Individuals‘ (re-)action in the face of global warming

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List of abbrevations

BMBF	Bundesministerium für Bildung und Forschung (German Federal Ministry of Education and Research)
CO_2e	Carbon dioxide equivalent
e.g.	exempli gratia (for example)
EU	European Union
G77	Group of 77
GDP	Gross domestic product
i.e.	id est (that is)
IPCC	Intergovernmental Panel on Climate Change
NEP	New environmental paradigm
NGO	Non-governmental organization
UBA	Umweltbundesamt (Federal Environment Agency)
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	World Tourism Organization
USA	United States of America
WTP	Willingness to pay

"There are cost for taking action,

but they are nothing compared to costs of inaction."[1]

1. Introduction

1.1 Background

Climate change remains a major challenge for today's and future societies due to its immense impacts on the natural environment and human lives. Global warming has been demonstrated to lead to melting glaciers, sea level rise, changing precipitation patterns, more frequent extreme weather events, as well as changes in ecological and economic systems (e.g., IPCC, 2013). Generally, two responses are possible in order to alleviate the negative consequences of climate change: (i) avoiding or sequestrating greenhouse gas emissions in order to reduce the risk of climate change (climate protection or mitigation) and (ii) adjusting to new climatic conditions to cope with the consequences of climate change and reduce the severity of potential negative impacts (adaptation to climate change) (e.g., Yohe and Tol, 2002).

On the public policy level, there is a broad consensus that efficient and cost-effective climate policy involves adaptation and climate protection measures (e.g., Klein et al., 2005; Tol, 2005; Swart and Raes, 2007; IPCC, 2014). The acceptance and participation of domestic citizens plays a key role for the success of these public measures and the achievement of climate policy objectives. U.S. President Obama's climate action plan, for instance, includes energy efficiency measures that are targeted at cutting consumers' annual electricity bills by billions of dollars.[2] Another example concerns the aim of Chinese, German, and U.S. governments to increase the share of renewable energies in gross domestic energy consumption which will also broadly depend on the participation of their residents. From a policy perspective it is therefore crucial to gain deeper insights into individuals' responses to global warming and their interrelation with public activities.

[1] Dr. R.K. Pachauri, head of the UN Intergovernmental Panel on Climate Change (IPCC) speaking at the inauguration of the UN Climate Change Summit

[2] Source: http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

This thesis contributes to the existing literature on the private provision of public goods as well as on self-insurance and self-protection in the context of climate change by taking a holistic view of adaptation and climate protection efforts of individuals. The following six sections shed light on the questions whether individuals are prepared to adapt to new climatic conditions and which factors motivate them to voluntarily change their consumption and behavior in order to reduce greenhouse gas emissions. Specifically, this thesis provides theoretical and empirical insights into the determinants and motives of individuals' adaptation and climate protection efforts, the interrelation between certain activities, individuals' evaluation of (international) climate policy and to what extent this perception influences their motivation to make voluntary contributions to climate protection themselves. The final research question connects these findings to investigate whether the possibility to self-protect through adaptation measures reduces individuals' incentive to contribute to climate protection.

Since global greenhouse gas emissions of all sources determine the concentration of greenhouse gases in the atmosphere, contributing to climate protection is inherently a public good problem (e.g., IPCC, 2001). An individual cannot be excluded from the benefits of climate protection and the enjoyment of these benefits by one individual does not reduce the benefits to others. Thus, the individuals' incentive to contribute to the public good is generally lower than necessary to reach the optimal Nash equilibrium (e.g., Holländer, 1990). Numerous theoretical and empirical studies, however, suggest that motives like altruism, feelings of warm glow and moral obligation, internalized social norms, and image motivation influence voluntary contributions to charities and public goods (e.g., Andreoni, 1995; Glazer and Konrad, 1996; Harbaugh, 1998; Crumpler and Grossman, 2008; Ariely et al., 2009; Shang and Croson, 2009).

The existing literature on public goods also indicates at existing interactions of private activities with public engagements, incentives, or institutional settings (e.g., Frey and Oberholzer-Gee, 1997; Bohnet et al., 2001; Frey et al., 2001; Brekke et al., 2003; Nyborg and Rege, 2003). Certain climate-friendly activities may also lead to behavioral responses that offset the positive effects from these activities. Extensive literature on rebound effects, for example, has

demonstrated that energy-efficiency improvements may increase energy demand for residential or transportation issues (e.g., Frondel, 2004). Other studies find interactions between the participation in green electricity programs and energy saving efforts (e.g., Kotchen and Moore, 2008; Jacobsen et al., 2012; Harding and Rapson, 2014). Carbon offsetting also faces substantial criticism for potentially substituting other climate protection activities and thereby leading to higher emission levels rather than reducing them (e.g., Kotchen, 2009b; Lange and Ziegler, 2012).

In contrast to climate protection efforts, benefits from adaptation activities are of exclusive use to the investor or to particular regions. Hence, adaptation to climate change is regarded as a private or club good. For policy and actors affected by the negative impacts of climate change adaptation is an attractive option to reduce climate-related losses (e.g., Barrett, 2011), since free-riding is not possible. The engagement in adaptation might, however, cause some kind of moral hazard (e.g., Hirshleifer and Riley, 1979; Dionne and St-Michel, 1991; Hellmann et al., 2000): The possibility to reduce the severity of potential losses from climate change may decrease the incentive to reduce the risk of climate change, i.e. to engage in climate protection.

Policy makers and regulators have to account for these side effects since the interrelations between individuals' adaptation and climate protection efforts have the potential to decrease or even reverse the intended impacts of environmental and climate policies. So far, however, there is only little knowledge about the potential and the determinants of private adaptation and climate protection efforts and their interrelation. Existing research is mostly unconnected and lacks a holistic view of these two potential responses to climate change (IPCC, 2007a).

1.2 State of research and objectives of this thesis

Research on climate protection primarily focuses on technological (e.g., Fischer and Newell, 2008; Bosetti et al., 2009; Dechezlepretre et al., 2011) and economic issues (e.g., Nordhaus, 1993; Fankhauser and Tol, 2005; Stern, 2006) and mainly concentrates on the international, national, or industry levels (e.g., IPCC, 2007b). Theoretical work on individual climate pro-

tection activities is closely related to the literature on the private provision of public goods (e.g., Kotchen, 2005, 2006) as discussed above. Empirical studies on individual climate protection activities mostly determine the factors that influence preferences are mainly concerned with energy-saving measures in residential buildings (e.g., Banfi et al., 2008; Achtnicht, 2011; Kwak et al., 2010) and the demand for renewable energies (e.g., Goett et al., 2000; MacMillan et al., 2006; Kotchen and Moore, 2007; Longo et al., 2008; Scarpa and Willis, 2010).

Studies on the determinants of carbon offsetting, i.e. measures which reduce carbon emissions indirectly through donations to climate protections projects, are rare. Recent exceptions are relatively restricted studies, for example, by Brouwer et al. (2008), Akter et al. (2009), and MacKerron et al. (2009) who analyze air travelers' WTP for carbon offsetting, as well as Yoshida et al. (2009) and Ziegler et al. (2012) who examine carbon offsetting in the context of vehicle use. Kesternich et al. (2014a) conduct a large-scaled field experiment to investigate the voluntary demand of carbon offsets for bus travels and Blasch and Farsi (2014) analyze the demand of individuals for carbon offsets in different contexts such as air travel, space heating, hotel stay, and car rental covering more than a thousand Swiss consumers.

At the individual level, research on climate change responses also raises the issue of preferences for adaptation and climate protection policies (e.g., Berrens et al., 2004). Only a small body of literature elicits negotiators' (e.g., Dannenberg et al., 2010; Lange et al., 2010; Kesternich et al., 2014b) or citizens' (e.g., Carlsson et al., 2013) preferences for particular rules in sharing the costs of global climate protection efforts. So far, citizens' perceptions of the process related to international climate negotiations as well as their preferences regarding public adaptation and climate protection activities have largely been unexplored.

Adaptation to climate change has only recently gained increased attention in the discipline of economics. This literature primarily focuses on adaptation in different industry sectors (Scott and McBoyle, 2007; Seo and Mendelsohn, 2008; Morton et al., 2011) and adaptation strategies at the firm level (e.g., Berkhout and Gann, 2006; Hoffmann et al., 2009; Linnenluecke et al., 2011). Literature on adaptation behavior of individuals is primarily concerned with residential issues (e.g., Zhai et al., 2006; Bichard and Kazmierczak, 2012; Botzen and v. d.

Bergh, 2009) and psychological aspects of adaptation (e.g., Grothmann and Patt, 2005; Osberghaus et al., 2010).

Studies considering adaptation and climate protection activities of individuals rarely go beyond the identification of specific options to adjust activities to climatic changes or to consume and behave in a climate-friendly way. There is still little research on the interrelation of these responses to climate change as well as the underlying processes of decision-making and conditions that stimulate or constrain these activities. Recent research (e.g., Kane and Shogren, 2000; Tol, 2005; Bosello et al., 2010; Barrett, 2011; Buob and Stephan, 2011; Ebert and Welsch, 2012) takes first steps to account for the interrelations between adaptation and climate protection primarily on the policy level (e.g., IPCC, 2007a), but there continues to be substantial need for further research that is targeted at supporting decisions on adaptation and climate protection activities (e.g., European Environment Agency, 2005).

In order to fill the described research gaps, this thesis pursues four main objectives: Firstly, the thesis aims at identifying the extent and the determinants of voluntary climate protection efforts of individuals. The second main objective is to gain more knowledge about the readiness and the determinants of adaptation to the short- and long-term consequences of climate change. The third main objective is to gain more insight into the interrelation between the individual preferences for adaptation and climate protection as well as between certain climate protection activities. Finally, this thesis aims at identifying individuals' evaluation of (international) climate policy and potential interactions between public and private responses to climate change.

1.3 Contributions and main results

This thesis takes a holistic view of adaptation and climate protection options of individuals and comprises six individual studies. The data for the microeconometric analyses were collected by professional market research institutes within the context of two projects which are funded by the German Federal Ministry of Education and Research (BMBF).

The first project “The relevance of voluntary efforts and fairness preferences for the success of international climate policy” (VolFair) analyzes how the interaction between the population and participants of international climate negotiations, preferences for certain burden-sharing rules in international climate negotiations, as well as voluntary climate protection activities of domestic citizens may influence the success of international climate policy. The project mainly aims at extending and deepening the understanding of successful international climate negotiations. The data for the microeconometric analyses are collected in three representative computer-based surveys among a total of 3445 citizens aged 18 and older in China, Germany, and the USA. China, the EU (with Germany as the largest economy), and the USA are large emitters with strong political clout and are therefore considered to play a key role in future international climate policy.

The second project “Evaluating climate mitigation and adaptation policies” (Eval-MAP) aims at implementing an extensive energy economic panel dataset and analyzing energy consumption and climate-related adaptation behavior of private households. These analyses aim at serving as a basis for the evaluation of climate policy as well as scientific policy advice. Within the scope of this project four survey waves are conducted, two on adaptation activities and two on the energy consumption.

The first paper entitled “Are German tourists willing to adapt? A microeconometric analysis of adaptation to climate change” examines the determinants of German tourists’ willingness to increasingly choose a different destination due to higher temperatures in the holiday region. This study thereby considers potential geographical shifts in tourism demand. The main contribution is the attempt to find an indicator for tourism-related adaptation of individuals that allows the examination of future effects of global warming on an industry with huge economic impacts. The microeconometric analysis is based on the representative dataset collected within the context of Eval-MAP and comprises more than 5500 German tourists. German tourists are an important target group with the highest travel expenditures among all European countries and may therefore be highly affected by the negative impacts of climate change during their holidays. The descriptive statistics reveal a large share of respondents who are pre-

pared to adapt their travel destination if temperatures rise in the future. The estimation results suggest that the subjective risk perception measured by various indicators is the main driver for tourism-related adaptation. Tourism-related adaptation is further significantly influenced by a higher age, available means, and a high level of information on adaptation for respondents with a high educational level. This identification of important focus groups of tourists with a higher propensity for changing travel habits might be used to develop successful future product strategies in the tourism industry. The findings in Section 7 indicate that these factors also determine other types of adaptation activities.

The second paper "Citizens' perceptions of justice in international climate policy – An empirical analysis" is the first study that explores individuals' perceptions of justification and trust in the context of climate policy. This study contributes to the literature on international climate policy by analyzing individuals' preferences for key guiding principles for sharing climate protection costs across countries. Specifically, respondents were asked to evaluate how strongly four burden-sharing principles discussed in the literature should be considered when allocating costs in order to reduce global greenhouse gas emissions. The main finding is that this ranking is identical in China, Germany, and the USA: Accountability followed by capability, egalitarianism, and sovereignty. Individuals in the three countries seem to share the same (normative) view of fairness which may be a starting point for future international climate agreements. Further results suggest that a substantial portion of individuals in all three countries regards international climate policy as justified, but shows a substantial lack of trust in international climate policy.

The third paper "Private provision of public goods: Do individual climate protection efforts depend on perceptions of climate policy?" analyzes the impact of these perceptions on the willingness of individuals in Germany and the USA to engage in climate protection themselves. Extensive literature on motivation crowding provides evidence that external circumstances like monetary incentives or institutional settings potentially lead to crowding-in or crowding-out of contributions to public goods or charities. This study is the first to link this literature to international climate policy. The key findings suggest that the perceived im-

portance of international climate policy is significantly positively related to voluntary contributions to climate protection in both countries. Individuals in the USA also seem to lower their climate protection activities if they perceive the process of international climate negotiations to be fair, while trust in this process has no significant effect. These results imply that future research should also account for the public good providing process when analyzing the factors explaining voluntary contributions to public goods.

The fourth paper "Offset carbon emissions or pay a premium for avoiding them? A cross-country analysis of motives for voluntary climate protection activities" makes an important contribution to the literature on pure and impure public goods by identifying the determinants and motives for voluntary climate protection activities. This is the first study that compares the motives for making direct donations to climate protection and demanding environmental impure public goods of individuals from Germany and the USA. In contrast to the existing research, this study accounts for several factors like the awareness of the free-rider problem, warm glow motives, social norms, green identity, and signaling. By considering the willingness to offset carbon emissions and to pay higher prices for goods and services that are better for the climate, the empirical findings suggest that the awareness of the free-rider problem, warm glow motives, and the desire to set a good example have the expected effects on the two consumption alternatives in both countries. Social norms seem to be of much higher relevance in the USA, while the results for green identity reflect the profound skepticism towards carbon offsetting among environmental groups and parties in both countries. The study reveals interesting differences between the motivational factors of direct donations and the consumption of impure public goods, but also between respondents in Germany and the USA.

The fifth paper "On the interrelation between carbon offsetting and other voluntary climate protection activities: Theory and empirical evidence" further investigates the relationship between different channels to voluntarily contribute to climate protection. This paper contributes to the theoretical literature on private provisions of public goods by adopting the characteristics approach of the impure public good framework to derive conditions under which direct donations to public goods (carbon offsets) and the consumption of impure public goods (clean

consumption alternatives) may be substitutes or complements. Theoretically, offsetting and the consumption of clean alternatives may be both, substitutes or complements. The empirical evidence is based on a cross-country analysis of the relationship between purchases of carbon offsets and the choice of seven pro-environmental activities. The findings are consistent with the theoretical predictions and indicate a significantly positive relationship between offsetting and other pro-environmental activities. Substitutions seem to only occur if individuals have higher environmental preferences or if they perceive offsetting to be very effective in contributing to climate protection. These results do not support the concerns that the availability of carbon offsets might crowd out other pro-environmental activities.

The sixth and final paper "Adaptation vs. climate protection: Responses to climate change and policy preferences of individuals in China, Germany, and the USA" is the first study that provides survey-based evidence on the interrelation between private adaptation and climate protection efforts as well as preferences for public adaptation and climate protection of individuals in China, Germany, and the USA. First, this interrelation is modeled for a representative individual that chooses adaptation and climate protection efforts by maximizing her subjective expected utility. This theoretical modeling already demonstrates that, at the individual level, private adaptation and climate protection efforts cannot be substitutes. While the subjective risk perception is predicted to be an important determinant of adaptation activities, climate protection efforts are shown to be solely motivated by balancing costs and benefits (e.g., financial advantages, feelings of warm glow, or social approval) from these efforts. The empirical results widely confirm these theoretical predictions in the three countries. Additionally, a perceived lack of public engagement in climate protection seems to be compensated by increasing private adaptation and climate protection efforts. The microeconometric analysis also considers individuals' preferences for public adaptation and climate protection, which are shown to be significantly determined by beliefs about the efforts of others, social norms, feelings of warm glow, and confidence in the effectiveness of climate protection.

