one even in generating the private characteristic. Here, the dirty good will never be consumed. In (A.1), the individual consumes only the clean good as this dominates offsets in the production of the public characteristic ($\beta_i^c > \beta_i^o$). In (A.2), offsetting may additionally be used. When $\alpha_i^c < 1$ and the effectiveness of offsets is low, case (B.1), the clean good dominates offsetting in the production of the public characteristic such that the clean and possibly the dirty alternative are used. In (B.2), the clean alternative and either the dirty alternative or offsetting are consumed, depending on the demand for y_i vs. x_i. Finally, in case (B.3) of highly effective offsetting, the clean alternative is not used as it is dominated by a combination of the dirty alternative and offsets.[11]

These considerations already show that an individual who uses a clean good when no offsetting options are available ($\beta_i^o = 0$) may fully substitute its use ((B.1) to (B.3)) when offsetting becomes highly effective. This would not occur, however, if the clean alternative already dominates the dirty one in terms of providing the private characteristics, i.e. saves costs relative to using the dirty alternative ((A.1) to (A.2)). We therefore predict for our empirical investigation that the extent to which substitution and/or complementarities between offsetting and clean consumption exist, crucially depends on the perceived effectiveness of offsetting (β_i^o vs. β_i^c) and the perceived costliness of clean consumption (inverse of α_i^c).

It is instructive to illustrate these cases in terms of the budget sets for consuming the characteristics (z_i, x_i, y_i). The budget sets for the cases (A.2), (B.2) and (B.3) are illustrated in Figure 1. The budget frontiers consist of either two (in case (B.2)) or one (in case (A.1) and (B.3)) facets. This geometric representation already lends insights into the impact of offsetting options on possible consumption choices. If $\alpha_i^c \geq 1$ and without effective offsetting ($\beta_i^o \leq$

[11] To mimic the private and public characteristics produced by one unit of the cleaner good (α_i^c, β_i^c), a combination of α_i^c units of the dirty good and β_i^c/β_i^o units of offsets could be used and would be less costly.

β_i^c), offsetting will not take place (the budget set collapses to the bold line in (A.2), while the optimal consumption may move into the interior of the facet for $\beta_i^o > \beta_i^c$).

For $\alpha_i^c \geq 1$ and $\beta_i^o \leq \beta_i^c$, the upper left facet *F1* in (B.2) would be dominated by the right lower facet *F2*. We denote the optimal consumption levels without offsetting options by (z_i^0, x_i^0, y_i^0). For intermediate cases ($\beta_i^c \leq \beta_i^o \leq \frac{\beta_i^c}{1-\alpha_i^c}$), both facets of the budget set frontier in case (B.2) exist. For convex preferences, however, the consumption choice will not change if consumption without offsetting options (z_i^0, x_i^0, y_i^0) was in the interior of *F2*. That is, offsetting will continue *not* to be used. Only if (z_i^0, x_i^0, y_i^0) was chosen along the bold line which separates the two facets in (B.2), i.e. did not involve any consumption of the dirty good, consumption may move into the interior of *F1*. In this range, the consumption patterns thus are similar to (A.2) as no dirty good is used. We will consider the impact of an increased offsetting effectiveness β_i^o on the consumption of the clean(er) good in this (intermediate) case below. Finally, in case (B.3) where the effectiveness of offsets is large ($\beta_i^o > \frac{\beta_i^c}{1-\alpha_i^c}$), the clean good would be dominated by combinations of the dirty good and offsetting.

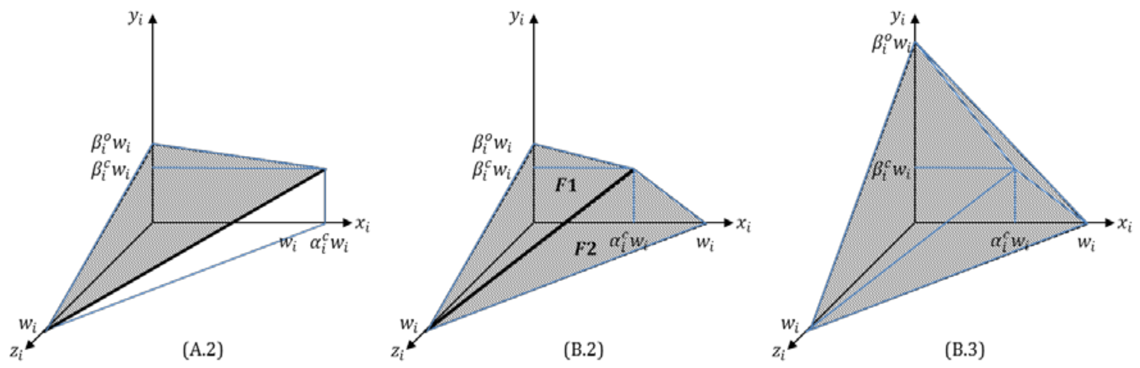

Figure 1: *Illustration of budget sets. Case* (A.2)*: clean consumption and offsetting (in the interior of the facet, only clean consumption along the bold line). Case* (B.2)*: consumption involves no offsetting (facet F2 of the budget frontier) or no consumption of the dirty good (F1). Case* (B.3)*: Consumption of clean good is dominated by combinations of dirty good and offsetting.*

If consumption in case ($\beta_i^c \leq \beta_i^o \leq \frac{\beta_i^c}{1-\alpha_i^c}$) is in the interior of facet *F1* of the budget frontier in (B.2) or in the interior of the budget set in (A.2), we have $g_i^d = 0$, $g_i^c = \frac{x_i}{\alpha_i^c}$ and $g_i^o = \frac{\alpha_i^c y_i - \beta_i^c x_i}{\beta_i^o \alpha_i^c}$. As such, we can rewrite the (relevant) budget constraint as:

$$z_i + x_i \frac{1}{\alpha_i^c}(1 - \frac{\beta_i^c}{\beta_i^o}) + \frac{1}{\beta_i^o} y_i \leq w_i$$

and define the implicit prices for private and public characteristics as $p_x = \frac{1}{\alpha_i^c}(1 - \frac{\beta_i^c}{\beta_i^o})$ and $p_y = \frac{1}{\beta_i^o}$. In order to derive how increases in the effectiveness of offsetting β_i^o may impact individual consumption choices of the impure public good in this range, we follow the technique by Chan and Kotchen (2014) to obtain:

$$\frac{dx_i}{d\beta_i^o} = \frac{\partial x_i}{\partial p_x}\frac{dp_x}{d\beta_i^o} + \frac{\partial x_i}{\partial p_y}\frac{dp_y}{d\beta_i^o} = \frac{\partial x_i}{\partial p_x}\frac{1}{\alpha_i^c}\frac{\beta_i^c}{(\beta_i^o)^2} - \frac{\partial x_i}{\partial p_y}\frac{1}{(\beta_i^o)^2}.$$