1.4 Conclusions and future research needs

This Section summarizes the results of this thesis and the implications of these findings for policy and other relevant stakeholders. First, individuals are willing to adapt to a changing climate which is not surprising since self-insurance and self-protection are in their own interest. The findings from two different samples show that the factors age, gender, education, income, and subjective risk perception significantly identify individuals with a higher propensity to engage in adaptation measures.

Second, the studies find hardly any evidence that adaptation activities (private or public) crowd out individuals' incentive to engage in climate protection. In contrast to adaptation, climate protection activities are not significantly affected by the perception of negative consequences of climate change, but broadly motivated by factors like financial advantages, warm glow motives, identification with a green ideology, and social approval. This knowledge is important to enhance private engagement in climate protection and can be used by governments and NGOs to promote these activities.[3]

Third, this thesis also reveals a significantly positive relationship between private and public climate protection as well as certain climate protection activities. Substitutions are found to occur, for example, if one measure is perceived to be more effective, such that even the identified substitution effects should, in sum, lead to lower emission levels. Governments could promote alternative ways to protect the climate and encourage their use by providing fundamental knowledge and eliminating existing reservations (particularly towards carbon offsetting or higher prices for climate-friendly products).

Finally, this thesis also provides some important findings regarding international climate policy. Disagreement over the distribution of climate protection costs across countries is blocking current negotiations about a new international climate agreement. At the heart of this disagreement are different perceptions of distributive justice. The empirical findings in this thesis show that there is no difference in the ranking of fairness principles across citizens in China,

[3] At Christmas time, for example, commercials to collect donations perfectly address such feelings of responsibility and warm glow.

Germany, and the USA, suggesting that the common ground for crafting a future agreement is larger than expected. In particular, the accountability principle should weigh heavily when deciding on the burden sharing. In addition, the findings suggest that in order to gain support among citizens, international climate policy may need to take measures to improve trust.

As discussed above, research on the potential and determinants of private adaptation and voluntary climate protection activities shows a tremendous need to catch up. This thesis takes first steps to find meaningful indicators for private adaptation efforts, motivational factors discussed in the literature, and perceptions of international climate policy. One direction of future research could account for richer sets of items capturing the various facets of adaptation behavior, intrinsic and extrinsic motivational factors, as well as perceptions of the public good providing process.

Future research could also investigate whether the behavioral findings in this thesis are robust using, for example, panel data which allow controlling for individual specific heterogeneity over time to further investigate the comparative static results from the theoretical literature. New experimental designs may also shed light on potential trade-offs between private adaptation and voluntary climate protection activities (e.g. air-conditioning which increases carbon emissions). One important research question is whether some groups of individuals are inclined to take adaptation measures which are more harmful than useful (mal-adaptation).

Another direction of future research is to investigate whether the findings in this thesis hold for other countries or may be applied to non-environmental consumption patterns such as fair-trade, Child-Labor-Free certified, products combined with charitable purposes, or voluntary donations for social or ethical purposes. Finally, since burden sharing of climate protection costs, financing adaptation, or technology transfer are central issues in future international climate negotiations, further research could explore the determinants of citizens' evaluations of these issues in more detail. A better understanding may help gather domestic support for international climate policy.

2. Are German Tourists Willing to Adapt?
A Microeconometric Analysis of Adaptation to Climate Change

Authors: Claudia Schwirplies and Andreas Ziegler

Abstract: This paper empirically analyzes the determinants of individual tourism-related adaptation to climate change, i.e. the stated willingness to increasingly choose a different destination due to higher temperatures in the holiday region. By examining the tourism sector, our study investigates an industry, which was not extensively considered in economic analyses of climate change so far in spite of its worldwide huge economic relevance and strong sensitivity to global warming. Our empirical analysis on the basis of unique representative data from 5370 German tourists first reveals a non-negligible extent of tourism-related adaptation to climate change in the amount of more than 22% of the respondents. Our microeconometric analysis indicates that tourists with a high awareness of climate change effects, increasing age, and higher disposable financial resources are more willing to adapt. The estimation results suggest no single significant effect of a high educational level or a high level of information on tourism-related adaptation to climate change, but a positive interaction effect. Our empirical results underline several challenges for the tourism industry and policy makers in order to transform the tourism infrastructure and to diversify holiday offers. They additionally reveal important focus groups of tourists such as (the increasing group of) elderly persons who are crucial for the development of successful future product strategies in the tourism sector.

Keywords: Climate change; adaptation; tourism

JEL: Q54, Q58

2.1 Introduction

Climate change is in the meantime mostly considered as scientifically proven due to the observation of increasing global average surface and ocean temperatures, widespread melting of snow and ice, and the rising global mean sea level (e.g., IPCC, 2007c). In general, two major strategies are pursued to meet the challenge of global warming: Reducing greenhouse gas emissions to abate climate change (i.e. mitigation of climate change) and adjusting to the new requirements (i.e. adaptation to climate change). In contrast to the broad literature on mitigation, adaptation to climate change has only recently gained increased attention in the discipline of economics. Eisenack (2014) and Heuson et al. (2012), for instance, give a comprehensive overview of the corresponding literature). This literature primarily focuses on adaptation at the industry level such as agriculture (e.g., Kelly et al., 2005; Seo and Mendelsohn, 2008), forestry (e.g., Guo and Costello, 2013), the building industry (e.g., Morton et al., 2011), and winter tourism (e.g., Abegg, 2007; Scott and McBoyle, 2007). Further studies are concerned with adaptation at the firm level. For example, Hoffmann et al. (2009) analyze adaptation activities of Swiss ski lift operators, Berkhout and Gann (2006) identify a framework for adaptation to the direct and indirect impacts of climate change in business organizations, and Linnenluecke et al. (2011) discuss firm relocation as a measure to adapt to climate change.

Academic studies on adaptation activities of private households and particularly reliable empirical analyses still remain sparse. Recent work in this field is primarily concerned with residential issues. For example, Bichard and Kazmierczak (2012) consider the preparedness of homeowners in England and Wales to make changes to their homes in response to the impacts of climate change. Botzen and v. d. Bergh (2009, 2012) analyze the determinants of contracting flood risk insurances by Dutch homeowners and estimate the willingness to pay as well as risk premiums for such insurances. Furthermore, Zhai et al. (2006) examine the willingness to pay for flood control activities by Japanese residents, Osberghaus et al. (2010) discuss the influence of information and personally perceived risk on the motivation of German individuals to adapt to global warming, and Kousky (2010) provide insight into the heterogeneity in

how disasters alter risk perceptions of homeowners in St. Louis County, Missouri. In addition, Grothmann and Reusswig (2006) consider the psychological aspects of adaptation and Fischer and Glenk (2011) analyze the preferences of Scottish residents for climate change adaptation policies concerning changes in river water flows.

According to IPCC (2007a), the tourism industry is a sector, which is likely to see substantial demand shifts due to the impacts of climate change. Thus, it is rather surprising that this sector has not been extensively considered so far since it is of particular economic importance as one of the largest drivers of employment and development worldwide. Taking account of its direct, indirect, and induced impacts in 2011, tourism generated about 9% of the worldwide GDP (6.3 trillion US-Dollar), provided more than 8% of the worldwide jobs (255 million), and comprised around 5% of the worldwide investments (743 billion US-Dollar) and exports (1.2 trillion US-Dollar) (e.g., World Travel & Tourism Council, 2012). Similarly, in the EU the tourism industry generated nearly 8% of the GDP, provided more than 8% of the total labor force (direct contribution more than eight million jobs, total contribution more than 18 million jobs) and comprised about 4% of total investments in 2011 (e.g., World Travel & Tourism Council, 2011). Tourism thus represents the third largest socioeconomic activity in the EU after the trade and distribution and construction sectors (e.g., European Commission, 2010).

Researchers and decision makers in the tourism sector have identified potential threats to tourism due to global warming, especially in mountain regions, small islands, coastal zones, and natural or cultural heritage destinations (e.g., IPCC, 2007a; UNWTO, 2008). For both summer and winter tourism, shifts in global tourist flows and travel patterns are expected as a result of the changing attractiveness of holiday destinations. This development implies the need to transform the tourism infrastructure (such as artificial snow making or landscaping and slope development in the case of ski lift operators, e.g., Hoffmann et al. (2009)) and to diversify holiday offers (such as alternative activities like wellness and cultural offerings, which are independent of weather conditions, or changing travel times, e.g., Kreilkamp (2011)). However, these adjustments are associated with immense investments and costs for

the tourism sector (e.g., Kemfert, 2007). As a consequence, knowledge about the tourism-related adaptation of households to climate change seems to be crucial for the development of successful and efficient future product strategies by tourism providers and affected holiday destinations as well as for policy makers in order to respond to the challenges of the predicted demand shifts due to climate change.

In this respect, German households certainly play a pivotal role, at least in Europe. Regarding journeys with a duration of one night or more in 2011, for example, German households have the highest expenditures among all European countries and thus about twice as much as tourists from the UK and even four times as much as Italian households (French tourists have the second highest expenditures in this respect, e.g., Eurostat (2012)). In 2011, German households had the worldwide highest expenditures on travels abroad and thus spent more money than American or Chinese tourists on such travels (e.g., UNWTO, 2012). Due to their frequency of traveling abroad, German households might be highly affected by impacts of climate change during their holidays and thus will certainly have a strong effect on the tourism industry, at least in Europe, if they extensively change their travel behavior in the future.

On the basis of unique data from a representative survey of 5370 tourists in Germany, this paper seeks to enhance the understanding of the extent and the determinants of tourism-related adaptation to climate change, which is measured by the stated willingness to increasingly choose a different destination due to higher temperatures in the holiday region. Our microeconometric analysis of these rich data is based on common binary probit models in order to test the role of the awareness of climate change effects, general risk aversion, health risks associated with climate change, and available means to cope with the impacts of climate change. We particularly evaluate the extent of the corresponding effects and thus not only the statistical, but also the economic significance in order to draw several conclusions for the necessary transformation of the tourism sector in response to future shifts in travel patterns of tourists, for example, in Germany.

The remainder of the paper is organized as follows: Section 2.2 discusses the background and Section 2.3 develops the hypotheses for our empirical analysis. Section 2.4 presents the data

and the variables in our microeconometric analysis. Section 2.5 discusses the estimation results and the final Section 2.6 draws some conclusions.

2.2 Background

The tourism industry is highly sensitive to the impacts of climate change (e.g., Aguiló et al., 2005; IPCC, 2007a; Scott et al., 2012). For example, Lise and Tol (2002) and Hamilton et al. (2005) predict changes in patterns of tourist flows and tourism demand due to increasing global temperatures. As a consequence, currently popular holiday destinations are expected to become less attractive due to rising temperatures and more frequent heat waves such as the Mediterranean region, Florida, Bali, Philippines, Sri Lanka, and the east coast of Australia (e.g., IPCC, 2007a; Deutsche Bank Research, 2008). In contrast, other tourism regions are predicted to gain attractiveness such as coastal regions in Central and Northern Europe, North America, Middle East, and New Zealand (e.g., IPCC, 2007a; Deutsche Bank Research, 2008). Further predictions for the next years and decades forecast changes in preferences for outdoor activities and seasonal shifts from summer to spring and autumn as temperatures rise (e.g., European Environment Agency, 2005).

Although the overall effects of climate change on global tourism demand and therefore the economic consequences for the tourism industry as a whole are assessed to be quite small, these predicted demand shifts due to climate change can lead to significant regional economic impacts (e.g., Berrittella et al., 2006; Scott et al., 2012). For the affected holiday destinations it is generally not trivial to respond to the challenges of these predicted shifts, for example, by changing the peak tourist seasons or by adjusting the infrastructure so that the stay and the activities in the holiday destination are less negatively affected by increasing temperatures. But it is slightly easier to react for tourism providers (by diversifying travel offers) and particularly easiest for an individual tourist who is very flexible in adjusting to climate change, for example, by substituting the travel destinations, the travel seasons, and the types of holiday (e.g., IPCC, 2007a; UNWTO, 2008; Scott et al., 2012).

Against this background, finding a meaningful indicator for tourism-related adaptation to climate change at the household level is a great challenge since climate and in particular higher temperatures are indeed among the most important motives for travelling, but individual travel behavior is also subject to various non-climatic influences. Moreover, it is more likely that changes in weather extremes like hot days and heat waves will be experienced much earlier and more noticeably than long-term climate change since changes in mean climatic conditions take a long time and are generally not consciously perceived by individuals (e.g., Fankhauser et al., 1999; Yohe and Tol, 2002). As a consequence, consideration of short- and medium-term weather and climate conditions may be useful to analyze the reaction and adaptation to long-term changes in weather and climate.

General adaptation strategies of households due to climate change are responses to perceived or expected effects with the intent to circumvent damage or exploit beneficial opportunities (e.g., IPCC, 2007a; Hisali et al., 2011). Adaptation measures are supposed to reduce the sensitivity to climate change, alter the exposure to climate change, and increase the resilience to cope with the consequences of global warming (e.g., Yohe and Tol, 2002). In terms of purposefulness, adaptation measures might be planned or autonomous and also anticipatory or reactive (e.g., Heuson et al., 2012; Eisenack, 2014). Smit et al. (1999) further specify three dimensions of adaption, i.e. climate-related stimuli (adaptation to what?), the adaptation system (who or what performs the adaptation?), and adaptation measures (how does adaptation occur?) (see also Heuson et al., 2012). Additionally, Eisenack and Stecker (2012) describe the stimulus as a change in statistical parameters (e.g. mean, frequency, or variance) of meteorological variables associated with climate change, which affects actors or systems (exposure units) and determines the impact of climate change.

Following these definitions and concepts, this paper carries out a first attempt to find a meaningful indicator for tourism-related adaptation to climate change by empirically analyzing the stated willingness of households (who are exposure units and thus the adaptation system) to increasingly choose a different destination (which is the adaptation measure) due to higher temperatures in the holiday region (which are climate-related stimuli). We thus refer to

planned and anticipatory adaptation in the short- and medium-term where information about weather and temperatures is deliberately used with the purpose to circumvent damages due to high temperatures when traveling (e.g. heat stress or health problems). In line with the concept introduced by Eisenack and Stecker (2012), households are thus exposure units, operators, and receptors of adaptation at the same time.

2.3 Hypotheses

Existing conceptual frameworks of adaptation (e.g., Fankhauser et al., 1999; Yohe and Tol, 2002; Smit and Wandel, 2006) as well as former empirical studies at the firm level (e.g., Becken, 2005; Hoffmann et al., 2009) and at the individual level (e.g., Zhai et al., 2006; Botzen and v. d. Bergh, 2012) mainly consider four main groups of determinants of adaptation to climate change: Awareness of climate change effects, general risk aversion, vulnerability, and adaptive capacity. At the same time, the concepts of vulnerability and adaptive capacity are subject of fundamental criticism for being ambiguous and not clearly enough defined (e.g., Hinkel, 2011; Eisenack and Stecker, 2012). This inaccurateness makes it very difficult to find and measure meaningful indicators for adaptation. Consequently, hypotheses and determinants are derived from the specific research question instead of those general definitions in this paper (e.g., Heuson et al., 2012).