Using the typical Slutsky decomposition into compensated price responses and income effects, we obtain

$$\frac{dx_i}{d\beta_i^o} = \left(\frac{\partial \bar{x}_i}{\partial p_x} - x_i^* \frac{\partial x_i}{\partial w_i}\right)\frac{1}{\alpha_i^c}\frac{\beta_i^c}{(\beta_i^o)^2} - \left(\frac{\partial \bar{x}_i}{\partial p_y} - y_i^* \frac{\partial x_i}{\partial w_i}\right)\frac{1}{(\beta_i^o)^2}.$$

where $\frac{\partial \bar{x}_i}{\partial p_x}$ and $\frac{\partial \bar{x}_i}{\partial p_y}$ are the compensated price responses and x_i^* and y_i^* denote the optimal choices. Using $g_i^o = \frac{\alpha_i^c y_i - \beta_i^c x_i}{\beta_i^o \alpha_i^c}$, we can rewrite this expression to obtain:

$$\frac{dx_i}{d\beta_i^o} = \frac{\partial \bar{x}_i}{\partial p_x}\frac{1}{\alpha_i^c}\frac{\beta_i^c}{(\beta_i^o)^2} - \frac{\partial \bar{x}_i}{\partial p_y}\frac{1}{(\beta_i^o)^2} + g_i^{o,*}\frac{\partial x_i}{\partial w_i}\frac{1}{\beta_i^o}.$$

Here, the first expression is negative and relates to a direct substitution effect. The third is positive as long as x_i is normal with respect to income which we assume. The sign of the second term depends on whether private and public characteristics enter the utility as net substitutes ($\frac{\partial \bar{x}_i}{\partial p_y}$ positive) or net complements ($\frac{\partial \bar{x}_i}{\partial p_y}$ negative). It thus becomes obvious that the positive income effect combined with complementarities between private and public characteristics may trigger the consumption of private characteristic, i.e. clean consumption (as $g_i^d = 0$), to increase in response to more effective offsetting options.

The potentially ambiguous impact of offsetting options on the consumption of the impure public good demonstrates that the availability of offsetting does not necessarily reduce, but may also increase the consumption of other clean goods. However, we want to highlight again that such a (local) complementarity may only occur if the clean good already dominates the dirty good in generating the private characteristic (i.e. is less costly, $\alpha_i^c > 1$) as in case (A.2), or for medium ranges of the offsetting effectiveness ($\beta_i^c \leq \beta_i^o \leq \frac{\beta_i^c}{1-\alpha_i^c}$) and if individuals have a strong enough preference for the public characteristic such that they would not consume the dirty good when offsets are not available. Individuals will stop consuming the clean technology if $\beta_i^o > \frac{\beta_i^c}{1-\alpha_i^c}$ (and $\alpha_i^c \leq 1$).[12] This extreme prediction clearly only results if clean and dirty consumption alternatives are perfect substitutes in generating the private good as assumed in our model. For less perfect substitutability, both alternatives may continue to be used.

A positive correlation between the usage of offsetting and consumption of impure public goods may also occur when comparing choices across individuals as those may differ in income and/or their preferences. As a consequence, we carry out an empirical analysis to investigate the interrelation between voluntary pro-environmental activities and carbon offsetting.

3. Data and variables

The empirical analysis is based on representative data from self-administered online surveys among a total of 1005 citizens in Germany and 1010 citizens in the U.S. aged 18 and older. The surveys were carried out simultaneously 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 two countries. The completion of the survey required about 30 minutes on average in both countries. Survey questions were carefully pretested and encompassed general personal assessments of climate change, specific attitudes towards international climate policy and negotiations, fundamental values as well as individual engagement in pro-environmental activities and carbon offsetting.

Specifically, the respondents were asked which of the following clean consumption alternatives they have already taken: buying energy-efficient appliances, actions to save energy at home, reducing the consumption of meat or dairy products, using or purchasing energy from renewable sources, buying a car with lower fuel consumption, reducing car use, and reducing the number of flights.[13] Based on the binary structure of the response options, we construct seven dummy variables that serve as dependent variables in our microeconometric analyses.[14]

[12] Naturally, further increases in the effectiveness of offsets may then also lead a complementary relationship between offsetting and dirty consumption.
[13] Note that these activities are means to generate the respective private characteristic such that typically alternatives exist (e.g., reducing flights by choosing alternative vacation destinations, other modes of travel, or telephone conferences instead of business trips). As such, they fit our theoretical modeling even though some may more easily be identified as impure public goods (e.g., buying energy-efficient appliances), while others appear as voluntary constraints (e.g., reducing flights). We also used the stated willingness to take one of these clean consumption alternatives in the future as well as counts of these activities as dependent variables. The estimation results of these models are qualitatively almost identical to those reported in Tables 4 to 8 and are not reported for reasons of brevity but are available upon request.
[14] Table 1 in the Appendix provides a full list of dependent variables and their definitions.

Our main explanatory binary variable *offsetting* indicates that the respondent already engaged in offsetting to compensate the carbon emissions caused by her.[15]

In addition to these variables which capture individual consumption patterns of the clean consumption alternative and offsets, we also include explanatory variables reflecting individual tastes and preferences which may influence these consumption patterns. The dummy variables *high contribution of clean good* and *financial advantages of clean good* reflect respondents' beliefs that the seven clean consumption alternatives contribute rather a lot or a lot to climate protection (capturing β_i^c in the model) and provides rather financial advantages for her personally (corresponding to $\alpha_i^c > 1$), respectively. Similarly, *high contribution of offsetting* captures the perceived effectiveness of offsetting options (capturing β_i^o in the model).[16] For measuring environmental preferences, we use six items from the New Environmental Paradigm (*NEP scale*) (Dunlap et al., 2000)[17] and additionally include an indicator for *warm glow* motives which takes the value one if respondents feel responsible for contributing to climate protection, if this contribution makes them feel good, or both. Table 2 in the Appendix provides a full list of explanatory variables (including several socio-economic control variables) and their definitions.

Table 3 reports descriptive statistics on the dependent and explanatory variables for our samples of 1005 German and 1010 U.S. respondents. Although about one half of the respondents in both countries believe that offsetting contributes rather a lot or a lot to climate protection, only eleven percent in Germany and 14 percent in the U.S. already engaged in carbon offsetting, respectively. On average, contributions to climate protection of the clean consumption alternatives are rated slightly higher compared to offsetting with one exception: only 35 percent of the respondents in Germany and 25 percent of the respondents in the U.S. believe that reducing the consumption of meat or dairy products makes a high contribution to climate protection. Financial advantages associated with the pro-environmental activities are rated remarkably lower (compared to the other pro-environmental activities) for using energy from renewable sources (only in Germany) and reducing the consumption of meat or dairy products (in both countries) and highest for buying energy-efficient appliances (in the U.S.) and saving energy (in Germany). Accordingly, a large proportion of the respondents have already bought

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[15] Since decisions to offset carbon emissions might be influenced by the decision to consume clean alternatives and both decisions may be further determined by the same unobserved factors, we tested the variable *offsetting* for endogeneity, which can be rejected at all common significance levels.

[16] A perceived high contribution of offsetting does not imply that offsets are perceived to be more effective in providing the public good compared to the clean consumption alternatives.

[17] The NEP scale is a standard instrument in the social and behavioral sciences and is also increasingly common in the economic literature (e.g., Kotchen and Moore, 2007).

energy-efficient appliances (77 percent in Germany and 69 percent in the U.S.) and have already saved energy at home (88 percent in Germany and 80 percent in the U.S.), while reducing the number of flights (24 percent in Germany and 37 percent in the U.S.) and reducing the consumption of meat or dairy products (40 percent in Germany and 31 percent in the U.S.) are the pro-environmental activities with the lowest average engagement. It is also noticeable that German respondents exhibit higher average values for the NEP scale and the warm glow indicator, while U.S. respondents are slightly older, higher educated and have more children compared to German respondents.[18]

For our microeconometric analysis of the general probability to have already taken one of the clean consumption alternatives, we treat the responses to each pro-environmental activity as a separate sample and arrange (i.e. stack) these samples as a panel dataset over the seven activities for each country. This arrangement of our data allows us to apply random effects binary probit models using the maximum likelihood method and thereby to control for unobserved heterogeneity.

This approach incorporates individual-specific random effects in the error term ε_{ij} which are constant over the clean consumption alternatives and are assumed to be uncorrelated with the explanatory variables. For both samples, a Hausman test fails to detect systematic differences in the coefficients of a fixed and random effects specification and a likelihood ratio test rejects the null hypothesis of no unobserved heterogeneity which justifies the application of random effects binary probit models.[19] In order to check the robustness of our results when not controlling for unobserved heterogeneity, we also estimate single binary probit models for each clean consumption alternative (with unstacked data). The results are qualitatively very similar to the parameter estimates obtained from the random effects probit models (reported in Table 5 and 6).[20]

To investigate further implications of our theoretical predictions, we include several two-way and three-way interaction terms in our models (reported in Table 7 and 8). We estimate average interaction effects across all observations following the approach of Ai and Norton

[18] For our econometric analyses all missing values are dropped. Nonetheless, descriptive statistics for individuals included in our econometric analyses only differ slightly from the descriptive statistics of the whole samples.
[19] Test results are available upon request.
[20] For the single binary probit models for each clean consumption alternative separately, we consider robust estimations of the standard deviation of the parameter estimates. For random effects binary probit models with the stacked data, the robustness of the estimations of the standard deviation of the parameter estimates was tested using bootstrapping methods, but the results hardly differ from those reported in Table 4 and thus are not reported.

(2003), Norton et al. (2004) as well as Cornelißen and Sonderhof (2009).[21] Specifically, we relate to the cases (A.2), (B.2), and (B.3).

Firstly, with offsetting being more effective in providing the public characteristic ($\beta_i^o > \beta_i^c$) and the clean consumption alternative being more effective in providing the private characteristic ($\alpha_i^c \geq 1$), offsetting and the pro-environmental activity might be used complementarily. To test this case (A.2) we include the interaction term *offsetting* × *high contribution of offsetting* × *financial advantages of clean good* (besides the three two-way interaction terms of the interacted variables).

Secondly, in case (B.2), where offsetting has a medium effectiveness in providing the public characteristic ($\beta_i^c \leq \beta_i^o \leq \frac{\beta_i^c}{1-\alpha_i^c}$), offsetting and the clean good can be complements if environmental preferences are high enough. In order to test this case, we include the interaction term *offsetting* × *medium effectiveness of offsetting*[22]. The new binary variable *medium effectiveness of offsetting* is also included as single explanatory variable and indicates that respondents rated the contribution of offsetting to climate protection as being equal or higher compared to the contribution of the clean consumption alternatives and at the same time believe that a certain pro-environmental activity provides neither financial advantages nor financial disadvantages or rather financial disadvantages.

Finally, we include the three-way interaction term *offsetting* × *high contribution of offsetting* × *ineffective clean* good (see footnote 19), which reflects case (B.3) where the clean consumption alternative is predicted to be substituted by offsetting and the dirty alternative if $\beta_i^o > \frac{\beta_i^c}{1-\alpha_i^c}$. For this interaction term, we construct a new binary variable *ineffective clean good* (also included as single explanatory variable) which indicates that the respondent perceives the pro-environmental activity to contribute rather little or very little to climate protection and provides rather financial disadvantages. In addition, we estimate the average interaction effects across all observations of the two-way interactions of *offsetting* with *NEP scale*, *warm glow indicator*, *financial advantages of clean good,* and *high contribution of offsetting*.

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[21] We add interaction terms to the initial model. We estimate eight different models to separately obtain the eight interaction effects. These models also contain the interacted variables as single explanatory variables and, in the case of three-way interaction terms, the three two-way interaction terms of the interacted variables. Estimation results are qualitatively very similar in the models with (results are available upon request) and without interaction terms. A joint estimation of all interaction terms fails due to collinearity.

[22] Due to potential problems of multicollinearity, in the new model specification with the variable *medium effectiveness of offsetting*, the variables *high contribution of offsetting*, *high contribution of clean good*, and *financial advantages of clean good* are dropped from the initial econometric model. When *ineffective clean good* is included, the variables *high contribution of clean good* and *financial advantages of clean good* are dropped since they are captured by the new variable.

4. Estimation results

Our discussion of the empirical findings focuses on the estimation results from the random effects probit models with stacked data. Parameter estimates (including z-statistics) are reported in Table 4, while the first columns of Tables 7 and 8 provide the extent of these effects by showing the estimates (including z-statistics) of the average interaction effects as well as the average discrete probability effects of the interacted variables.[23]We also report the results for single binary probit models for each pro-environmental activity (Tables 5 and 6 and columns 2-7 of Tables 7 and 8).[24]

Before turning to the determinants of voluntary clean consumption and its relation with offsetting, we note that substantial differences exist in the levels of the respective activities (Table 4): relative to the base activity *reducing the consumption of meat or dairy products*, we find that respondents from both countries are more likely to buy energy-efficient appliances and to save energy at home and we find a smaller propensity of German respondents to reduce the number of flights. U.S. respondents have a higher propensity to use energy from renewable sources, while they are more likely to reduce car use than to reduce the consumption of meat or dairy products. These differences may indicate that the activities differ in their substitutability through alternatives that generate the same underlying private consumption characteristics.

We also note that only a few socio-economic and socio-demographic characteristics influence the probability to use clean consumption alternatives. German respondents who are older, female, and earn a higher household income and U.S. respondents with a higher age show a significantly higher propensity to take one of the pro-environmental activities.

For Germany and the U.S., our estimation results imply a strong significantly positive relationship between *offsetting* and the probability to use one of the clean consumption alternatives.[25] For German respondents, this probability[26] is 6 percentage points higher and even 20 percentage points for U.S. respondents (Tables 7 and 8) for respondents who also use offset-

[23] Two-way interaction effects capture how one variable affects the impact of the other variable on the binary dependent variable, i.e. the effect of a discrete change in one variable on the discrete probability effect of the other variable. Three-way interaction effects reflect how one variable affects the interaction effect of the two other dummy variables on the binary dependent variable, i.e. the discrete change in one variable on the interaction effect of the other two variables.

[24] Our results are very robust using random effects logit as well as pooled probit models and also to alternative model specifications regarding the inclusion of different control variables.