Awareness and the perception of threats by climate change effects are of high importance with respect to natural hazard response (e.g., Grothmann and Reusswig, 2006). Especially planned or proactive adaptation, in contrast to autonomous adaptation, is based on the awareness that conditions have changed or are about to change and that activities are required to return to, maintain, or achieve a desired state (e.g., IPCC, 2007a). Accordingly, with decreasing uncertainty about the (negative) consequences of climate change the propensity of households to conduct adaptation activities should increase. Thus, a subjective perception of the consequences of global warming can, for example, be triggered by personal experiences with extreme weather events and disasters, which can at least potentially be caused by climate change (e.g., Zhai et al., 2006; Deutsche Bank Research, 2008). A higher awareness of clima-

te change effects and a greater need to adapt travel behavior may also arise from increasing travel frequencies, particularly if the type of travel is strongly dependent on weather and climate (e.g., Deutsche Bank Research 2008). This leads to the following hypothesis that is examined in our empirical analysis:

> *Hypothesis 1: Tourists with a higher awareness of climate change effects are more likely to adapt their travel behavior due to global warming.*

Moreover, Zhai et al. (2006) argue that, apart from the awareness of climate change effects, adaptation activities depend on the perception of other risks. Since long- and medium-term weather forecasts due to climate change are quite uncertain, attitudes towards risk and the degree of risk aversion are pivotal indicators (e.g., Heal and Kriström, 2002), which influence travel and adaptation decisions of households. Furthermore, the destination choice is strongly determined by risk aversion and motives of risk reduction and the perceptions of risk (e.g., Gitelson and Crompton, 1984; Ryan, 1995). This leads to the following hypothesis that is examined in our empirical analysis:

> *Hypothesis 2: Tourists with a higher general risk aversion are more likely to adapt their travel behavior due to global warming.*

Furthermore, certain groups of people are certainly more affected by the impacts of global warming than others. Due to their physical constitution, for example, elderly and very young people are more vulnerable from increasing temperatures and thus have a higher health risk (e.g., Bartlett, 2008). This leads to the following hypothesis that is examined in our empirical analysis:

> *Hypothesis 3: Tourists with a higher health risk associated with climate change are more likely to adapt their travel behavior due to global warming.*

In line with the framework of Eisenack and Stecker (2012) for analyzing adaptations to climate change, the implementation of adaptation measures requires resources, in the following referred to as means. Those means include all indicators, which influence the ability to adjust to the new climate conditions, for example, human capital including education, knowledge,

and information as well as the ability of decision makers to manage this information (e.g., Yohe and Tol, 2002; IPCC, 2007a; Eisenack and Stecker, 2012). Moreover, former studies on adaptation to climate change at the individual level reveal a positive relationship between income and the propensity to adapt (e.g., Grothmann and Reusswig, 2006; Osberghaus et al., 2010). Since choosing an alternative travel destination may be associated with transaction costs, households with higher income and particularly wealth (and thus disposable financial resources) might have a higher ability to adapt to climate change. This leads to the following hypothesis that is examined in our empirical analysis:

> *Hypothesis 4: Tourists with available means to cope with the impacts of climate change are more likely to adapt their travel behavior due to global warming.*

2.4 Data and variables

For our empirical analysis we use unique data from a representative online-in-home survey among private households in Germany, which were randomly selected by the German survey institute forsa. The survey was conducted in October and November 2012. Overall, 6049 respondents (i.e. heads of the household) completed the questionnaire which collected information about the purchase of natural hazard insurances, the provisions for indoor climate and flood control, as well as tourism-related adaptation to climate change. Further questions referred to general personal assessments (e.g. concerning global challenges) and experiences (e.g. with extreme weather events), specific attitudes to climate change, recreational behavior, general information on accommodation, financial resources, as well as socio-economic information. However, the target population is the universe of all German tourists and not the universe of all German households so that we only consider 5578 respondents out of these 6049 observations who undertook at least one journey during the past two years. In order to circumvent possible distortions of our estimation results for the determinants of tourism-related adaptation to climate change, we furthermore exclude the rather negligible small group of 208 tourists who already changed the destination due to high temperatures in the past (or did not answer to this question) so that our empirical analysis is based on overall 5370 tourists.

With respect to the dependent variable in our microeconometric analysis, the tourists were asked if they think that they might increasingly choose a different destination for future travels (winter sports trips excluded) due to higher temperatures in the holiday region. Since the analysis focusses on the general willingness to choose alternative holiday destinations, no distinction has been made between international and domestic tourism. The question was asked before several questions about attitudes towards climate change and particularly refrains to mention the term climate change in order to avoid that the answers are influenced by these attitudes (e.g. whether the respondent personally believes that global warming is not going to occur at all). The hypothetical nature of this question may result in a higher number of positive responses compared to actual behavioral responses. This phenomenon is often referred to as hypothetical bias and might be attributed to the uncertainty about future behavior as well as the propensity of respondents to answer in a way that is perceived favorably by others. We tried to address the uncertainty bias by a "don't know/no answer" option to allow for unsure responses. Furthermore, we think that answering the question about increasingly choosing a different destination due to high temperatures in the holiday region should not create social desirability bias since no additional comments were received regarding the region, travel mode, or price of the journey, which might be subject to social desirability. Therefore, the corresponding variable is one of several potential indicators for tourism-related adaptation to climate change if we consider global warming as scientifically proven in the meantime as discussed above. Based on the binary structure of the response options, we construct a dummy variable "tourism-related adaptation to climate change" that takes the value one if the tourist stated to increasingly choose a different destination due to higher temperatures in the holiday region in the future.

In order to capture the awareness of climate change effects as one main group of explanatory variables (in order to test hypothesis 1), two obvious indicators are the attitudes towards climate change as aforementioned as well as expectations about the consequences of climate change. Therefore, we consider the dummy variable "expected rising temperatures" that takes the value one if the respondent expects increasing average global surface temperatures up to 2100 compared to pre-industrial levels and the dummy variable "expected negative conse-

quences" that takes the value one if the respondent expects negative or very negative consequences of climate change for his or her personal living conditions (and thus chose one of the two negative expectations on a five-stage ordinal scale). Since awareness of climate change effects can additionally benefit from the engagement in environmental issues, another dummy variable "member of environmental organization" takes the value one if the respondent is a member of a group or organization that engages in the preservation and protection of the environment and nature. Furthermore, as discussed in the previous section, an increasing awareness of climate change effects can be triggered by personal experiences with extreme weather events. Therefore, we construct the four dummy variables "personal experience of heat waves", "personal experience of floods", "personal experience of heavy rain", and "personal experience of storms" that take the value one if the respondent already underwent heat waves, floods, heavy rain, or storms, respectively, at home or when travelling. Finally, we consider the dummy variable "frequent journeys" that takes the value one if the respondent undertook at least four journeys with duration of at least two days during the past two years.

The next two groups of explanatory variables (in order to test hypotheses 2 and 3) are concerned with the general risk aversion and the health risk associated with climate change. The general risk aversion is measured through two different indicators. The first indicator refers to the readiness to assume risk relating to recreation and sports. The underlying question was based on an ordinal scale from zero (not willing to take risks at all) to ten (very willing to take risks) and the corresponding dummy variable "risk aversion recreation and sports" takes the value one if the respondent indicated values from zero to three. The second indicator refers to the extent of general risk aversion with respect to financial investments. The corresponding dummy variable "risk aversion financial investments" takes the value one if the respondent pursues very strong or rather strong security objectives in financial investments (and thus indicated one of the two highest degrees of security objectives on a five-stage ordinal scale). Concerning health risk associated with climate change, we consider the variable "age" of the respondent (in years) as perhaps most important indicator and the variable "number of children under 18 years" living in the household of the respondent.

Available means to cope with the impacts of climate change as fourth group of explanatory variables (in order to test hypothesis 4) are captured by two indicators for general financial resources. The first 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 (in 2011 the average disposable income of German households added up to 2590 Euros, e.g., German Federal Statistical Office (2012)). The second dummy variable "disposable financial resources" refers to the wealth and savings and takes the value one if the household is able to save a certain amount of the monthly income. Two other indicators for available means to cope with the impacts of climate change refer to the educational level and the level of information. The dummy variable "highly educated" takes the value one if the respondent received at least the general qualification for university entrance (i.e. the German Abitur) and the dummy variable "very well informed" takes the value one if the respondent feels very well informed (and thus indicated the highest level of information on a five-stage ordinal scale) about possible adaptation activities to climate change. In addition, we consider the interaction term of "highly educated" and "very well informed" in order to test whether a high level of information has a stronger impact on tourism-related adaptation to climate change if the respondent is highly educated.

Along with these main explanatory variables, we also include several control variables, namely the gender dummy variable "female", the regional dummy variable "Eastern Germany", and the occupation dummy variable "full-time employment". Table 3 reports several descriptive statistics (i.e. mean, median, standard deviation, minimum, and maximum) for the dependent and the explanatory variables in the microeconometric analysis. The main result is the fairly high relative frequency of more than 22% of tourists who stated to increasingly choose a different destination due to higher temperatures in the holiday region. In this respect, it can only be speculated whether the non-negligible group of 633 tourists who have not answered to this question has a higher propensity for this type of adaptation so that the share is possibly even higher. Overall, the frequency clearly indicates a non-negligible extent of tourism-related adaptation to climate change which has the potential to have significant effects on the tourism sector. It should be noted that our microeconometric analysis of the determinants

of this type of adaptation is not affected by the possible case that this share is slightly under- or overestimated in the survey.

Due to the binary structure of the dependent variable, we apply common binary probit models to estimate the determinants for this type of adaptation. In this framework, we assume that the individual *i* (*i* = 1, …, n) will increasingly choose a different destination due to higher temperatures in the holiday region if the expected benefit from journeys with this adaptation measure is greater than the expected benefit from journeys without this adaptation measure. The underlying continuous latent variable can be interpreted as the utility of *i* and is specified as follows:

$$U_i = \beta' x_i + \varepsilon_i$$

The vectors $x_i = (x_{i1}, \dots, x_{ik})$ of the *k* explanatory variables particularly comprise our indicators for the awareness of climate change effects, for general risk aversion, for the health risk associated with climate change, and for available means to cope with the impacts of climate change. The corresponding unknown parameter vector is $\beta = (\beta_1, \dots, \beta_k)'$. In binary probit models the stochastic component ε_i has a standard normal distribution (with expected value of zero and variance one). The latent variable U_i is not observable, but can be related to the observed binary dependent variable y_i that takes the values one if an individual states to conduct the tourism-related adaptation:

$$y_i = \begin{cases} 1 \; if \; U_i \geq 0 \\ 0 \; if \; U_i < 0 \end{cases}$$

The parameter vector β is estimated by the maximum likelihood method (ML). We consider heteroscedasticity-robust estimates of the standard deviations of the estimated parameters and thus heteroscedasticity-robust z-statistics. Besides the parameter estimates, we particularly discuss the estimates of average marginal and discrete probability effects. The consistent estimation of the interaction effect of “highly educated” and “very well informed” (which is not necessarily in line with the parameter of the underlying interaction term) and the calculation of the corresponding z-statistics are based on the approach of Ai and Norton (2003) and Norton et al. (2004), which was commonly not considered in former empirical analyses of inter-

action effects with possible distorted conclusions if only the parameter of the interaction term is interpreted (for a general derivation of interaction effects in non-linear econometric models see also Frondel and Vance, 2012).

It should be noted that the number of observations in this microeconometric analysis decreases to 3232 tourists due to incomplete data for the dependent or the explanatory variables as it is obvious from Table 3. However, the corresponding descriptive statistics for this smaller group of observations are qualitatively almost identical to the values in Table 3.[4] All calculations and estimations were conducted with the statistical software package Stata.

2.5 Estimation results

Table 4 reports the main estimation results in the binary probit model for the determinants of tourism-related adaptation to climate change. While the first column refers to the ML estimates of the parameters (including robust z-statistics), the second column reports the estimates of average marginal probability effects (in the case of the two continuous explanatory variables "age" and "number of children under 18 years"), of average discrete probability effects (in the case of the other dummy variables), and of the interaction effect for "highly educated × very well informed".

Regarding the control variables, the parameter estimates in Table 4 suggest that the propensity for tourism-related adaptation to climate change is significantly higher for females and tourists from Western Germany, whereas full-time employment has no significant impact. The estimated average discrete probability effect of more than seven percentage points for females is in line with results from former studies of adaptation activities (e.g., Richardson and Loomis, 2004; Osberghaus et al., 2010).

Both the expectation of rising temperatures in the future and the expectation of negative consequences of climate change have positive impacts on tourism-related adaptation to climate change at least at the 5% significance level. It should be noted that the effect of "expected

[4] These values are not reported due to brevity, but are available upon request.

negative consequences" is not only statistically significant, but also of high relevance due to the estimated average discrete probability effect of almost twelve percentage points. According to Table 5, which reports the estimates of average probabilities at minimum and maximum values of explanatory variables with a significant effect, this means that the estimated average probability of this type of adaptation increases by more than 34% from 18.4% if negative consequences of climate change for the living conditions are not expected to 24.7% if such consequences are expected. In addition, members of environmental organizations have a significantly higher propensity for tourism-related adaptation to climate change. Concerning the variables of personal experiences with extreme weather events, experiences with heat waves have a strong significantly positive effect (with an estimated average discrete probability effect of almost twelve percentage points), whereas the parameters of the other three variables are not different from zero at the 10% significance level. This result is not very surprising since experiences with heat waves are apparently more relevant. Our indicator for adaptation to climate change explicitly refers to the stated willingness to increasingly choosing a different destination due to higher temperatures in the holiday region which tourists obviously rather associate with heat waves than with floods, heavy rain, or storms. Overall, however, hypothesis 1 can strongly be confirmed.

In contrast, hypothesis 2 cannot be confirmed since none of the parameters of the two variables for general risk aversion is different from zero at the 10% significance level. While this estimation result refers to the readiness to assume risk relating to recreation and sports as well as to financial investments, it should be noted that we have also analyzed the effects of other indicators for general risk aversion such as the readiness to assume risk in general, the readiness to assume risk relating to health or traveling by car, as well as the readiness to assume risk in a lottery game. In line with the estimation results in Table 4, however, no other general risk aversion indicator has a single significant effect and no group of these risk aversion variables has (on the basis of the results from Wald tests) a joint significant impact on tourism-related adaptation to climate change.[5]

[5] The corresponding estimation results are not reported due to brevity, but are available upon request.

Similarly, the number of children under 18 years living in the household and a number of journeys greater than three during the past two years have no significant effect, either. This result would imply that hypothesis 3 cannot be confirmed. However, it should be noted that the number of children in the household play an ambiguous role as determinant of tourism-related adaptation to climate change. While this number may be an indicator for health risk associated with climate change as discussed above, it can also decrease the available means to cope with the impacts of climate change by increasing transaction costs of increasingly choosing a different destination due to higher temperatures in the holiday region in the future. The number of children or more generally family size can therefore be considered as a proxy for the opportunity costs of leisure time (e.g., Scarpa et al., 2007). In contrast, age has the expected strong positive impact at very low significance levels. The estimated average discrete probability effect implies an increase by 0.2 percentage points for each additional year. According to Table 5, this means that the estimated average probability of this type of adaptation increases from 17.1% for an 18 years old tourist to 33.6% for an 87 years old tourist. Overall, hypothesis 3 can be confirmed for this important component of health risk associated with climate change.

The impact of available means to cope with the impacts of climate change is again not completely unambiguous since the parameter of a high household income is not significantly different from zero, whereas disposable financial resources have a strong significantly positive impact. While the insignificance of the effect of a high household income is very robust[6], this result is not very surprising since a high income is not necessarily connected with disposable money, for example, in the case of a high debt level due to a major purchase such as the purchase of a house. Therefore, our variable "disposable financial resources" is certainly a better indicator for available means to cope with the impacts of climate change. But the insignificant effect of high household income could also be plausible. On the one hand, choosing different destinations might not consequently result in higher overall costs for the journey. On the other hand, the income indicator might also suffer from potential problems of endogeneity, which

[6] We have also experimented with alternative bounds for the construction of the dummy variable for high income which leads to very similar estimation results. These results are not reported due to brevity, but are available upon request.

can be explained by a variation in the choice of destination and travel type for different income groups.