[25] Since flying is the most common context for compensating carbon emissions, it could be expected that offsetting is a substitute to reducing the number of flights. Surprisingly, however, *offsetting* is also significantly complementary to *reducing flights* in both countries

[26] We interpret this relationship as a correlation rather than a causal effect since we have no time reference for these measures. For future research, panel data might be useful to identify a causal relationship between clean consumption and offsetting activities.

ting options. Considering the activities separately, this generally positive relationship with offsetting is confirmed. It is strongest for *using energy from renewable sources* (19 percentage points in Germany and 29 percentage points in the U.S.) which might be attributed to the similarities between the demand for offsets and renewable energies. The relationship is only negative for *saving energy at home* in Germany. One reason for this finding might be that (some) individuals – while feeling a moral obligation to contribute to the environmental – may have exhausted energy saving options such that they are more inclined to turn to compensatory measures like carbon offsetting.

In both countries, the probability to use one of the clean consumption alternatives is significantly higher with higher environmental preferences measured by the variables *NEP scale* and *warm glow indicator*. A perceived *high contribution of clean good* (corresponding to large β_i^c in the theoretical model) has a significantly positive effect on clean consumption (11 percentage points in Germany, 5 percentage points in the U.S.). Our estimation results also reveal a highly significantly positive effect of perceived financial advantages associated with the pro-environmental activity (16 percentage points in Germany, 25 percentage points in the U.S.), which is in line with our theoretical prediction that for $\alpha_i^c > 1$ the clean good dominates the dirty alternative (cases (A.1) and (A.2)).[27] A perceived high contribution of offsetting to climate protection (reflected by β_i^o in the model) significantly reduces the probability to use the clean consumption alternatives by 6 percentage points in Germany and 7 percentage points in the U.S. This finding is consistent with our predictions that individuals who perceive offsetting as highly effective (case (B.3)) may revert back to the dirty alternative.

Our theoretical model did, however, also predict that the relationship between offsetting and clean consumption activities crucially depends on the relative effectiveness of offsetting vs. the clean activity in providing the public good, and clean vs. dirty consumption options in providing the private characteristic. We now discuss the estimates of the corresponding two-way and three-way interaction effects as described in Section 3 (see Tables 7 and 8).

For Germany, the average effects of the three-way interactions reflecting cases (A.2) and (B.3) are not significantly different from zero. In contrast, the estimated average two-way interaction effect of *offsetting* with *medium effectiveness of offsetting* (corresponding to case (B.2) in the model) is positive and highly significant. This finding implies that the complementary relationship between offsetting and other pro-environmental activities gets even 8 percentage points larger if offsetting has a medium effectiveness in providing the public good.

[27] In the U.S., financial advantages associated with an activity are significantly positively related to all of the seven climate protection activities.

Conversely, the interaction effect of *offsetting* and *financial advantages of clean good* is negative (9 percentage points) and thereby weakens the complementary relationship between offsetting and other pro-environmental activities, perhaps because financial advantages alone are sufficient in triggering the use of clean consumption options such that offsetting (options) cannot further stimulate this clean consumption.

We find a similar picture for U.S. respondents: again, the average two-way interaction effect of *offsetting* with *medium effectiveness of offsetting* is significantly positive (14 percentage points) and the interaction between *offsetting* and *financial advantages of clean good* is significantly negative (12 percentage points). Additionally, the negative interaction effects of *offsetting* and *NEP scale* as well as *offsetting* and *warm glow indicator* are significantly different from zero for U.S. respondents. Similar to the negative interaction with financial advantages discussed above, the consumption of clean alternatives is substantially higher for individuals with higher environmental preferences, such that additional offsetting (options) may have a limited impact or even gives these individuals an option to convert back to choose dirty consumption alternatives.[28]

Importantly, for U.S. respondents, the two average three-way interaction effects are highly significantly different from zero and have the predicted sign: the interaction effect of *offsetting* with *high contribution of offsetting* and *financial advantages of clean good* is significantly positive (27 percentage points), while the interaction of *offsetting* with *high contribution of offsetting* and *ineffective clean good* reduces the propensity to use clean alternatives by 69 percentage points. In other words, offsetting and the clean consumption alternatives might be complements in particular if offsetting is perceived to be highly effective in providing the public good and, at the same time, the clean consumption alternative being highly effective in providing the private characteristic (case (A.2)), while this complementary relationship is inverted for ineffective clean goods (case (B.3)). This finding implies that the clean consumption alternatives may be substituted by offsetting and the dirty consumption alternatives if offsetting is perceived to be highly effective in providing the public good, while the clean

[28] As mentioned in the introduction, Kotchen and Moore (2008) as well as Harding and Rapson (2014) find a similar result in their studies of the green-electricity market. They argue that conservationists already internalized negative externalities by reducing their use of conventional energy before participating in green-energy programs, but that these individuals may also be less flexible in their energy demand due to these voluntary restraints.

consumption alternatives are perceived to be relatively ineffective in providing the private and the public characteristic. [29]

5. Summary and conclusions

This paper provides theoretical and empirical insights on the extent to which the possibility of making direct donations to a public good may substitute the individual use of impure public goods. Our theoretical predictions, based on a theory that explicitly considers the consumption patterns of private and impure public goods (dirty vs. clean(er) consumption alternatives) in interaction with direct donations to the public good (voluntary carbon offsetting), demonstrate a potentially ambiguous impact of donations on the consumption of the impure public good, but also predicts its full crowding out when donations are highly effective in generating the public good.

Relying on data from representative surveys among more than 2000 participants from Germany and the U.S., our empirical results in the context of climate change mitigation confirm the theoretical predictions that offsetting and pro-environmental activities may be both, substitutes or complements. Generally, our results indicate a positive relationship between offsetting and other pro-environmental activities. While this complementary relationship is even strengthened for medium levels of offsetting effectiveness, we also identify conditions under which offsetting may rather substitute certain clean consumption alternatives. This is the case if individuals lay a sufficiently large weight on environmental preference or if offsetting is relatively effective in providing the public good climate protection. These empirical findings do not support the concerns that the availability of carbon offsets might have a negative net impact on environmental quality.

While our data is unique in providing cross-country evidence for the relationship between offsetting and clean consumption patterns as alternative ways to contribute to a public good, we cannot fully establish causal effects between these alternatives. It clearly would be desirable to investigate whether our behavioral findings are robust on the basis of panel data or when considering the *revealed* willingness to pay for carbon offsetting and other pro-environmental activities. Left for future research is also a check of the robustness of our results on the private provision of impure public goods vs. direct donations when applied to other fields of charitable giving.

[29] Highly effective offsetting alone has no impact on the positive relation between offsetting and clean consumption, since the interaction of *offsetting* and *high effectiveness of offsetting* is not significantly different from zero. For the interpretation of the three-way interactions see also footnote 23.

References

Ai, C.; Norton, E. C. (2003): Interaction terms in logit and probit models, *Economics Letters* 80 (1), 123–129.

Andreoni, J. (1993): An experimental test of the public-goods crowding-out hypothesis, *The American Economic Review* 83 (5), 1317–1327.

Bénabou, R.; Tirole, J. (2006): Incentives and prosocial behavior, *American Economic Review* 96 (5), 1652–1678.

Blasch, J.; Farsi, M. (2014): Context effects and heterogeneity in voluntary carbon offsetting – a choice experiment in Switzerland, *Journal of Environmental Economics and Policy*, 1–24.

Brekke, K. A.; Kverndokk, S.; Nyborg, K. (2003): An economic model of moral motivation, *Journal of Public Economics* 87 (9–10), 1967–1983.

Brown, E.; Lankford, H. (1992): Gifts of money and gifts of time estimating the effects of tax prices and available time, *Journal of Public Economics* 47 (3), 321–341.

Chan, N. W.; Kotchen, M. J. (2014): A generalized impure public good and linear characteristics model of green consumption, *Resource and Energy Economics* 37, 1–16.

Clot, S.; Grolleau, G.; Ibanez, L. (2014): Smug alert! Exploring self-licensing behavior in a cheating game, *Economics Letters* 123 (2), 191–194.

Cornelißen, T.; Sonderhof, K. (2009): Partial effects in probit and logit models with a triple dummy-variable interaction term, *Stata Journal* 9 (4), 571–583.

Croson, R.; Treich, N. (2014): Behavioral environmental economics: Promises and challenges, *Environmental and Resource Economics* 58 (3), 335-351.

Duncan, B. (1999): Modeling charitable contributions of time and money, *Journal of Public Economics* 72 (2), 213–242.

Dunlap, R. E.; Van Liere, K. D.; Mertig, A. G.; Jones, R. E. (2000): New trends in measuring environmental attitudes: Measuring endorsement of the new ecological paradigm: A revised NEP scale, *Journal of Social Issues* 56 (3), 425–442.

Falk, A.; Kosfeld, M. (2006): The hidden costs of control, *The American Economic Review* 96 (5), 1611–1630.

Frondel, M. (2004): Energy conservation, the rebound effect, and future energy and transport technologies: An introduction to energy conservation and the rebound effect, *International Journal of Energy Technology and Policy* 2 (3), 203–208.

Gans, J. S.; Groves, V. (2012): Carbon offset provision with guilt-ridden consumers, *Journal of Economics and Management Strategy* 21 (1), 243–269.

Gneezy, U.; Rustichini, A. (2000): Pay enough or don't pay at all, *The Quarterly Journal of Economics* 115 (3), 791–810.

Greenberg, A. E. (2014): On the complementarity of prosocial norms: The case of restaurant tipping during the holidays, *Journal of Economic Behavior & Organization* 97, 103–112.

Harding, M.; Rapson, D. (2014): Do voluntary carbon offsets induce energy rebound? A conservationist's dilemma, *Working Paper*.

Jacobsen, G. D.; Kotchen, M. J.; Vandenbergh, M. P. (2012): The behavioral response to voluntary provision of an environmental public good: Evidence from residential electricity demand, *European Economic Review* 56 (5), 946–960.

Kollmuss, A.; Zink, H.; Polycarp, C. (2008): Making sense of the voluntary carbon market: A comparison of carbon offset standards, WWF Germany, Stockholm Environment Institute and Tricorona.

Kotchen, M. J. (2009a): Offsetting the green guilt, *Stanford Social Innovation Review* 7 (2), 26–31.

Kotchen, M. J. (2009b): Voluntary provision of public goods for bads: A theory of environmental offsets, *The Economic Journal* 119 (537), 883–899.

Kotchen, M. J. (2005): Impure public goods and the comparative statics of environmentally friendly consumption, *Journal of Environmental Economics and Management* 49 (2), 281–300.

Kotchen, M. J.; Moore, M. R. (2007): Private provision of environmental public goods: Household participation in green-electricity programs, *Journal of Environmental Economics and Management* 53 (1), 1–16.

Kotchen, M. J.; Moore, M. R. (2008): Conservation: From voluntary restraint to a voluntary price premium, *Environmental and Resource Economics* 40 (2), 195-215.

Lange, A.; Ziegler, A. (2012): Offsetting versus mitigation activities to reduce CO2 emissions: A theoretical and empirical analysis for the U.S. and Germany, *MAGKS Joint Discussion Paper No. 18-2012*.

List, J. A. (2011): The market for charitable giving, *The Journal of Economic Perspectives* 25 (2), 157–180.

List, J. A.; Price, M. K. (2011): Charitable Giving Around the World: Thoughts on How to Expand the Pie, *CESifo Economic Studies*.

MacKerron, G. J.; Egerton, C.; Gaskell, C.; Parpia, A.; Mourato, S. (2009): Willingness to pay for carbon offset certification and co-benefits among (high-)flying young adults in the UK, *Energy Policy* 37 (4), 1372–1381.

Mellström, C.; Johannesson, M. (2008): Crowding out in blood donation: Was Titmuss right?, *Journal of the European Economic Association* 6 (4), 845–863.

Norton, E. C.; Wang, H.; Ai, C. (2004): Computing interaction effects and standard errors in logit and probit models, *The Stata Journal* 4 (2), 154–167.

Ploner, M.; Regner, T. (2013): Self-image and moral balancing: An experimental analysis, *Journal of Economic Behavior & Organization* 93, 374–383.

Schwirplies, C.; Ziegler, A. (2015): Offset carbon emissions or pay a price premium for avoiding them? A cross-country analysis of motives for climate protection activities, *MAGKS Discussion Paper No. 04-2015*.

Stringham, E. P. (2011): Embracing morals in economics: The role of internal moral constraints in a market economy, *Journal of Economic Behavior & Organization* 78 (1–2), 98–109.

Tiefenbeck, V.; Staake, T.; Roth, K.; Sachs, O. (2013): For better or for worse? Empirical evidence of moral licensing in a behavioral energy conservation campaign, *Energy Policy* 57, 160–171.

Appendix

Table 1: Description of dependent variables

Variables	Description
Buying energy-efficient appliances	1 if the respondent plans to buy energy-efficient appliances in the future, 0 otherwise.
Saving energy at home	1 if the respondent plans to take actions to save energy at home in the future, 0 otherwise.
Reducing meat or dairy products	1 if the respondent plans to reduce the consumption of meat or dairy products in the future, 0 otherwise.
Using energy from renewable sources	1 if the respondent plans to use or purchase energy from renewable sources in the future, 0 otherwise.
Buying a car with lower fuel consumption	1 if the respondent plans to buy a car with lower fuel consumption in the future, 0 otherwise.
Reducing car use	1 if the respondent plans to reduce car use in the future, 0 otherwise.
Reducing flights	1 if the respondent plans to reduce the number of flights in the future, 0 otherwise.

Table 2: Description of explanatory variables

Variables	Description
Offsetting	1 if the respondent already engaged in offsetting, 0 otherwise.
High contribution of offsetting	1 if the respondent believes offsetting contributes rather a lot or a lot to climate protection, 0 otherwise. The underlying question is “how effective is CO2 offsetting in protecting the climate?” with the five ordered response categories: “Very ineffective”, “rather ineffective”, “neither effective nor ineffective”, “rather effective”, and “very effective”.
High contribution of clean good	1 if the respondent believes that a certain pro-environmental activity contributes rather a lot or a lot to climate protection, 0 otherwise. The underlying question is “how much do you believe the following measures contribute to climate protection” with the five ordered response categories: “Very little”, “rather little”, “neither a little nor a lot”, “rather a lot”, and a lot”.
Financial advantages	1 if the respondent believes that a certain pro-environmental activity provides rather financial advantages for her personally, 0 otherwise. The underlying question is “in your opinion, do the following measures provide rather financial advantages (e.g., saving money, financial gains) or rather financial disadvantages (e.g., costs) for you personally” with the three ordered response categories: “Rather financial disadvantages”, “neither financial advantages nor disadvantages”, and “rather financial advantages”.
Warm glow indicator	1 if the respondent agreed rather strongly or very strongly to the statement “it makes me feel good to contribute to climate protection” or to the statement “I feel responsible for making a contribution to climate protection”, 0 otherwise. The underlying question is “how strongly do you agree to the following statement” with the five ordered response categories “very weakly”, “rather weakly”, “neither weakly nor strongly”, “rather strongly”, and “very strongly”.