Finally, another interesting estimation result refers to our further indicators for available means to cope with the impacts of climate change. While a high educational level and a high level of information on possible adaptation activities to climate change do not have significant impacts, the average interaction effects of these two variables as well as the single interaction effects for each respondent are highly significant according to Figure 2. This estimated interaction effect in addition to the insignificant single effects implies that only a high level of information in conjunction with a high educational level is an appropriate indicator for available means to cope with the impacts of climate change. A high level of information alone is thus obviously not sufficient for more tourism-related adaptation to climate change, but has to be supported by a high educational level. Overall, however, the estimation results provide sufficient evidence that available means to cope with the impacts of climate change play an important role so that hypothesis 4 can be confirmed.[7]

2.6 Conclusions

On the basis of unique representative data from 5370 German tourists, this paper examines the determinants of tourism-related adaptation to climate change. Our empirical analysis first reveals a non-negligible extent of this type of adaptation since more than 22% of the respondents stated to increasingly choose a different destination due to higher temperatures in the holiday region in the future. This frequency for German households, who have the highest travel expenditures in Europe, clearly suggests significant effects on the tourism sector in the future, at least in Europe. In 2011, the most favorite holiday destinations of German tourists were Spain, Italy, and Turkey with a common market share of nearly 30% (e.g., Deutscher

[7] In order to check the robustness of our estimation results, we have analyzed further model specifications in addition to the aforementioned approaches. For example, we have excluded this interaction term or included travel types (i.e. dummy variables that take the value one if the respondent undertook at least one beach, hiking, wellness, or city journey in the past 2 years, respectively) as explanatory variables, which have, however, no significant effects and furthermore do not affect the other estimation results in any way. The corresponding results are not reported due to brevity, but are available upon request.

Reiseverband, 2012). Since these Mediterranean regions are expected to become less attractive for tourists due to increasing temperatures and more frequent heat waves, they will be highly affected by future demand shifts of German tourists. The consequences concern a sector which is of particular economic importance as one of the largest drivers of employment and development not only in Europe, but also worldwide.

Our empirical results therefore underline several challenges for the tourism industry in order to transform its infrastructure and to diversify holiday offers due to the adaptation of tourists to climate change. In this respect, it is particularly not trivial to respond to these challenges for the affected holiday destinations since necessary adjustments can be associated with immense investments and costs. While the economic consequences for the tourism industry as a whole are assessed to be quite small, the future demand shifts of tourists due to global warming can lead to significant regional economic impacts. In Europe, for example, countries such as Spain and Italy, but also Greece, and thus countries with currently immense economic problems could be negatively affected. Therefore, these economic consequences for the tourism industry in specific regions, but also the reduction of seasonality and financial assistance for changes to the tourism infrastructure are certainly an important direction for national and supranational policy makers such as in the EU in order to support necessary transformations. In contrast, it seems to be easier for tourism providers and operators to react, for example, by adjusting the travel offers in response to the demand shifts or by influencing the travel choices of tourists through targeted marketing campaigns.

In line with former empirical analyses of the determinants of adaptation to climate change, our microeconometric analysis with binary probit models implies an expected strong positive effect of a high awareness of climate change effects, i.e. of expected rising temperatures in the future, expected negative consequences of climate change, engagement in environmental issues, and personal experiences of heat waves, on tourism-related adaptation to climate change. In contrast, we cannot support any effect of our indicators for general risk aversion. Instead, age as indicator for health risk associated with climate change, and disposable financial resources as indicator for available means to cope with the impacts of climate change

obviously play important roles. Interestingly, a high educational level and a high level of information on possible adaptation activities to climate change do not lead to single significant impacts, whereas the interaction effects of these two variables are highly significant. This suggests that a high level of information about adaptation to climate change has to be supported by a high educational level.

With respect to the necessary transformations in the tourism sector, our estimation results suggest important focus groups of tourists with a higher propensity for tourism-related adaptation to climate change such as households with higher disposable financial resources and females. The tourism industry could react to this information by new travel offers and particularly new infrastructure measures in the affected holiday destinations that are specifically addressed to these population groups. However, the perhaps most important focus group for the tourism industry are elderly tourists. Due to the increasing demographic ageing and the increasing ability (due to improved health and rising financial resources of seniors) and willingness of elderly persons to travel, the needs of this group with a higher propensity for tourism-related adaptation to climate change will play a significant role in the development of successful future product strategies in the tourism industry.

This paper makes a first attempt to find a meaningful indicator for tourism-related adaptation, but is somewhat limited to the analysis of choosing different destinations and thus on geographical shifts in tourism demand. The economic consequences of such behavioral changes are obviously very serious for the tourist destinations. In order to draw more specific conclusions, it would certainly be relevant to have more precise information about tourism-related adaptation to climate change, for example, with respect to travel destinations, travel seasons, and types of holiday. However, such specific representative data at the individual or household level are to the best of our knowledge not available yet so that this analysis is left for future research. Another direction for further research is the analysis of winter sports tourism as well as an international comparison, for example, across several EU countries. A necessary condition for such empirical analyses is again the availability of corresponding micro data. To our knowledge, however, such comparable data have not been collected so far, either.

3. Citizens' perceptions of justice in international climate policy: An empirical analysis

Authors: Joachim Schleich, Elisabeth Dütschke, Claudia Schwirplies, and Andreas Ziegler

Abstract: Relying on a recent survey of more than 3400 participants from China, Germany and the USA, this paper empirically analyzes citizens' perceptions of key guiding principles for sharing mitigation costs across countries, justification of climate policy and trust in climate policy. Our findings suggest that the ranking of the main principles for burden-sharing is identical in China, Germany and the USA: Accountability followed by capability, egalitarianism, and sovereignty. Thus, on a general level, citizens across these countries seem to have a common (normative) understanding of fairness. We therefore find no evidence that citizens' (stated) fairness preferences are detrimental to future burden-sharing agreements. In all three countries a majority of citizens considers international climate policy to be justified, but citizens' perceptions differ across specific items and countries. Finally, a substantial portion of citizens in all countries exhibit a lack of trust in international climate agreements.

Keywords: Climate policy; climate change; burden-sharing; equity; fairness; distributive justice; trust; public opinion

JEL: H41, Q54, Q58

3.1 Introduction

The international community generally agrees that to prevent dangerous anthropogenic interference with the climate system, the increase in average global temperature needs to be limited to 2°C compared to its pre-industrial levels[8]. To achieve this target, immediate, substantial and sustained reductions of greenhouse gas emissions are required (e.g., IPCC, 2013). Countries disagree, however, on how to allocate the efforts of doing so. This lack of consensus on the intra-generational burden-sharing (or effort-sharing) helps explain the lack of sufficient progress in international climate policy.[9] Allocating emission reduction efforts across countries may be regarded as a typical problem of distributive justice. In 1992, countries agreed on fundamental principles for such an effort-sharing in Article 3.1 of the United Nations Framework Convention on Climate Change (UNFCCC, 1992):

> *The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof (UNFCCC, 1992).*

These principles of *equity* and *common but differentiated responsibilities and respective capabilities* (CBDR&RC) build the basis for all negotiations under the UNFCCC such as those under the Ad Hoc Working Group on the Durban Platform for Enhanced Action, which is in charge of crafting a new global climate agreement for the period beyond 2020. So far, however, in particular the principles of CBDR&RC have turned out to be difficult to apply in actual policy making. While equity is generally understood as distributive justice, there are numerous interpretations of what this actually means in the context of the UNFCCC. For example, the third assessment report of the IPCC lists 13 different approaches, and no common understanding has emerged (see UNFCCC, 2012). Among others, Ringius et al. (2002) or Lange et

[8] The Copenhagen Accord adopts the 2°C target by recognizing "the scientific view that the increase in global temperature should be below 2°C" (UNFCCC, 2009).

[9] The recent UNEP "Gap-Report" estimates that global greenhouse gas emissions in 2020 will be at least 59 $GtCO_2e$, and hence 8-12 $GtCO_2e$ above emissions pathways deemed consistent with a likely chance of meeting a 2°C target (UNEP, 2013).

al. (2010) categorize these approaches along four main principles. First, *accountability* (or responsibility) relates to past and current levels of greenhouse gas emissions (polluter pays principle). Second, *ability to pay* highlights countries' heterogeneous financial and technological *capabilities* to reduce emissions versus economic development needs.[10] Third, e*galitarian* approaches underline that all people should have equal initial rights to use the atmosphere. Finally, *sovereignty*-based rules stress countries' rights to govern their own climate policy targets which typically imply preserving the current pattern of countries' shares of global emissions (grandfathering).[11]

The different burden-sharing rules have very different distributive implications. For example, the USA or the EU would be better off under a grandfathering principle than under an equal-per-capita rule. The reverse would be true for China. Incidentally, the USA has for the longest time refused to discuss equity issues in the burden-sharing debate and essentially stressed the sovereignty principle. In contrast, Brazil, China, or India consider equity to be central to any future climate agreement, stressing, in particular, the need to recognize cumulative historic emissions, i.e. the accountability principle. The EU, while acknowledging the need to consider accountability, stresses the importance to also factor in countries' capability to combat global warming.

The thrust of the academic literature on distributive justice entails conceptual studies such as Rose et al. (1998), Ringius et al. (2002), Aldy (2003), Klinsky and Dowlatabadi (2009), Okereke (2010), Gupta (2012), Winkler and Rajamani (2014), Garibaldi (2014) or Kallbekken et al. (2014). Also, several quantitative analyses calculate the future emission budgets of countries and regions under particular burden-sharing rules (e.g., den Elzen et al., 2007; Chakravarty et al., 2009; den Elzen and Hof, 2010; den Elzen and Hoehne, 2010; Höhne et

[10] Article 3.3 of UNFCCC (1992) demands "*full consideration of specific needs and special circumstances of developing country Parties*".

[11] Of course, two or more of these burden-sharing principles may also be combined. For example, the 'equal cumulative per capita emissions' approach derives emissions from a carbon budget and essentially combines the accountability and egalitarian principles Kanitkar et al. (2010). Similarly, multiple principles may be employed, typically via an ad-hoc weighting scheme. Such burden-sharing approaches are likely to be politically more palatable, and may be seen as a compromise solution.

al., 2014) or assess their economic implications (e.g., Jacoby et al., 2010; Bosetti and Frankel, 2012; van Ruijven et al., 2012).[12]

Only a few studies so far have attempted to empirically elicit negotiators' or citizens' preferences for particular burden-sharing rules. The studies by Dannenberg et al. (2010), Lange et al. (2010), Hjerpe et al. (2011) and Kesternich et al. (2014b) rely on individuals who had been involved in international climate policy negotiations as country delegates or as observers[13], while Carlsson et al. (2013) and Bechtel and Scheve (2013) study ordinary citizens and Kriss et al. (2011) use college students. The findings by Lange et al. (2010) in particular suggest that negotiators from the EU, Russia and the USA (but not from the G77/China) prefer burden-sharing rules that are in their countries' economic interest. This finding on the so called in-group or self-serving bias is also supported by Carlsson et al. (2013).[14] Relying on a discrete choice experiment, the authors find that citizens in China and the USA tend to favor the burden-sharing principle that is least costly to their home country. Employing a similar methodology with Swedish citizens, Carlsson et al. (2011), however, did not find evidence for a self-serving bias. Based on representative surveys for France, Germany, the UK and the USA, the conjoint analysis by Bechtel and Scheve (2013) suggests that average household costs are the most important criteria for citizens to endorse a particular climate agreement, thus it also provides some evidence for a self-serving bias at the household level. But support is also more likely for agreements that distribute the costs according to a polluter-pays-principle rather than an ability-to-pay-principle. Conducting surveys among college students in China and the USA on how to allocate mitigation costs between both countries, Kriss et al. (2011) find divisions of the burden that are consistent with a self-serving bias. However, the surveys vary in the type of information provided to participants on the costs associated with a particular fairness principle. In Dannenberg et al. (2010), Lange et al. (2010), Hjerpe et al. (2011), and

[12] Note that ambitious emission targets do not necessarily translate into high mitigation costs for countries with a large potential of low-cost mitigation measures. Also, if trading of emission certificates or of credits from offsetting projects across countries is allowed, the distribution of costs does not necessarily correspond to the distribution of emission reduction efforts. The focus of our analysis is on citizens' fairness perceptions of the distribution of costs (rather than emission reductions).

[13] For simplicity we will refer to those as 'negotiators' for the remainder of the paper.

[14] See Brekke and Johansson-Stenman (2008) for an overview of the behavioral economics literature on the self-serving bias.

Kesternich et al. (2014b) participants received no information on those costs, and Kriss et al. (2011) provide rather general cost information on costs at the country level. In contrast, the citizens in Carlsson et al. (2011, 2013) and Bechtel and Scheve (2013) also received information on the (hypothetical) costs for an average household. In conclusion, the rather scarce empirical literature suggests a tendency toward self-serving biases for negotiators' attitudes and tentatively also in the citizens' attitudes towards burden-sharing rules. The relation between a self-serving bias and the provision of information on the concrete economic implications of burden-sharing rules in surveys or experiments, however, is not clear. Also, responses may differ depending on whether subjects evaluate and chose the burden-sharing rules according to their personal preferences (as, for example, in choice experiments) or according to their fairness perceptions (i.e. in a normative sense).

According to Lind and Tyler (1988) individuals are often as concerned about the justice of the process as with the outcome itself. Legitimacy and acceptance of the outcome depend on whether individuals perceive the process to be fair and transparent. Procedural justice of international climate policy, however, has attained considerably less attention than distributive justice (e.g., Okereke, 2010). Among others, Klinsky and Dowlatabadi (2009) and Okereke (2010) point out that procedural justice requires representation of the interests of all countries in the climate negotiations, in particular of those countries that are most vulnerable to climate change. Similarly, following Furlong (2005), perceived legitimacy and acceptance may depend on individuals' confidence in the structure or the process of international climate policy (procedural trust). While several studies analyze how individuals' perception of fairness and trust in politicians or governments affect their attitudes towards policy instruments (e.g., Hammar and Jagers, 2006; Torgler and García-Valiñas, 2007; Jagers and Hammar, 2009; Jagers et al., 2010), citizens' perceptions of procedural justice and procedural trust related to international climate negotiations have largely been unexplored. So far, comparisons across different countries are typically limited to analyses of individuals' awareness of climate change (e.g., European Commission, 2011; Leiserowitz et al., 2012).

In sum, only Bechtel and Scheve (2013) have analyzed and compared citizens' preferences for burden-sharing rules across countries, and no study has yet explored and compared individuals' perceptions of justification and trust in the context of climate policy across countries. As noted by Grubb (2006, p. 506) though, effective future climate policy "will require widespread and ongoing acceptance either that it is a 'just cause' or that the benefits, in the broadest sense, outweigh the costs". A better understanding of cross-national differences and similarities in citizens' perceptions of fairness, justification and trust is expected to be conducive to effective future climate policy, in particular if politicians try to take their citizens' stance on these issues into account. More generally, since the decisions at the international level get executed at the domestic level, perceived justification of climate policy indicate the level of domestic public support for these measures. Thus, analogous to Oberholzer-Gee et al. (1997), a higher acceptance of international climate policy implies that citizens are more likely to be willing to take on financial burdens associated with national implementations of climate policies. More concretely, high perceived justification and trust in the context of climate policy among citizens in the respective regions should increase the chances that developed countries follow through on their emissions reduction commitments, and that developing countries will limit their greenhouse gas emissions in the future.

The main objective of this paper therefore is to explore citizen's perceptions on distributive justice across countries with regard to the key burden-sharing rules. We further explore citizen's perceptions on justification of climate policy and on trust in climate policy. To do so, surveys were conducted simultaneously in China, Germany (i.e. the most populous EU Member State) and the USA. Due to their respective greenhouse gas emissions, economic strength, and political clout, these countries are expected to play a key role in the success of future climate policy.

The remainder of the paper is organized as follows: Section 3.2 presents a description of the survey, sample demographics and descriptive statistics for the three countries. Section 3.3 then presents the findings, distinguishing between citizens' perceptions on distributive justice, on justification of climate policy and on trust in climate policy. The concluding Section 3.4

discusses our main findings, relates them to the literature, derives policy implications and points to future research needs.