Table 2: Description of explanatory variables (continued)

Variables	Description
NEP scale	Additive indicator using the following six items from the NEP scale: - "humans have the right to modify the natural environment to suit their needs" - "humans are severely abusing the planet", - "plants and animals have the same right to exist as humans", - "nature is strong enough to cope with the impacts of modern industrial nations", - "humans were meant to rule over the rest of nature", - "the balance of nature is very delicate and easily upset". The underlying question is "how strongly do you agree to the following statement" with the five ordered response categories "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly". The variable is designed by constructing dummy variables that take the value one if the respondent agrees to the respective statement rather or very strongly (in the case of positively keying items) or rather or very weakly (in the case of negatively keying items), respectively, and adding up the six dummy variables. Accordingly, the variable takes values from 0 to 6.
Age	Age of the respondent in years.
Female	1 if the respondent is a woman, 0 otherwise.
High household income	1 if the household net income of the respondent is above median category of the sample (i.e. at least € 3,000 in Germany and $ 4,000 in the U.S.), 0 otherwise.
Highly educated	1 if the respondent's highest level of education is at least secondary (Abitur in Germany, College degree in the U.S.), 0 otherwise.
Number of own children	Number of own children of the respondent.
Western Germany	1 if the respondent lives in Western Germany, 0 otherwise.
Northeast (Midwest, West)	1 if the respondent lives in the Northeast (Midwest, West) of the USA, 0 otherwise.
Ineffective clean good	1 if the respondent perceives the pro-environmental activity to contribute rather little or very little to climate protection and at the same time provides rather financial disadvantages for her personally, 0 otherwise. Underlying questions and response categories are described for the variables high contribution of clean good and financial advantages of clean good.
Medium effectiveness of offsetting	1 if the respondent rated the contribution of offsetting to climate protection as being equal or higher compared to the contribution of the pro-environmental activities to climate protection and at the same time believes that a certain activity provides neither financial advantages nor financial disadvantages for her personally, 0 otherwise. Underlying questions and response categories are described for the variables high contribution of offsetting, high contribution of clean good and financial advantages of clean good.

Table 3: Descriptive statistics of dependent and explanatory variables for overall 1,005 observations in Germany and 1,010 observations in the U.S.

Variables	Germany			U.S.		
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation
Buying energy-efficient appliances	969	0.77	0.42	952	0.69	0.46
Saving energy at home	973	0.88	0.33	965	0.80	0.40
Reducing meat or dairy products	964	0.40	0.49	939	0.31	0.46
Using energy from renewable sources	942	0.37	0.48	890	0.23	0.42
Buying a car with lower fuel consumption	929	0.46	0.50	915	0.38	0.48
Reducing car use	805	0.52	0.50	739	0.57	0.50
Reducing flights	547	0.24	0.43	371	0.37	0.48
Offsetting	788	0.11	0.31	750	0.14	0.35
High contribution of offsetting	892	0.54	0.50	778	0.49	0.50
Financial advantages						
Buying energy-efficient appliances	956	0.62	0.49	914	0.73	0.44
Saving energy at home	956	0.81	0.39	919	0.76	0.43
Reducing meat or dairy products	897	0.37	0.48	833	0.39	0.49
Using energy from renewable sources	879	0.29	0.45	813	0.50	0.50
Buying a car with lower fuel consumption	912	0.61	0.49	877	0.66	0.47
Reducing car use	928	0.62	0.48	896	0.64	0.48
Reducing flights	834	0.56	0.50	805	0.55	0.50
High contribution						
Buying energy-efficient appliances	966	0.61	0.49	926	0.63	0.48
Saving energy at home	964	0.61	0.49	924	0.61	0.49
Reducing meat or dairy products	948	0.35	0.48	847	0.25	0.43
Using energy from renewable sources	949	0.67	0.47	875	0.60	0.49
Buying a car with lower fuel consumption	956	0.63	0.48	918	0.61	0.49
Reducing car use	958	0.63	0.48	925	0.59	0.49
Reducing flights	944	0.62	0.49	854	0.50	0.50
Warm glow indicator	957	0.66	0.47	934	0.60	0.49
NEP scale	967	4.04	1.82	978	3.03	1.88
Age	1,005	41.13	12.52	1,010	48.51	14.46
Female	1,005	0.49	0.50	1,010	0.53	0.50
High household income	822	0.41	0.49	864	0.37	0.48
Highly educated	1,000	0.55	0.50	1,006	0.68	0.47
Number of own children	1,005	0.95	1.12	1,010	1.32	1.39
Western Germany	1,005	0.79	0.41			
Northeast				1,010	0.20	0.40
Midwest				1,010	0.23	0.42
West				1,010	0.22	0.41

Table 4: Maximum Likelihood estimates (z-statistics) of parameters in binary random effects probit models for Germany and the U.S., dependent variable: use of one of the clean consumption alternatives, base activity: reducing the consumption of meat or dairy products

Explanatory variables	Germany	U.S.
Buying energy-efficient appliances	1.00***	1.08***
	(11.23)	(10.14)
Saving energy at home	1.50***	1.56***
	(14.43)	(13.68)
Using energy from renewable sources	-0.09	-0.37***
	(-1.09)	(-3.47)
Buying a car with lower fuel consumption	-0.05	0.00
	(-0.53)	(0.03)
Reducing car use	0.10	0.55***
	(1.15)	(5.20)
Reducing the number of flights	-0.69***	-0.06
	(-6.48)	(-0.47)
Offsetting	0.21**	0.70***
	(1.98)	(4.90)
High contribution of offsetting	-0.20***	-0.25**
	(-2.83)	(-2.08)
High contribution of clean good	0.36***	0.18**
	(5.81)	(2.13)
Financial advantages of clean good	0.52***	0.82***
	(8.89)	(10.55)
Warm glow indicator	0.37***	0.35***
	(4.50)	(2.72)
NEP scale	0.08***	0.06*
	(3.73)	(1.92)
Age	0.01***	0.01*
	(3.82)	(1.87)
Female	0.20***	0.03
	(2.79)	(0.26)
Number of own children	0.01	0.04
	(0.17)	(1.04)
High household income	0.14**	0.09
	(2.02)	(0.84)
Highly educated	0.10	0.11
	(1.35)	(0.90)
Western Germany	-0.01	
	(-1.39)	
West		0.15
		(1.08)
Northeast		-0.01
		(-0.06)
Midwest		-0.08
		(-0.59)
Constant	-1.74***	-1.93***
	(-9.32)	(-7.72)
Number of observations	3,641	3,212
Number of respondents	591	541