3.2 Data

The data for our analysis was collected from three representative computer-based surveys among a total of 3445 citizens aged 18 and older in China, Germany, and the USA. To ensure a high level of comparability and sample quality all surveys were carried out simultaneously in May and June 2013 by the international market research company GfK (Gesellschaft für Konsumforschung). In total, 1430 respondents in China, 1005 respondents in Germany, and 1010 respondents in the USA completed the questionnaire. In Germany and the USA, the sample was drawn from representative GfK Online Panels. Respondents were invited via email to attend a self-administered interview in a web-based online environment. In China, respondents were recruited by employees of GfK China in eleven core regions, invited to centrally located test studios, and interviewed face-to-face. This approach was chosen since an online survey in China is likely to lead to a systematic bias because internet access is typically lacking in rural areas and market research is less common than in Western countries. In the test studios respondents answered the survey questions without any interference by the interviewers. Furthermore, interviewers were intensively briefed and survey questions were carefully pretested to avoid misunderstandings. Although the survey method in China differs from the online-in-home method in Germany and the USA, it carefully tried to avoid biases due to regional conditions and interviewer interference to make the results obtained for China comparable.

The questions encompassed general personal assessments of climate change, specific attitudes towards international climate policy and negotiations, and individual engagement in climate-friendly behavior. To complete the survey, respondents in all three countries needed about half an hour. Appendix I documents the sample demographics.

In most questions, participants were asked to specify their level of agreement or disagreement with a particular statement or to subjectively assess the importance of a particular principle on

a symmetric scale with five ordered response levels. Potential problems associated with this type of scale are: Central tendency bias (especially in China) acquiescence bias, and social desirability bias (e.g., Chen et al., 1995). These issues were addressed by "don't know/no answer" options to distinguish true neutral from unsure responses, a scale design involving balanced keying, as well as closed ended and "neutral" wording of the items.

To draw reliable conclusions for the total population, the statistical analyses employed specific weights which were calculated by the survey institute to ensure offline representativeness of the results, and to address systematic bias and sampling error. Differences across countries or across items are assessed via z-tests[15]. Rather than comparing the means of responses, we compare the shares of responses, typically adding up the shares for the two highest or two lowest response levels. For example, we first add the (shares of the) responses "strongly agree" and "agree" for a particular item and then conduct a standard z-test to compare findings across countries. In this sense, our statistical analysis is conservative, since it does not assume the data to be interval data.

In general, a large majority of citizens in all three countries believes that climate change is an important challenge (Q1), is already happening (Q2), that it is caused jointly by human activities and natural effects (Q3), and that future generations in particular will be negatively affected by climate chance (Q4).[16] But there are also significant cross-national differences in citizens' perceptions of importance, causes and consequences of climate change. For example, a larger share of citizens in the USA considers climate change less important than in China or Germany. While only a minority of citizens in all three countries feels well informed about climate conferences (Q5) and how their position is represented at international climate negotiations (Q6), German citizens feel particularly poorly informed and represented.

[15] The large sample size allows us to use two-sample z-tests to test for differences in the shares between observations for two countries. Note that compared to t-tests, z-tests are less restrictive since they do not require variables to be normally distributed.

[16] Table 12 reports all general questions on climate change and climate policy together with descriptive statistics on the responses by country and the results of the z-tests for differences across countries.

3.3 Results

This section presents the findings for our core research questions. We first report the findings on citizens' perceptions of distributive justice, then on justification and eventually on trust of international climate policy. For all questions, differences in citizens' responses across countries are highlighted.

3.3.1 Distributive justice

The questionnaire informed participants that to mitigate climate change and its consequences, international climate policy had attempted for some time to reach internationally binding regulations on carbon and other greenhouse gas emissions at several world climate conferences (e.g., Rio de Janeiro, Kyoto, or Copenhagen). They were then asked to assess the relevance of four key principles underlying potential rules to allocate mitigation costs across countries (Q7a to Q7d)[17]: *accountability* (every country has to bear costs according to the emissions it causes), *capability* (every country has to bear costs according to its economic strength), *egalitarian* (every country is allowed to produce the same amount of emissions per capita), and *sovereignty* (every country is allowed to produce the same share of global emissions as in the past). Table 6 reports the exact wording in the questionnaire and – together with Figure 3 – also shows citizens' assessments of these principles.

First, we explore citizens' preferences for particular burden-sharing rules within countries. Our findings suggest that the ranking of the distributive justice principles considered in the survey is identical in all three countries. Using the initials of the principles as abbreviations, we get the following orderings[18]:

China: $A \succ^{*} C \succ^{*} E \succ^{*} S$

Germany: $A \succ^{*} C \succ^{*} E \succ^{*} S$

USA: $A \succ^{*} C \succ E \succ^{*} S$

[17] In the survey, we randomized the order in which the items were displayed to avoid order bias effect.
[18] '*' means statistically significant differences between the principles at the 1% significance level (based on z-tests on the shares of responses in the categories 'consider rather strongly' and 'consider very strongly').

Thus, apart from the ranking between the capability principle and the egalitarian principle in the USA, all components of "ACES" are statistically significantly different from each other in each country.

Second, we analyze differences in preferences for distributive justice across countries. Preferences for the *accountability (polluter pays)* principle are highest in Germany, where about four out of five citizens think this principle should be considered strongly[19] when deciding on how to split up mitigation costs across countries. In China and in the USA the support for this principle is about 10 percentage points lower than in Germany. Citizens' preferences for the *capability* (ability to pay) principle are highest in China, where about two thirds feel this principle should feature strongly in the burden-sharing. In Germany and in the USA support for the *capability* principle is somewhat lower than in China. For *egalitarian* (equal right to pollute) principle we find no differences in preferences across countries. About half the citizens in China, Germany and the USA believe this principle should weigh strongly in allocating the mitigation costs across countries. Finally, preferences for the *sovereignty* (status quo) principle are higher in China than in the other countries, and particularly low in Germany.

Additional calculations show that in all three countries a large portion of the citizens simultaneously rate several principles highly. For China, for example, about 55% of the citizens believe that accountability and capability should both be considered strongly. Similarly, 38% think that accountability, capability and the egalitarian principle should all be considered strongly. Qualitatively similar findings hold for Germany and the USA.

3.3.2 Justification of climate policy[20]

The items capturing justification of climate change refer to effectiveness of past and future climate policy, its scientific underpinning, and the main topics discussed at the UNFCCC cli-

[19] In this section "strongly" combines "rather strongly" and "very strongly". Similarly, "successful" and "important" also combine the answers for the two highest response levels.

[20] The questions in 3.3.2 and 3.3.3 were only asked to those respondents who believe that climate change is real. The order of the items was randomized. Figures given in the text and tables refer to valid responses (i.e. "don't know / no answer" are not included in the calculations).

mate conferences. Table 7 summarizes the survey findings on items related to justification of international climate policy.

Accordingly, a majority of German, U.S. American, and, in particular Chinese citizens, believes that climate change may still be effectively limited (Q8). Almost all Germans and Chinese and about two out of three U.S. Americans think that humans should act to limit climate change (Q9). In each country a bit more than a third of the citizens agree strongly with the statement that scientific findings are too uncertain to serve as the basis for climate negotiations (Q10). An overwhelming majority of citizens in the USA and especially in Germany doubt the success of international climate policy: Only about one in four U.S. Americans and less than one in ten Germans, but more than one in two Chinese perceive previous international agreements to have been successful in combating climate change (Q11). Nevertheless, in all countries a fairly large share of citizens considers future international agreements important for combating climate change (Q12). While this is true for about three out of four Chinese and U.S. Americans, and for almost nine out of ten Germans, about two thirds of the population in all three countries agrees with the statement that all countries can benefit from international climate agreements (Q13). Finally, roughly four out of five Chinese, Germans and U.S. Americans approve the main issues discussed at international climate conferences, i.e. comprehensive quantitative targets to reduce global greenhouse gas emissions, measures to reduce global greenhouse gas emissions, and adaptation measures to the consequences of climate change (Q14). In all countries, comprehensive quantitative targets and measures to reduce emissions are considered more important than adaptation measures. Also, all three topics receive statistically significantly higher approval rates in China and Germany than in the USA.

3.3.3 Trust in climate policy

The survey included several items on citizens' perceptions of international climate negotiations and agreements and of governments' intentions, thus reflecting trust in climate policy. The findings on these perceptions appear in Table 8.

Accordingly, about two thirds of the German, half the US, and one third of the Chinese population strongly believes that commitments made at international climate negotiations will not be kept (Q15a). Three quarter of the Chinese citizens, but only about half the German or U.S. citizens, think that industrialized countries should show they can successfully reduce emissions first before the developing countries have to do so (Q15b). German citizens are particularly skeptical about governments' intentions: Two thirds of the German population as well as about half the Chinese and U.S. population believe that governments use international climate negotiations to pacify their citizens instead of reducing global greenhouse gas emissions (Q15c). Finally, about five out of ten Chinese, four out of ten U.S. Americans, and three out of ten Germans think that climate negotiations are used to publicly denounce the industrialized countries (Q15d).

More than half of the population in all three countries, and especially in Germany and China, believes that richer (industrialized) countries use international climate negotiations to push through their own economic interests vis-a-vis other countries (Q16a). In comparison, less than half the population in all three countries believes that poorer (developing) countries manage to do so (Q16b). For all three countries, the share of citizens who think that richer countries rather than poorer countries are able to push through their interests is higher (statistically significant at $p<0.01$). At the same time, 71% of the Chinese and 50% of the U.S. citizens, but only 39% of the Germans think that all countries have the same opportunities to represent their interests at international climate conferences (Q16c).

3.4 Conclusions

In this section we summarize and discuss the main empirical findings, relate them to the literature and highlight policy implications.

Distributive justice

Our main finding on distributive justice suggests that, on average, citizens in all countries prefer the following ranking of the key guiding principles for the burden-sharing of mitigation

costs: Accountability first, then capability, egalitarianism, and, lastly, sovereignty. Hence, perceptions about various principles of distributive justice appear to be fairly consistent across China, Germany and the USA. Hence, on a general level, we find no evidence that citizens' (stated) fairness preferences are countervailing across countries and hence detrimental to future burden-sharing agreements. Citizens' personal connection to international climate agreements seems to be low, so respondents may decide strictly according to individual normative judgments. Findings from experiments suggest that as people are exposed to additional information about the implications of different normative principles, they typically depart from more egalitarian principles (e.g., Gächter and Riedl, 2006; Konow, 2000). In our context, respondents were informed about the distribution of costs associated with a particular burden-sharing rule (see Table 6). In a different context, but in line with our findings, Gächter and Riedl (2006), among others, have shown that the accountability (responsibility) principle matches people's individual normative judgments best. In the case of mitigating global warming, accountability is most accurately reflected by the polluter pays principle. From this perspective governments in all three countries could point out a country's responsibility for climate change in communicating and justifying costly domestic climate policies to the electorate.

In particular for the USA, the government's strong focus on the sovereignty principle in climate negotiations appears to reflect citizens' fairness perception incompletely. Likewise, we find only limited support for a potential self-serving bias, which had been identified in the studies by Lange et al. (2010) for negotiators and Carlsson et al. (2013) and also Bechtel and Scheve (2013) for ordinary citizens, or Kriss et al. (2011) for college students. Neither citizens of Germany nor of the USA appear to clearly favor burden-sharing principles that are in their countries' best economic interest. Unlike Germany or the USA, China, may benefit from the accountability principle because historic emissions were relatively low. Since 2006, however, China is believed to be the largest annual emitter of greenhouse gases, and its cumulative emissions are expected to soon pass those of the EU. That is, depending on the actual implementation, China would not benefit from using the accountability principle for the burden sharing of mitigation efforts.

Comparing findings across studies is problematic, however, since methodologies differ. In particular, Carlsson et al. (2011, 2013) and Bechtel and Scheve (2013) rely on choice experiments to study citizens' preferences for a particular principle. Compared to our study, in (Lange et al., 2010), conference delegates were presented with more complex decision tasks and more complicated burden-sharing options. Arguably, negotiators may also have better knowledge than ordinary citizens when assessing the country-specific implications of different burden-sharing principles, in particular their economic consequences.

In addition, actual behavior may differ from normative judgment (e.g., Gächter and Riedl, 2006). Even though our survey items on distributive justice also describe the economic consequence of a particular fairness rule for countries, citizens may perceive these consequences as rather abstract. If the economic implications had been more salient, citizens' rankings of fairness principles might have been more self-serving.

We further find that a fairly large share of citizens in all three countries rate several principles highly, reflecting high support in particular for the accountability, the capability and the egalitarian principle. However, this survey did not allow for the exploration of rates of substitution between these principles. For example, individuals' preferences may be convex in these principles, i.e. people may prefer averages to extremes. In this case a mix of burden-sharing of principles would gather higher support among citizens than relying on a single criterion. Yet, there are tradeoffs between these principles. For example, applying the egalitarian rule entails a relatively large emission budget and thus low costs for China. In contrast, relying on the accountability rule, may cause the emission budget for China to be relatively small, particular if a country's current and expected future emissions are used to implement accountability (in addition to historic emissions) (e.g., Lange et al., 2010). Thus, consensus-oriented practical decision making may require a burden sharing rule which simultaneously enjoys high support and low opposition such as the capability rule (e.g., Hjerpe et al., 2011).

Justification of climate policy

We further find that a majority of those citizens who believe that climate change is real considers climate policy to be justified. In general, "approval rates" tend to be substantially high-

er in China and Germany than in the USA. Yet there are strong concerns about the scientific basis for climate policy in all three countries. Given that climate change is a highly complex issue entailing a substantial degree of uncertainty (e.g., IPCC, 2013, 2014), this finding is little surprising. At the same time, policy design is not based on scientific evidence alone, but the outcome of a socio-political process also involving value judgments (e.g., Oppenheimer, 2005). In our survey, the Chinese citizens appear to be generally more optimistic than German or U.S. citizens about the effectiveness of past and future climate accords. Similarly, Yu et al. (2013) find that Chinese citizens tend to have high confidence in their government's ability to effectively combat climate change.

The Germans seem particularly skeptical about the chances to limit climate change and largely consider past policy efforts to be a failure. Nevertheless, they overwhelmingly consider future international agreements important for combating climate change. A fairly large share of about one third of citizens from China, Germany and the USA does not believe that all countries can benefit from climate negotiations. Thus, a substantial part of the population may not be aware that international cooperation in climate policy can produce a global public good.[21] Our findings on the relevance of negotiation topics suggest that citizens in all three countries associate international climate agreements somewhat stronger with emission targets and mitigation measures, i.e. the likely causes of climate change, rather than with adaptation issues, i.e. the symptoms of climate change. In the USA, the portion of citizens which do not consider adaptation measures to be a relevant topic for international climate negotiations is particularly high. Incidentally, unlike Australia or several European countries (including Germany), the USA has not yet contributed or pledged to contribute to the UNFCCC Adaptation Fund.

[21] A prime justification for international cooperation in climate policy is the public goods (global commons) character of mitigation efforts. That is, no country can be excluded from the benefits (e.g., lower risk of climate damage) of emission reduction efforts by one country (non-excludability). Also, all countries may simultaneously enjoy these benefits, without lowering the benefit for any other country (non-rivalry). Mitigation efforts, however, incur costs. When countries decide on their efforts without taking into account the benefits of these efforts on other countries' wellbeing, global mitigation efforts will be too low. In principle then, all countries may benefit from well-designed international climate agreements, providing the economic rationale and justification for such agreements. Differences in costs (and benefits) across countries further complicates international cooperation.

Trust in climate policy

Our survey results also indicate that international climate agreements suffer from a lack of trust among a large portion of citizens in all countries, but the extent differs substantially across countries and issues. In all countries (in particular in Germany), a substantial part of the population believes that commitments made at international climate negotiations will not be kept. Most prominently, these responses may reflect the well-publicized fact that the USA never ratified the Kyoto Protocol, or that Canada formally withdrew from it in 2011. More recently, and after our survey was conducted, Japan weakened its reduction commitment under the Copenhagen Pledges/Cancun Agreements at the climate summit in Warsaw in 2013, thus further undermining trust in international climate agreements. Possibly also motivated by the lack of trust in developed countries' sincerity, a large part of the population in China, Germany, and the USA believes that industrialized countries should first show they successfully reduce emissions before the developing countries have to do so. Likewise, this claim may reflect the distributive justice principal 'capability', which essentially echoes Article 3.1 of the climate convention (UNFCCC, 1992), and requires developed countries to take the lead in combating climate change. In any case, these findings are in line with large developing countries' ongoing requests for steeper emissions cuts from the USA and other developed countries as a precondition for taking on their own targets. Many developing and emerging countries fear that a cap on emissions implies a cap on development. A large share of citizens in all countries believes that climate negotiations are used for purposes other than intended, i.e. to publicly denounce the industrialized countries or by national governments to pacify their citizens. In this sense, national governments are perceived to abuse international climate policy to push their own domestic political agenda.

Finally, our findings provide some evidence that international climate negotiations suffer from a perceived lack of procedural justice as defined by Klinsky and Dowlatabadi (2009) and Okereke (2010). Large shares of citizens in Germany and also in the USA (but not in China) doubt that all countries have the same chances to represent their interests at interna-

tional climate conferences. Richer countries rather than poorer developing countries are thought to be more able to push through their interests at these conferences.

Overall, these findings suggest that to gain support among citizens, international climate policy may need to take measures to improve trust among citizens.

Limitations and future research

As is typical for surveys relying on self-assessments, the validity of our findings may suffer from respondents' propensity to answer the survey questions in a way that will be perceived favorably by others. We tried to address this *social desirability bias* by choosing "neutral" wording, closed ended items and granting anonymity. Nevertheless, while social desirability bias cannot be generally excluded in survey data, we believe that social desirability bias does not distort questions related to guiding principles for the sharing of mitigation costs across countries. Social desirability bias is typically associated with more sensitive issues like illegal behavior, social fraud, or unsocial attitudes (e.g., Krumpal, 2013), or to situations in which participants anticipate that responses will result in normatively influenced or evaluative consequences, e.g., during job interviews (e.g., King and Bruner, 2000). Furthermore, it is a precondition to social desirability bias that social norms or expectations exist and are explicitly or implicitly perceived by respondents (e.g., Nederhof, 1985). Whether these social norms exist in the context of climate policy is subject to debate and may require further research. While we expect that environmentalism or opinions about the relevance of combating climate change are subject to social norms, we do not consider this to be equally true for principles of sharing mitigation costs across countries, which is a topic not highly discussed in daily life by ordinary citizens. In any case, although social desirability bias may influence the absolute evaluation of principles for sharing mitigation costs across countries, leading to an overestimation of support for the principles presented, these biases are not expected to systematically distort the ranking of these principles.

While our research provides empirical evidence that international climate negotiations are perceived as lacking procedural fairness and trust, these findings would have to be further explored in depth with a richer set of items. Previous research has focused on the impact of

perceived fairness and trust in politicians or governments on people's attitudes towards public policy and environmental policy instruments. Future research could explore the effects of citizens' perceptions of procedural justice and trust in climate negotiations on their attitudes towards such policies, their willingness to accept costly national climate policies or their voluntary efforts to reduce greenhouse gases. In addition, while our analysis focuses on differences between citizens' perceptions of various principles of distributive justice within and across countries, future studies could explore the determinants of these perceptions, e.g., via multivariate analyses. A better understanding of citizens' justice perceptions may help gather domestic support for international policy towards the burden sharing of mitigation costs, but also towards financing adaptation or technology transfer. These latter issues are about to take center stage at international climate negotiations.

4. Private provision of public goods: Do individual climate protection efforts depend on perceptions of climate policy?

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Abstract: This paper extends the economic literature on the private provision of public goods by examining the relevance of perceptions of climate policy to voluntary contributions to the public good of climate protection. Based on an analytical model which allows for perceptions of climate policy such as justification of international climate policy, procedural trust and procedural justice to affect voluntary climate protection activities, we examined data from representative surveys among citizens in the USA and Germany. Our microeconometric analysis confirmed the prediction that the perceived justification of international climate policy is positively related to voluntary contributions to climate protection in both countries. We also found empirical support (mainly for the USA) that higher perceived procedural justice lowers citizens' propensity to adopt climate protection activities. In contrast, we found no support that higher perceived procedural trust reduces citizens' propensity to adopt such measures. In a broad interpretation, our empirical results imply that individuals' perceptions about the process of providing public goods should also be considered when analyzing the factors explaining voluntary individual contribution to public goods.

Keywords: Public good, voluntary contribution, perceptions of international climate policy, climate protection activities

JEL: H41, Q54, Q58

4.1 Introduction

Standard economic theory predicts that the individuals' incentive to contribute to the public good is generally lower than necessary to reach the optimal Nash equilibrium (e.g., Holländer, 1990). Nonetheless, the findings from numerous free-rider experiments and stated preferences studies suggest that individuals do not only act in their own self-interest (e.g., Andreoni, 1988b; Blanco et al., 2012; Kerr et al., 2012). Social preferences like prestige, respect, reputation, the contempt of others (e.g., Olson, 1965; Becker, 1974; Banerjee and Shogren, 2012), preferences for fairness, and inequity aversion (e.g., Fehr and Schmidt, 1999; Dannenberg et al., 2012), or feelings of warm glow (e.g., Andreoni, 1990) may motivate individuals to voluntarily contribute to the provision of a public good. Social preferences and feelings of warm glow also affect individual contributions to climate protection (e.g., Ahlheim and Schneider, 2002; Kotchen and Moore, 2008; Allcott, 2011; Araghi et al., 2014; Blasch and Farsi, 2014) – arguably the most prominent global public good.

In this paper, we study whether perceptions and beliefs associated with the process of the provision of a public good also influence the willingness for voluntary contributions to public goods. Specifically, we explore whether voluntary climate protection efforts depend on beliefs in the justification of international climate policy as well as on perceptions of procedural trust and procedural justice in international climate policy.

This research question is related to previous studies on the private provision of public goods in various ways. First, external interventions may enhance or decrease intrinsic motivation to adopt pro-social behavior (e.g., Frey, 1994; d'Adda, 2011). Extensive literature on motivation crowding has demonstrated that external circumstances like monetary incentives or institutional settings have the potential to change preferences or the perceived moral obligation. They can lead to crowding-in or crowding-out effects, i.e. enhance or reduce the motivation to voluntarily contribute to public goods (e.g., Frey and Oberholzer-Gee, 1997; Bohnet et al., 2001; Frey et al., 2001; Brekke et al., 2003; Nyborg and Rege, 2003). These findings imply that perceptions and beliefs associated with the public good providing process may influence private contributions positively or negatively. Additionally, Frey et al. (2001) showed that

individuals derive procedural utility from the political process itself, while Nyborg and Rege (2003) and Bó et al. (2010) found that the presentation of a policy as well as the political institution influence moral motivation as much as the policy instrument itself.

Second, the belief or trust that the public good providing process leads to a socially optimal provision of the public good may motivate private contributions. Experimental studies on 'conditional cooperation' have found that people are more willing to contribute to charities and public goods if they observe, believe, or are informed that others are willing to do the same (e.g., Fischbacher et al., 2001; Kocher et al., 2008; Alpizar et al., 2008; Herrmann and Thöni, 2009; Khadjavi and Lange, 2013). Similarly, subjects who contribute and while becoming aware that others do not tend to lower their contributions (e.g., Fehr and Gächter, 2000). Conformity, social norms, or reciprocity have been found to be reasons to motivate this behavior (e.g., Frey and Meier, 2004; Nielsen et al., 2014). Thus, motivation of individuals to voluntarily contribute to public goods may depend on the perceived trustworthiness of their counterpart and beliefs about actual behavior and motives of others (e.g., Rabin, 1993; Berg et al., 1995; Fischbacher and Gächter, 2010).

While the existing literature provides evidence that perceptions of the public good providing process may indirectly affect individuals' contributions to a public good, such a direct link has not been established yet. This paper attempts to take a first step towards closing this gap by analyzing the impact of individuals' perceptions of international climate policy on their voluntary contributions to climate protection. We first derived testable predictions from a simple analytical model, in which a representative individual's utility function also includes perceptions of climate policy such as justification, procedural trust, and procedural justice. We then econometrically analyze the impact of these perceptions on the willingness to adopt five domestic climate protection activities. Our microeconometric analyses are based on unique data from representative surveys conducted simultaneously among citizens in the USA and Germany. Both countries are large emitters with strong political clout and are therefore considered to play a key role in future international climate policy. Thus, our analysis also allows for a comparison across countries.

The remainder of this paper is structured as follows: Section 4.2 offers a brief background on the state of the United Nations climate negotiations and also discusses justification, procedural trust and justice in international climate policy. Section 4.3 presents the analytical approach and derives the theoretical predictions for our empirical analyses. Section 4.4 describes the survey and our econometric approach. Results are presented in Section 4.5. The concluding Section 4.6 discusses our main findings and points out future research needs.

4.2 Climate policy background

Within the United Nations' climate negotiations, countries have recognized that the global mean temperature must not rise by more than 2°C above the pre-industrial level in order to limit the dangerous impacts of anthropogenic climate change to acceptable levels (UNFCCC, 2009). However, the voluntary pledges countries made to the Copenhagen Accord in 2009 as well as decisions reached at subsequent climate summits are unlikely to be consistent with a path towards reaching the 2°C target (e.g., Höhne et al., 2012). Moreover, progress on a post Kyoto global climate agreement, which is scheduled to come into effect after 2020, has been slow. Industrialized countries (particularly the USA) fear that greenhouse gas emission targets may negatively affect the competitiveness of their economy (e.g., Pauwelyn, 2007) while emerging and developing countries (e.g., China) fear that emission targets will inhibit their future economic growth ("cap on development") (e.g., Banerjee, 2012). The widening gap between actual and required climate protection efforts raises doubts about the effectiveness of current international climate policy in general, thereby undermining its justification even for those not questioning the existence of climate change. Since decisions at the international level are executed at the domestic level, perceptions of justification may also influence the individual willingness for contributions to climate protection. The findings by Oberholzer-Gee et al. (1997), for instance, suggest that a higher social acceptability of international climate agreements may lead to a higher propensity to take on financial burdens associated with national implementations of international climate policy.

International climate policy is further characterized by a lack of procedural trust and procedural justice. Procedural trust is generally defined as the confidence in a structure or process (e.g., Furlong, 2005) but may also reflect a belief in sufficiently high social preferences of the counterpart instead of selfish motives (e.g., Sliwka, 2007). In climate policy, the free-rider problem in particular has challenged procedural trust. For example, the USA never ratified the Kyoto Protocol and in 2011 Canada formally withdrew from it. In 2012, Japan reneged on its voluntary pledge made under the Copenhagen Accord. Likewise, China for a long time refused to have its greenhouse gas emissions monitored by others and current dispute revolves around procedures to verify the pledges by third parties. In the absence of a supranational authority, however, procedural trust is particularly conducive to enforcing the outcomes of international climate negotiations. The belief in the process of international climate policy may lead to binding agreements even if parties distrust each other. The conceptual study by Pittel and Rübbelke (2013) pointed out that increased trust in the process of international climate policy and the perceived intentions of other countries may raise the probability of cooperative behavior in climate protection. Several studies also suggested that attitudes towards policy instruments are influenced by the trust in politicians or governments (e.g., Torgler and García-Valiñas, 2007; Jagers and Hammar, 2009; Jagers et al., 2010).

Unlike distributive justice (e.g., Lange et al., 2007; Dannenberg et al., 2010; Carlsson et al., 2013), procedural justice has gained little attention in the climate policy literature (e.g., Okereke, 2010; Schleich et al., 2014a). The concept of procedural justice traces back to Lind and Tyler (1988) who find that individuals are often as concerned about the justice of the process as they are about the outcome itself. If individuals perceive the process as lacking fairness and transparency, they are reluctant to consider the outcomes as legitimate and acceptable. In the context of international climate policy, procedural justice requires adequate representation of all countries at the climate negotiations, in particular of those countries that are most vulnerable to climate change (e.g., Klinsky and Dowlatabadi, 2009; Okereke, 2010).

4.3 Analytical approach

We present a simple analytical model which allows perceptions of climate policy such as justification, procedural trust, and procedural justice to affect voluntary climate protection activities. The following equation describes the utility of a representative individual *i* with quasi-linear preferences defined over a numeraire good and a public good (i.e. climate protection in our case):

$$u_i = \omega_i - C_i(g_i) + \alpha B_i(\beta G_{-i} + g_i) \quad (1)$$

Here, ω_i is the fixed income by individual *i*, g_i reflects her voluntary contributions to the public good climate protection, and G_{-i} is the perceived contribution of the *n-1* representative individuals in the other countries. $C_i(.)$ reflects the costs individual *i* faces when contributing to climate protection. Marginal costs are positive and increase for higher individual contributions to climate protection, i.e. $C_i'(.) > 0$ and $C_i''(.) > 0$. $B_i(.)$ captures the benefits that *i* enjoys from climate protection. Marginal benefits are positive and decrease in climate protection, i.e. $B_i'(.) > 0$ and $B_i''(.) < 0$.

By maximizing her utility, the individual may account for perceptions of international climate policy for two types of reasons. First, she may have little faith in the usefulness of international climate negotiations per se since she does not believe that protecting the climate is a public good problem. This perceived lack of justification of climate policy is assumed to be captured by the parameter α ($0 \leq \alpha \leq 1$) which discounts the perceived benefits from climate protection. Second, an individual may discount the contribution by representative individuals from other countries because she distrusts other countries' intentions and motives or disapproves of the procedures at international climate conferences. This perceived lack of procedural trust and perceived lack of procedural justice is assumed to be captured by the parameter β ($0 \leq \beta \leq 1$).

The representative individual chooses her contribution to the public good g_i to maximize her utility. Assuming that she takes the contributions of the representative individuals of other countries as given leads to the first order condition for a Nash Equilibrium:

$$C'(.) = \alpha B'(.) \tag{2}$$

Totally differentiating equation (2) and further assuming that the representative individuals are identical in all *n* countries, i.e. $G_{-i} = (n-1)g_i$, yields:

$$\frac{dg_i}{d\alpha} = \frac{B'(.)}{C''(.) - \alpha[\beta(n-1)+1]B''(.)} > 0 \tag{3}$$

$$\frac{dg_i}{d\beta} = \frac{\alpha(n-1)g_i B''(.)}{C''(.) - \alpha[\beta(n-1)+1]B''(.)} < 0 \tag{4}$$

Note that the numerator is positive by the second order condition.

Our analytical model therefore leads to the following predictions:

Prediction 1: The propensity of individuals to voluntarily adopt climate protection activities increases with perceived justification of international climate policy.

Prediction 2: The propensity of individuals to voluntarily adopt climate protection activities decreases with perceived procedural trust in international climate policy.

Prediction 3: The propensity of individuals to voluntarily adopt climate protection activities decreases with perceived procedural justice in international climate policy.

In our econometric analysis, we test these theoretical predictions by examining the relationship between perceptions of international climate policy and the stated willingness of citizens in the USA and Germany to adopt five different climate protection activities.

4.4 Empirical analysis

4.4.1 Data and variables

Our data were collected in two representative online surveys of citizens aged 18 and older in the USA and Germany between May and June 2013. Both samples were drawn from the GfK (Gesellschaft für Konsumforschung) Online Panel. In the USA, 1010 respondents and in Germany 1005 respondents completed the self-administered questionnaire. The questions referred to general assessments of climate change, specific voluntary climate protection ac-

tivities, assessments of international climate policy and climate negotiations, basic values, as well as socio-demographic and socio-economic information. On average, respondents in both countries took about 30 minutes to complete the survey. While we cannot entirely rule out potential self-selection, we have no evidence that our samples are not representative for the underlying populations of U.S. and German adults based on the socio-demographic characteristics age, income, education, marital status, and household size.

The respondents in the survey were asked whether they planned to adopt the following climate protection activities: Actions to save energy at home, buy energy-efficient appliances, buy a fuel-efficient car, use or purchase renewable energy, and reduce the consumption of meat and dairy products. Based on the binary structure of the response options, we constructed the five dummy variables *energy savings*, *energy-efficient appliances*, *fuel-efficient car*, *renewable energy*, and *less meat or dairy products* that take the value one if the respondent plans to adopt the respective activity. These variables serve as the dependent variables in our econometric analyses. Table 13 reports the means for all variables across all respondents from the USA and Germany. Accordingly, the percentages range from 42% for *less meat or dairy products* in the USA to 87% for *energy savings* in Germany. For all activities, the percentages are higher for Germany than for the USA.