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

Table 5: Maximum Likelihod estimates (z-statistics) of parameters in binary probit models in Germany, dependent variables: use of single clean consumption alternatives

Explanatory variables	Buying energy-efficient appliances	Saving energy at home	Reducing meat or dairy products	Using energy from renewable sources	Buying a car with lower fuel consumption	Reducing car use	Reducing flights
Offsetting	-0.01	-0.50**	0.03	0.50***	0.25	0.26	0.42*
	(-0.03)	(-2.15)	(0.17)	(2.87)	(1.41)	(1.34)	(1.90)
High contribution of offsetting	-0.17	-0.29	-0.37***	-0.08	-0.03	-0.18	-0.14
	(-1.29)	(-1.59)	(-3.05)	(-0.65)	(-0.24)	(-1.37)	(-0.88)
High contribution of clean good	0.27**	0.66***	0.47***	0.14	0.17	0.10	0.53***
	(2.11)	(3.94)	(3.71)	(1.08)	(1.27)	(0.73)	(2.97)
Financial advantages of clean good	0.36***	0.66***	0.41***	0.22*	0.43***	0.68***	0.10
	(2.91)	(3.96)	(3.29)	(1.70)	(3.64)	(5.31)	(0.57)
Warm glow indicator	0.18	0.32*	0.63***	0.38***	0.24*	0.42***	0.54**
	(1.24)	(1.69)	(4.30)	(2.70)	(1.67)	(2.88)	(2.47)
NEP scale	0.11***	0.22***	0.06	0.02	0.02	0.06	0.07
	(3.00)	(4.73)	(1.60)	(0.58)	(0.54)	(1.62)	(1.32)
Age	0.01	0.02***	0.02***	-0.00	0.01***	0.01**	0.01*
	(1.27)	(2.65)	(2.89)	(-0.00)	(2.70)	(2.17)	(1.66)
Female	0.27**	0.24	0.55***	-0.08	0.01	0.08	0.19
	(2.16)	(1.50)	(4.62)	(-0.64)	(0.08)	(0.64)	(1.12)
Number of own children	-0.01	0.08	-0.09	0.06	0.07	-0.09	0.05
	(-0.11)	(0.95)	(-1.58)	(1.05)	(1.28)	(-1.56)	(0.61)
High household income	0.38***	-0.00	0.13	0.21*	0.43***	-0.32***	0.04
	(3.06)	(-0.03)	(1.07)	(1.80)	(3.65)	(-2.60)	(0.23)
Highly educated	-0.11	0.12	0.23*	-0.04	0.12	0.11	0.11
	(-0.86)	(0.74)	(1.85)	(-0.29)	(1.04)	(0.85)	(0.62)
Western Germany	-0.18	0.05	-0.08	-0.10	0.01	-0.03	-0.21
	(-1.44)	(0.30)	(-0.69)	(-0.84)	(0.12)	(-0.21)	(-1.22)
Constant	-0.49*	- 1.34***	-2.06***	-0.89***	-1.64***	-1.25***	-2.40***
	(-1.68)	(-3.44)	(-6.63)	(-3.13)	(-5.54)	(-4.00)	(-4.77)
Number of respondents	587	585	552	542	552	494	329

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

Table 6: Maximum Likelihood estimates (z-statistics) of parameters in binary probit models in the U.S., dependent variables: use of single clean consumption alternatives

Explanatory variables	Buying energy-efficient appliances	Saving energy at home	Reducing meat or dairy products	Using energy from renewable sources	Buying a car with lower fuel consumption	Reducing car use	Reducing flights
Offsetting	0.34*	0.19	0.50***	0.87***	0.33**	0.68***	0.75***
	(1.78)	(0.94)	(2.74)	(5.08)	(2.08)	(3.66)	(3.42)
High contribution of offsetting	-0.44***	-0.58***	0.01	0.13	-0.15	-0.28*	-0.02
	(-2.91)	(-2.94)	(0.04)	(0.84)	(-1.08)	(-1.87)	(-0.08)
High contribution of clean good	0.12	0.18	0.52***	0.10	0.07	0.05	0.46**
	(0.82)	(1.09)	(3.26)	(0.55)	(0.54)	(0.35)	(2.33)
Financial advantages of clean good	0.64***	0.69***	0.40***	0.35**	0.47***	0.42***	0.44**
	(4.52)	(4.56)	(2.83)	(2.28)	(3.56)	(2.94)	(2.28)
Warm glow indicator	0.43***	0.41**	0.27*	0.28	-0.04	0.43***	0.07
	(2.80)	(2.19)	(1.66)	(1.59)	(-0.28)	(2.71)	(0.30)
NEP scale	0.04	0.18***	0.05	-0.03	0.03	0.09**	-0.09
	(1.05)	(3.49)	(1.35)	(-0.73)	(0.96)	(2.18)	(-1.59)
Age	0.01**	0.02***	0.00	-0.02***	0.00	0.01***	0.01
	(2.11)	(3.69)	(0.61)	(-3.32)	(0.11)	(2.74)	(1.11)
Female	0.01	0.28*	0.15	0.07	-0.06	-0.01	-0.31
	(0.04)	(1.83)	(1.13)	(0.50)	(-0.49)	(-0.09)	(-1.54)
Number of own children	0.06	0.03	-0.03	0.10*	0.02	-0.01	0.01
	(1.19)	(0.48)	(-0.71)	(1.96)	(0.38)	(-0.20)	(0.18)
High household income	0.10	0.07	0.09	0.09	0.28**	-0.24*	-0.29
	(0.73)	(0.43)	(0.67)	(0.66)	(2.30)	(-1.83)	(-1.52)
Highly educated	-0.04	0.25	-0.08	0.07	0.31**	0.06	0.12
	(-0.31)	(1.53)	(-0.56)	(0.48)	(2.28)	(0.40)	(0.47)
West	0.08	-0.14	0.21	0.30*	0.12	0.04	0.06
	(0.47)	(-0.76)	(1.25)	(1.66)	(0.74)	(0.23)	(0.27)
Northeast	-0.06	0.14	-0.01	-0.06	-0.05	0.05	-0.14
	(-0.36)	(0.66)	(-0.07)	(-0.31)	(-0.34)	(0.27)	(-0.54)
Midwest	-0.09	-0.19	-0.30*	-0.05	-0.08	0.02	0.02
	(-0.54)	(-1.03)	(-1.70)	(-0.26)	(-0.51)	(0.12)	(0.06)
Constant	-0.74**	-1.41***	-1.30***	-0.66**	-1.02***	-1.21***	-0.91**
	(-2.54)	(-4.11)	(-4.30)	(-2.24)	(-3.87)	(-4.05)	(-2.14)
Number of respondents	521	534	486	479	512	447	233

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

Table 7: Estimates (z-statistics) of average discrete probability effects and average interaction effects in Germany[i]