To elicit their perceptions of international climate policy, the survey asked respondents how strongly they agreed with particular statements on a symmetric scale with five ordered response categories.[22] In order to construct an indicator for perceived justification of international climate policy, we use the citizens' responses to the question "How important do you consider future international agreements are for combating climate change?".[23] On this basis, we construct the dummy variable *perceived justification* for the observations where "rather important" or "very important" is chosen as the answer. To create an indicator for perceived

[22] Potential problems with this kind of scale are central tendency bias, acquiescence bias, and social desirability bias. These issues were addressed by "don't know/no answer" options to distinguish true neutral from unsure responses, a scale design involving balanced keying, and closed ended and "neutral" wording of the items (for a detailed discussion see also Schleich et al. (2014a).

[23] We differentiated between "very unimportant", "rather unimportant", "neither important nor unimportant", "rather important", and "very important". This question was only posed to the large majority of the respondents in both countries who stated that global climate change is already occurring or will occur in the future. Only these observations enter the econometric analysis.

procedural trust in international climate policy we examine to which extent respondents agree with the statement "Commitments made at international climate negotiations will not be kept anyhow". The dummy variable *perceived procedural trust* is set equal to one if the respondent agreed "very weakly" or "rather weakly".[24] Finally, to build an indicator for perceived procedural justice in international climate policy we rely on the respondents' agreement with the statement "All countries have the same opportunities to represent their interests at international climate conferences".[25] The dummy variable *perceived procedural justice* equals one for the answer categories "rather strongly" or "very strongly.

Table 13 reports the means for these three variables. The percentages for perceived justification are fairly high, for perceived procedural trust are moderate, and for perceived procedural justice are quite low in both countries, but responses differed slightly across countries. Our theoretical approach predicts a positive effect of *perceived justification* and negative effects of *perceived procedural trust* and *perceived procedural justice* on the propensity to adopt climate protection activities.

In addition to these climate policy indicators, our econometric analysis included a wide range of control variables. The first group of control variables refers to the estimated contribution and the estimated financial consequences of the climate protection activities. The dummy variables *effectiveness* takes the value one if the respondent believed the respective activity to contribute "rather a lot" or "a lot" to climate protection[26]. Similarly, *financial advantage* is equal to one, if a respondent believed an activity to provide personal financial advantages.[27] The second group of control variables includes two indicators for environmental preferences, *environmental awareness* and *identification with green politics*. *Environmental awareness* is constructed by adding up the values of six dummy variables, which are based on six state-

[24] Since these statements are negatively keyed we used these answer categories to reflect weak agreement.
[25] In all cases we differentiated between "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly".
[26] The underlying question is "How much do you believe the following measures contribute to climate protection" with the following five ordered response categories: "very little", "rather little", "neither a little nor a lot", "rather a lot", and "a lot".
[27] 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 following three ordered response categories: "rather financial disadvantages", "neither financial advantages nor disadvantages", and "rather financial advantages".

ments from the new ecological paradigm (NEP) scale for measuring environmental concern (Dunlap et al., 2000).[28] Thus, *environmental awareness* ranges from zero (lowest level) to six (highest level). If a respondent strongly or rather strongly identified herself with green politics, *identification with green politic* equals one.[29] *Effectiveness, financial advantage, environmental awareness* and *identification with green politics* are expected to positively affect the adoption of climate protection activities.

The third group of control variables captures the socio-demographic characteristics of the respondents. *Age* as measured in years and varies between 18 and 85 in the USA and between 18 and 89 in Germany. *Female* is equal to one if the respondent is a woman. The *number of children* varies between zero and eleven in the USA and between zero and five in Germany. *Living together* takes the value one for the respondent's marital status "living with a partner" or "married", and zero otherwise. *High education* equals one if the respondent is qualified to pursue a degree in higher education (i.e. high-school degree in the USA and "Abitur" in Germany). The final group of control variables reflects regional heterogeneity. For the USA, we include the dummy variables *west, midwest, northeast,* and *south* (which is treated as the omitted category in the econometric analysis). For Germany, we add the dummy variable *west* for respondents living in Western Germany. Our econometric approaches comprise single-country models and combined-countries model. For analyses involving observations from both countries, the dummy variable *USA* stands for respondents from the USA.

4.4.2 Econometric approaches

In our econometric analyses, the dependent variables y_{ij} are dummies which indicated whether a citizen $i = 1,\ldots, n$ plan to adopt a climate protection activity $j = 1,\ldots, 5$. Our first economet-

[28] The underlying six statements are "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", and "The balance of nature is very delicate and easily upset" with the five ordered response categories "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly". The corresponding dummy variables takes the value one if the respondent agreed to the respective statement rather strongly or very strongly or (in the case of negative keying) rather weakly or very weakly, respectively.

[29] The underlying statement was "I identify myself closest with green politics" with the five ordered response categories "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly".

ric approach involved stacking the data over all activities *j*. This *aggregate model* allows estimating the determinants of the propensity to adopt one of the five climate protection activities. Therefore, the underlying unobservable latent variable for each citizen *i* is:

$$y_{ij}^{*} = \beta_j^{'} x_{ij} + \varepsilon_{ij} \quad (5)$$

For each citizen *i* and for each planned climate protection activity *j*, the vector x_{ij} comprises a set of explanatory variables with the unknown parameter vector β_j. The dummy variables y_{ij} takes the value one if $y_{ij}^{*} > 0$. $P(y_{ij} = 1)$ denoted the probability that citizen *i* plans to adopt the climate protection activity *j*. We employ binary probit models, i.e. the error terms ε_{ij} are assumed to be normally distributed. To account for unobserved heterogeneity over the different activities, we estimated binary random effects probit models.[30] Unobserved heterogeneity is incorporated in the error terms ε_{ij} and is assumed to be uncorrelated with the explanatory variables in x_{ij}. Stacking the data across activities allows us to capture differences in the conditional means of the activity dummies. In all cases, the dummy variable *less meat or dairy products* is treated as the omitted category, i.e. the activity with the smallest percentage in both countries (see Table 13).

In our second econometric approach, we employ binary probit models without random effects to separately estimate the determinants of the planned adoption of the five climate protection activities. Thus, unlike the *aggregate model*, this *single activity model* does not assume the parameter estimates to be identical across the activities. Since the decision to adopt a particular climate protection activity may depend on the choices for the other activities, the use of univariate binary probit models can lead to biased and inconsistent parameter estimations (Greene, 2012). We therefore used multivariate binary probit models, where the error terms captured possible correlations between the dependent variables.[31]

[30] All maximum likelihood and (in the case of multivariate binary probit models) simulated maximum likelihood estimations were carried out with Stata 12.

[31] The simulated maximum likelihood estimations relied on robust estimations of the standard deviation of the parameter estimates.

4.5 Results

4.5.1 Aggregate model

Table 14 reports the estimation results for the binary random effects probit models. The first column refers to the combined-countries model, while the second and third columns refer to the single-country models for the USA and for Germany. Statistical tests imply that the hypothesis of no unobserved heterogeneity can be rejected at the 1% significance level, which supports the random effects specification. The results for all combined and single-countries models suggest that the propensity to save energy at home, buy energy-efficient appliances, buy a fuel-efficient car, and use or purchase energy from renewable sources is significantly higher than to reduce the consumption of meat and dairy products.

The estimated parameters for *effectiveness of activity* shows the expected positive sign and are significantly different from zero for the combined-countries model and for Germany but not for the USA alone. Thus, the findings for the combined-countries model are mostly driven by the observations from Germany. As expected, *financial advantages* and *identification with green politics* has a significantly positive impact on the planned adoption of climate protection activities in all models. In contrast, *environmental awareness* only has a significant effect in the combined-countries model.[32] In general, socio-demographic variables only show weak correlations with the planned adoption of climate protection activities. For the combined-countries model we find that women and citizens with high education are significantly more likely to adopt climate protection activities. Higher education also had a significantly positive effect in Germany but not in the USA.

Our main interest is directed at the impact of perceptions of international climate policy. The estimated parameter for *perceived justification* is positive and significantly different from zero for the combined-countries and both single-country models. This finding provides strong support for our first prediction. In addition, *perceived procedural justice* has a significantly negative effect on the planned adoption of climate protection activities in the combined-

[32] The insignificant effects in the separate countries models are possibly due to multicollinearity problems with *identification with green politics*.

countries model and in the single-country model for the USA but not for Germany. In general though, these findings confirm our third prediction, at least for the USA.

In contrast, *perceived procedural trust* does not have a significant effect in any model. Hence, we find no empirical support for our second prediction. We also experimented with three additional indicators for perceived procedural trust in international climate policy, derived from the respondents' view on the self-interested use of international climate negotiations by richer or by poorer countries and on the use of international climate negotiations by governments to pacify their citizens. However, none of these three variables was found to have a robust separate effect on the planned adoption of climate protection activities. When all four indicators reflecting procedural trust are included, the null hypothesis that the four parameters were jointly zero cannot be rejected at common significance levels on the basis of Wald and likelihood ratio tests for any of the models.[33]

To assess the robustness of our aggregate model results, we conducted several additional estimations. The results of estimating binary random effects logit models are qualitatively almost identical to those of the binary random effects probit models.[34] While this finding is to be expected given the similar distributions of the error terms in the logit and probit models, it should be noted that both models are based on the potentially restrictive assumption that the unobserved heterogeneity is uncorrelated with the explanatory variables.[35] Although we rejected the hypothesis of no unobserved heterogeneity in the random effects binary probit model at common significance levels, we also estimated pooled binary probit models as a further robustness check. Qualitatively, the estimation results for perceptions of justification,

[33] We also tested whether the negatively keyed statement, which underlies *perceived procedural trust* contributed to the insignificant parameter estimate. For this, we assigned the value of one to a new dummy variable if the respondent agreed "very weakly", "rather weakly", or "neither weakly nor strongly" to the underlying statement. The parameter estimate associated with this new variable is also statistically insignificant.
[34] All results which are not reported for brevity are available upon request from the authors.
[35] Applying binary fixed effects logit models is not appropriate in our case since these models can only include explanatory variables which vary across the different climate protection activities, whereas our main interesting indicators for perceptions of international climate policy are invariant.

procedural trust, and procedural justice are almost identical to the results reported in Table 14.[36]

Our estimation results are very robust when we include additional control variables such as household size[37]. In addition, we also analyzed two further climate protection activities, i.e. reducing car use and reducing the number of flights so that the data were stacked over seven activities. The estimation results for perceptions of justification, procedural trust, and procedural justice with these seven activities are qualitatively very similar to the results presented in Table 13. However, it should be noted that the underlying questions for these two activities were filtered, i.e. only citizens who reported a positive number of kilometers or a positive number of flights could answer these questions so that the number of observations is considerably lower in this case.

As an alternative to the binary probit specification, we also estimated the aggregate model as a count data model, where the dependent variable was the number of activities. Since the dummy variables *effectiveness of activity* and *financial advantage of activity* were measured for a specific activity, they could not be included in these models. To allow for underdispersion, we used generalized poisson models instead of the usual poisson models which are based on a distribution characterized by only one parameter and thus assume equidispersion. While these count data models explicitly weighted all five activities equally by simply adding them up, the estimation results for perceptions of justification, procedural trust, and procedural justice were qualitatively almost identical to the results reported in Table 14.

4.5.2 Single activity models

The estimation results of the multivariate binary probit models are reported in Table 15 for the combined-countries model, in Table 16 and Table 17 for the single-country models. To

[36] This pooled approach provided more significant effects for some control variables, however. For example, the coefficients for *environmental awareness*, *living together*, and *high education* were positive and significant, and the coefficient for *age* was negative and significant. Of course, these differences may have been due to erroneously neglecting random effects in the pooled binary probit models.

[37] Our results are also very robust if we include warm glow motives and other factors as explanatory variables which are analyzed in another study (Lange et al., 2014).

save space, we do not report the estimated correlation coefficients in the error terms between the five dependent dummy variables. Since several correlations were significantly different from zero, we prefer the multivariate binary probit model over the univariate binary probit models.[38]

In general, the findings for the single activity models are quite similar to those for the aggregate model, in particular for the effects of climate policy. *Perceived justification* of climate policy is significant for all climate protection activities (except for *less meat or dairy products*) in the combined-countries model and in both single-country models. *Perceived procedural justice* turns out to be significant for all activities (except for *less meat or dairy products*) in the combined-countries model and for all activities (except for *renewable energy* and *less meat or dairy products*) in the single-country model for the USA. For Germany, *perceived procedural justice* is found to be statistically significant for *energy savings* only. Also in line with the findings for the aggregate model, *perceived procedural trust* is not consistently significant in any single activity model. Among the climate protection activities considered in the single activity models, only the consumption of meat and dairy products does not appear to be related to the perception of climate policy, neither among U.S. nor German citizens.

Consistent with the findings for the aggregate model, *financial advantages* of the climate protection activities exhibits significantly positive effects on the planned adoption of climate protection activities in the single activity models for all activities in the combined-countries model and in the single-country model for the USA as well as for most activities in the single-country model for Germany. In contrast, the impact of *effectiveness* and of *identification with green politics* appears to be more heterogeneous across activities. Both variables seem to matter primarily for the planned adoption of *renewable energy* and *less meat and dairy products*.

[38] In the multivariate probit models, the number of respondents is slightly lower than in the random effects binary probit analysis since only observations of those citizens with complete information about all dependent and explanatory variables can be included. In order to test the robustness of these results, we also analyzed univariate binary probit models for each activity. The corresponding estimation results were qualitatively almost identical to those discussed in Section 4.5.2.

The findings for the single activity models further suggest that the effect of socio-economic characteristics on the adoption of climate protection measures vary by activity and country. Younger citizens are found to be more likely to adopt *renewable energy* (in all single activity models) and *energy savings* for the single activity model for Germany. For all other activities and models, *age* was not found to be statistically significant. Similarly, women appeared to be more likely to consume *less meat* and *dairy products* in all single activity models and to engage in *energy saving* activities in the singly-country model for the USA. For the adoption of other activities and models, our gender variable is not statistically significant. The *number of children* also fails to be statistically significant for any activity or model. In contrast, and in line with the findings for the aggregate model, *living together* is positively related to most climate protection activities in the combined-countries model and in the single activity model for Germany but not for the USA. Finally, we find that *high education* increases the likelihood of adopting a *fuel-efficient car* in the combined-countries model and for the singly-country model for the USA but not for Germany. Similarly, *high education* is positively related to the adoption of *renewable energy* in the combined-countries model and for the singly-country model for Germany but not for the USA.

4.6 Conclusions

A substantial body of theoretical and empirical economic studies, focusing on social objectives or warm glow motives, has identified factors that help explain the private provision of public goods. We extend this literature by examining the relevance of perceptions of international climate policy to voluntary contributions to the global public good climate protection. Specifically, we explored whether beliefs in the justification of international climate policy as well as perceptions of procedural trust and procedural justice in international climate policy affected individuals' voluntary climate protection efforts. Based on an analytical model which allows perceptions of climate policy to affect voluntary climate protection activities, we derived three predictions. The findings from our microeconometric analysis of representative surveys among citizens in the USA and Germany suggest that *perceived justification* of cli-

mate policy increases the propensity to adopt climate protection measures (prediction 1) in both countries. Also, a higher *perceived procedural justice* appears to be related to a lower propensity to adopt climate protection measures (prediction 2), in particular in the USA. Third, we found no empirical support that higher *perceived procedural trust* reduces the propensity to adopt climate protection measures (prediction 3). These findings are robust to a wide range of alternative specifications, including aggregate and single activity models.

Our findings are closely related to the literature on motivation crowding: Our results imply that voluntary climate protection activities are motivated by the belief in the justification of international climate policy which leads to a crowding-in effect. In contrast, a perceived lack of procedural justice seems to be compensated by a higher propensity to adopt additional climate protection activities thus leading to a crowding-out effect.

In a broad interpretation, our empirical results imply that individuals' perceptions about the process of providing public goods should also be considered when analyzing the factors explaining the voluntary contribution to public goods. Future research could therefore explore this relationship for the private provision of public goods other than climate protection, such as voluntary donations for social or ethical purposes. Future research could also allow for a richer set of items capturing the various facets of climate policy than that included in our study to better understand the relationship between the perception of international climate policy and the adoption of climate protection activities.