Variables and interaction terms	Random effects binary probit models: Stacked data	Binary probit models: Buying energy-efficient appliances	Saving energy at home	Reducing meat or dairy products	Using energy from renewable sources	Buying a car with lower fuel consumption	Reducing car use	Reducing flights
Offsetting	0.06**	0.00	-0.09*	0.01	0.19***	0.09	0.09	0.13*
	(2.00)	(0.00)	(-1.92)	(0.15)	(2.85)	(1.39)	(1.39)	(1.84)
High contribution of offsetting	-0.06***	-0.05	-0.04*	-0.12***	-0.03	-0.02	-0.06	-0.03
	(2.83)	(-1.37)	(-1.68)	(-3.15)	(-0.68)	(-0.36)	(-1.38)	(-0.72)
High contribution of clean good	0.11***	0.08 **	0.11***	0.16***	0.05	0.07	0.03	0.14***
	(5.51)	(2.07)	(3.99)	(3.61)	(1.06)	(1.45)	(0.68)	(2.83)
Financial advantages of clean good	0.16***	0.11***	0.12***	0.14***	0.08*	0.16***	0.25***	0.03
	(7.71)	(2.90)	(3.50)	(3.21)	(1.72)	(3.70)	(5.47)	(0.72)
Warm glow indicator	0.11***	0.05	0.05*	0.21***	0.14***	0.09*	0.15***	0.14***
	(4.55)	(1.31)	(1.69)	(4.58)	(2.87)	(1.68)	(2.89)	(2.65)
NEP scale	0.02***	0.03***	0.03***	0.02	0.01	0.01	0.02	0.02
	(3.52)	(3.01)	(4.92)	(1.60)	(0.56)	(0.60)	(1.58)	(1.27)
Offsetting × high contribution of offsetting	-0.02	-0.04	-0.11	-0.03	-0.01	-0.28**	0.24*	-0.03
	(-0.27)	(-0.39)	(-1.23)	(-0.23)	(-0.06)	(-2.10)	(1.66)	(-0.20)
Offsetting × financial advantages of clean good	-0.09**	-0.23**	-0.18*	-0.04	0.04	0.04	-0.21	0.07
	(-2.05)	(-2.09)	(-1.70)	(-0.32)	(0.29)	(0.29)	(-1.57)	(0.50)
Offsetting × warm glow indicator	-0.02	0.02	0.06	-0.24	-0.04	0.06	-0.08	-0.01
	(-0.21)	(0.14)	(0.47)	(-1.54)	(-0.20)	(0.37)	(-0.54)	(-0.01)
Offsetting × NEP scale	-0.00	0.04	0.04	-0.03	-0.01	0.00	-0.06	-0.05
	(-0.12)	(1.18)	(1.28)	(-0.67)	(-0.31)	(0.11)	(-1.57)	(-0.97)
Offsetting × high contribution of offsetting × financial advantages of clean good	-0.01	-	-	-	-	-	-	-
	(-0.14)							
Offsetting × medium effectiveness of offsetting	0.08**	0.23**	0.22*	0.00	0.02	-0.07	0.17	-0.12
	(1.98)	(2.08)	(1.90)	(0.03)	(0.18)	(-0.50)	(1.26)	(-0.83)
Offsetting × high contribution of offsetting × ineffective clean good	-0.26	-	-	-	-	-	-	-
	(-0.60)							

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

Table 8: Estimates (z-statistics) of average discrete probability effects and average interaction effects in the U.S.[i]

Variables and interaction terms	Random effects binary probit models	Binary probit models						
	Stacked data	Buying energy-efficient appliances	Saving energy at home	Reducing meat or dairy products	Using energy from renewable sources	Buying a car with lower fuel consumption	Reducing car use	Reducing flights
Offsetting	0.20***	0.10*	0.04	0.17***	0.29***	0.12**	0.22***	0.27***
	(5.47)	(1.93)	(0.99)	(2.61)	(4.74)	(2.07)	(4.11)	(3.46)
High contribution of offsetting	-0.07**	-0.13***	-0.12***	0.00	0.04	-0.05	-0.10*	-0.01
	(-2.12)	(-3.06)	(-3.11)	(0.04)	(0.83)	(-1.09)	(-1.93)	(-0.08)
High contribution of clean good	0.05**	0.04	0.04	0.18***	0.03	0.03	0.02	0.16**
	(2.15)	(0.81)	(1.07)	(3.10)	(0.55)	(0.54)	(0.35)	(2.32)
Financial advantages of clean good	0.25***	0.22***	0.17***	0.13***	0.10**	0.17***	0.15***	0.15**
	(8.88)	(4.36)	(4.15)	(2.72)	(2.28)	(3.68)	(2.91)	(2.31)
Warm glow indicator	0.10***	0.14***	0.09**	0.08*	0.08	-0.02	0.16***	0.02
	(2.79)	(2.76)	(2.12)	(1.65)	(1.62)	(-0.28)	(2.69)	(0.30)
NEP scale	0.02*	0.01	0.04***	0.02	-0.01	0.01	0.03**	-0.03
	(1.92)	(1.05)	(3.66)	(1.35)	(-0.73)	(0.97)	(2.21)	(-1.61)
Offsetting × high contribution of offsetting	0.12	-0.00	0.10	0.08	0.10	0.18	0.14	0.16
	(1.56)	(0.08)	1.20	(0.57)	0.78	(1.48)	(1.12)	(0.99)
Offsetting × financial advantages of clean good	-0.12***	-0.15	-0.07	-0.32***	0.09	-0.12	-0.09	-0.07
	(-4.23)	(-1.41)	(-0.84)	(-2.59)	(0.76)	(-0.97)	(-0.86)	(-0.48)
Offsetting × warm glow indicator	-0.21***	-0.14	-0.08	-0.31**	-0.07	-0.31**	-0.16	-0.24
	(-3.24)	(-1.32)	(-1.03)	(-2.16)	(-0.51)	(-2.54)	(-1.47)	(-1.52)
Offsetting × NEP scale	-0.04**	-0.06**	-0.03	-0.09***	-0.00	-0.01	-0.01	0.01
	(-1.99)	(-1.98)	(-1.07)	(-2.66)	(-0.04)	(-0.38)	(-0.49)	(0.24)
Offsetting × high contribution of offsetting × financial advantages of clean good	0.27**	-	-	-	-	-	-	-
	(2.02)							
Offsetting × medium effectiveness of offsetting	0.14***	0.10	0.10	0.25**	-0.04	0.16	0.13	0.14
	(4.30)	(0.92)	(1.10)	(2.06)	(-0.37)	(1.33)	(1.19)	(0.92)
Offsetting × high contribution of offsetting × ineffective clean good	-0.69***	-	-	-	-	-	-	-
	(-3.93)							

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

[i] Interaction effects for three-way interaction terms can only be estimated with stacked data. Using unstacked data, the underlying group of respondents is too small to obtain robust and meaningful results from the single binary probit models for each pro-environmental activity.

Average discrete probability effects are estimated from the initial model without interaction terms. The estimated effects are very similar in the models with and without interaction terms.

For estimating the interaction effects, we add interaction terms to the initial model. We estimate eight different models to separately obtain the eight interaction effects. These models also contain the interacted variables as single explanatory variables and, in the case of three-way interaction terms, the three two-way interaction terms of the interacted variables. A joint estimation of all interaction terms fails due to collinearity.