5. Offset carbon emissions or pay a premium for avoiding them? A cross-country analysis of motives for voluntary climate protection activities

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Abstract: Understanding the determinants and motivations for voluntary climate protection activities is crucial for implementing new climate policy objectives and reducing the negative impacts of consumption on the climate. This paper contributes to the economic literature on pure and impure public goods by considering two consumption alternatives for contributing to the public good climate protection: Compensating carbon emission from conventional consumption or paying higher prices for climate-friendly products. We analytically and empirically examine a wide range of motives and their impact on individuals' choice in favor of the two consumption alternatives. Relying on data from representative surveys among more than 2000 participants from Germany and the USA, our results indicate that some motives differ considerably between the two consumption alternatives and the two countries. Warm glow motives and the desire to set a good example significantly motivate the consumption of the two alternatives in both countries. A green identity enhances the willingness to pay higher prices for climate-friendly goods in Germany, while social norms seem to be of much higher relevance in the USA. Voluntary contributions to climate protection are further driven by environmental awareness and a higher educational level. Our results further suggest that the choice of climate protection activities, especially of voluntary carbon offsetting, entails a high degree of uncertainty.

Keywords: Climate change; climate protection; carbon offsetting; price premium; warm glow; moral obligation; identity; social norms; signaling

JEL: H41, Q54, Q58

5.1 Introduction

In recent years, markets for pro-environmental consumption goods have grown rapidly worldwide. Prominent examples include carbon neutral, Rainforest Alliance certified, and certified organic consumption goods or plant-based alternatives for meat and dairy products, as well as energy from renewable sources and related products, vehicles with alternative drives, and energy efficient appliances. Since 2007, worldwide global sales of organic food, for example, nearly doubled and reached almost 64 billion US-Dollar in 2012 (e.g., Soil Association, 2009, 2014). In 2013, Rainforest Alliance certified farms produced more than 450,000 tons of coffee representing an increase of 20% compared to the previous year and a market share of 5.2% of the global coffee production.[39] Understanding the motivation for the demand of pro-environmental products is of particular importance in order to enhance environmentally responsible consumption and to reduce the negative impacts of consumption on the natural environment and climate.

In this paper, we analytically and empirically examine motives for choosing consumption patterns that produce less carbon emissions and help combating global warming. Consumers face two options for making a contribution to the public good climate protection. On the one hand, they might pay higher prices for everyday products or services that are better for the climate than competing products. This alternative can be regarded as the consumption of an impure public good. On the other hand, they have the possibility to engage in carbon offsetting to compensate carbon emissions from their consumption of conventional goods by directly donating money to climate protection projects.

By now we have substantial evidence suggesting that extrinsic and intrinsic motives like altruism, feelings of warm glow and moral obligation, social norms, and image motivation influence voluntary contributions to charities and public goods (e.g., Andreoni, 1995; Glazer and Konrad, 1996; Harbaugh, 1998; Crumpler and Grossman, 2008; Ariely et al., 2009; Shang and Croson, 2009). These factors have also been found to potentially motivate pro-environmental consumption and in particular climate protection activities.

[39] Source: http://www.rainforest-alliance.org/publications/sustainable-coffee-farming-report.

Akter et al. (2009) and Lange and Ziegler (2012), for instance, show that feelings of responsibility have positive effects on the probability to pay a carbon travel tax or to purchase carbon offsets and less emitting vehicles. Further studies also support the hypothesis that a perceived moral obligation leads to a higher willingness to engage in carbon offsetting (e.g., Brouwer et al., 2008; Blasch and Farsi, 2014). Araghi et al. (2014) demonstrate that travelers are more likely to offset their carbon emissions from air-traveling if the collective participation rate is high. Welsch and Kühling (2009) show that the social environment influences the use of green energy, the use of solar thermal systems, and the consumption of organic food. Further evidence for the impact of the contribution of others is provided by Blasch and Farsi (2014) who find carbon offsetting to be strongly driven by the adherence to social norms and the expectations about the cooperation of others. Kotchen and Moore (2008) use 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. Videras et al. (2012) find behaviors like the consumption of fair trade products or recycling activities to be positively correlated with an environmentalist identity. Evidence on warm glow giving in the context of individual climate protection activities is ambiguous. In the study by Clark et al. (2003), for example, participants of a green electricity program in the USA rank warm glow as their least important motive. In contrast, Menges et al. (2005) find evidence for impure altruistic behavior in their experiment on the willingness to pay for green electricity.

We contribute to this literature by identifying several motives for voluntary climate protection activities of citizens in Germany and the USA. In contrast to former studies (Lange et al., 2014; Schleich et al., 2014b), we regard two consumption alternatives for making voluntary contributions to the public good climate protection which provide no additional co-benefits like financial advantages or positive health effects for the consumer. We account for several psychological motives like feelings of warm glow or moral obligation, social norms, green identity, and signaling. To the best of our knowledge, our study is the first to investigate such a wide range of motivational factors in a cross-country comparison. Previous literature usual-

ly considers one single motive for voluntary contributions to public goods by capturing (lump-sum) utility gains or losses (e.g., Kotchen and Moore, 2008; Lange et al., 2014).

The paper is structured as follows. In Section 5.2, we analytically investigate motives from the psychological and economic literature and derive hypotheses for our econometric analyses using the characteristics approach of the impure public goods model for purposes of illustration. Relying on data from representative surveys among more than 2000 citizens from Germany and the USA, in Sections 5.3 and 5.4 we econometrically analyze the determinants of the willingness to demand carbon offsets and to pay higher prices for everyday products or services that are more climate-friendly. Section 5.5 summarizes our results and draws some important conclusions.

5.2 Discussion of motives and hypotheses

The concept "warm glow" has been found to be an important approach for explaining contributions to public goods. In his model of impure altruism, Andreoni (1989, 1990) describes the motivation for voluntary contributions to a public good as "some private goods benefit from their gift per se" but does not provide a thorough explanation of the psychological processes behind this warm glow feeling. In this section, we regard two alternatives for contributing to the public good climate protection, i.e. consuming a conventional good and compensating the carbon emissions from this consumption by carbon offsetting or paying a price premium for the consumption of a good or service which is better for the climate. We discuss psychological benefits or losses for individuals which are generated by the mix of motives discussed below and capture the meaning that the individual attaches to the two alternatives for contributing to climate protection (e.g., Bénabou and Tirole, 2006).[40]

A prominent example for potential psychological losses refers to the free-rider phenomenon reflecting the belief that others benefit from the contribution of an individual without making

[40] The focus on the psychological gains and losses distinguishes our study from accompanying studies (e.g., Lange et al., 2014) that investigate how changes in the effectiveness of carbon offsetting and climate-friendly products in contributing to climate protection affect the consumption patterns of polluting vs. climate-friendly consumption when direct donations to the public good climate protection are possible.

a contribution themselves. This phenomenon intensifies as the number of people who benefit from the public good increases, while the effect of the own contribution remains relatively or even negligibly low (e.g., Stiglitz, 2000). Individuals who believe that their contribution alone cannot make any difference may derive no psychological benefits or even suffer psychological losses from their demand for carbon offsets and the more expensive climate-friendly good or service. Thus, the individual may reach a higher utility level by solely consuming the conventional good.

> *Hypothesis 1: The free-rider rationale decreases both the willingness to engage in carbon offsetting and the willingness to pay a price premium for the climate-friendly good or service.*

The concept of impure altruism or "warm glow", as discussed above, could be described as a good feeling, which is experienced through the sole act of giving and can be regarded as a private benefit from contributing to a public good. Similarly, individuals may also be motivated by avoiding negative consequences. According to Schwartz (1973), behaviors are activated by an underlying system of values and norms. If individuals are aware of the consequences of their activities and ascribe responsibility for these consequences to themselves they perceive a moral obligation to engage in climate protection activities. With such warm glow motives individuals derive (higher) psychological benefits from carbon offsetting and the more expensive climate-friendly product, while the psychological utility remains unchanged with the consumption of the conventional good.

> *Hypothesis 2: Warm glow motives increase both the willingness to engage in carbon offsetting and the willingness to pay a price premium for the climate-friendly good or service.*

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). Akerlof and Kranton (2000) describe the identity of a person as the internalization of the behavioral rules belonging to a certain social category. Choosing activities which are not compliant with these rules lead to a loss in identity accompanied by a loss in

utility for the individual and other members of this social category. Hence, individuals who identify with a "green" social category may suffer a psychological loss when consuming the conventional good which can be compensated by the purchase of carbon offsets, while consuming the more expensive climate-friendly good or service is associated with psychological gains. In this case, individuals derive (higher) psychological benefits from consuming the more expensive climate-friendly product.

> *Hypothesis 3: A green identity only increases the willingness to pay a price premium for the climate-friendly good or service.*

Similarly, Holländer (1990) defines social norms as being the object of others' positive emotions. By complying with social norms individuals seek to get social approval and avoid disapproval (e.g., Nyborg and Rege, 2003). According to 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 deviations, individuals adjust their behavior. In addition, 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), while behaviors based on different social norms may crowd out each other (e.g., Greenberg, 2014). On the one hand, the behavior of individuals can be highly dependent on the social behavior of their peers. If individuals observe that their social environment does not contribute to climate protection, they may suffer a psychological loss from contributing themselves. This case is similar to the case of the free-rider rationale. On the other hand, individuals may believe that society expects them to contribute to climate protection and derive psychological gains from carbon offsetting and the more expensive climate-friendly product. This case is similar to the case of warm glow motives.

> *Hypothesis 4: The perception that the social environment does not contribute to climate protection decreases both the willingness to engage in carbon offsetting and the willingness to pay a price premium for the climate-friendly good or service.*

Hypothesis 5: Social pressure in terms of expectations of the society increases both the willingness to engage in carbon offsetting and the willingness to pay a price premium for the climate-friendly good or service.

The contributions to a public good may also depend substantially on their visibility (e.g., Bénabou and Tirole, 2006; Ariely et al., 2009). The concept of signaling was primarily applied in contract theory (e.g., Spence, 1973), but is also transferable to the impacts of image and acting as an example in consumption behavior (e.g., Frank, 1985; Ariely et al., 2009). The contribution to a public good may also be seen as a positive signal to others belonging to the same social category (e.g., Glazer and Konrad, 1996), if this contribution can be easily observed by others. If the contribution to the public good depends on its visibility, the consumption of the conventional good may be interpreted as a bad signal, while carbon offsetting provides no signal due to its lacking visibility and the consumption of the more expensive climate-friendly good or service provides a positive signal. In this case, individuals derive (higher) psychological benefits from consuming the more expensive climate-friendly product.

Hypothesis 6: Signaling motives increase only the willingness to pay a price premium for the climate-friendly good or service.

Decisions in favor of certain alternatives for contributing to the public good climate protection may also be influenced by individual preferences for the public and private characteristics. Individuals with a greater environmental awareness draw a higher marginal utility from their contribution to climate protection compared to individuals who are less environmentally aware. If the two alternatives are substitutes in providing climate protection, individuals who are more environmentally aware should be indifferent between these two alternatives.

Hypothesis 7: A greater environmental awareness increases both the willingness to engage in carbon offsetting and the willingness to pay a price premium for the climate-friendly good or service.

In addition, choices in favor of the two alternatives for contributing to climate protection and the mix of motives may vary substantially across individuals (e.g. with socio-economic char-

acteristics and regional factors) and situations. Therefore, we test the seven hypotheses in a microeconometric analysis for Germany and the USA including such additional factors.

5.3 Data and variables

The data for our microeconometric analyses stem from representative web-based surveys among citizens aged 18 or older. Overall, 1005 respondents in Germany and 1010 respondents in the USA participated in the surveys which collected information on general personal assessments of climate change, specific attitudes towards international climate policy and negotiations, as well as voluntary climate protection activities. Survey questions were thoroughly pre-tested by the market research company GfK (Gesellschaft für Konsumforschung) before carrying out the surveys in May and June 2013. The sample was drawn from the GfK Online Panel based on the official population statistics of the two countries and the completion of the survey required about 30 minutes on average in both countries.

In order to test our hypotheses derived in Section 5.2, we construct two binary dependent variables *carbon offsetting* and *price premium*. The underlying questions are whether respondents would be prepared to engage in carbon offsetting in the future to compensate the carbon emissions they caused and if they are willing to pay higher prices for everyday products or services that are better for the climate than competing products. Based on the binary structure of our dependent variables, we apply bivariate binary probit models to estimate the determinants of *carbon offsetting* and *price premium* and thereby allow for potential interdependencies between the decisions in favor of the two consumption alternatives. The parameters are estimated by the maximum likelihood method.[41] The estimation of bivariate probit models incorporates the estimation of correlation coefficients between the dependent dummy variables in the error terms of the underlying latent variables. These correlation coefficients are estimated to be 0.41 for Germany and 0.55 for the USA and are both different from zero at the 1% significance level.

[41] We consider heteroskedasticity robust z-statistics. As a robustness check for our results, we also use common univariate binary probit models. The estimation results are very similar to those from the bivariate binary probit models and are thus not reported but are available upon request.

The base categories of the binary dependent variables are very heterogeneous[42] such that the binary probit analysis is not suitable to identify specific consumption patterns of *carbon offsetting* and *price premium*. Therefore, we additionally apply multinomial logit models by constructing the mutually exclusive consumption alternatives *neither carbon offsetting nor price premium (base category)*, *price premium but not carbon offsetting*, *carbon offsetting but not price premium*, as well as *carbon offsetting and price premium.* These models are also estimated using maximum likelihood method.

Our main explanatory variables capture the motives discussed in Section 5.2: *free-rider rationale* (hypothesis 1), *warm glow motives* (hypothesis 2), *green identity* (hypothesis 3), *no contribution of social environment* (hypothesis 4), *expectation of society* (hypothesis 5), as well as *act as an example* as a potential indicator for an environmentally conscious identity according to hypothesis 3 or for signaling according to hypothesis 6. Regarding hypothesis 7, environmental preferences (i.e. respondents' preferences for the public characteristic Y) are measured through the index variable *NEP scale* which is constructed using six items from the New Environmental Paradigm (Dunlap et al., 2000). All motivational factors are measured by asking respondents to specify their level of agreement with particular statements (which are reported in Table 2) on a symmetric scale with five ordered response levels (i.e. "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly").[43]

We also include a dummy variable *high contribution of carbon offsetting* reflecting respondents' beliefs that carbon offsetting is rather or very effective in providing climate protection suggesting that carbon offsetting is perceived to be less costly than alternative climate protection activities. We additionally control for socio-demographic characteristics of the respondents, namely the variable *age* (in years), the gender dummy variable *female*, the variable *number of own children*, the dummy variable *highly educated* indicating that the respondent's highest level of education is at least secondary (Abitur in Germany and high school degree in the USA), as well as the regional dummies W*estern Germany* for Germany and *midwest*,

[42] For example, the base category of *carbon offsetting* comprises both respondents who are willing to pay a price premium for the climate-friendly good and respondents who are not.
[43] Among others, Schleich et al. (2014a) discuss potential problems associated with this kind of scale.

northeast, *west*, and *south* for the USA.[44] Table 2 provides a full list of explanatory variables and their definitions.

5.4 Results

Table 18 reports the descriptive statistics of the dependent and explanatory variables for our samples of 1005 German and 1010 U.S. respondents. While the average readiness to engage in carbon offsetting in the future is quite similar in both countries (55% in Germany and 54% in the USA of those respondents who answered the question), the willingness to pay higher prices for climate-friendly goods is much lower in the USA (54% in Germany and 37% in the USA of those respondents who answered the question). The table also shows that a large proportion of respondents did not answer to these two questions in both countries: 43% of German and 46% of U.S. respondents are unsure about their willingness to offset carbon emissions and about one quarter of respondents in each country refused to answer the question about their willingness to pay higher prices for climate-friendly goods. The free-rider rationale is nearly equal in both countries (34% in Germany and 35% in the USA), but the mean values for all other motives differ considerably. In Germany, respondents show on average higher mean values for the NEP scale, warm glow motives, and green identity, while U.S. respondents are more likely to wish to act as an example, to believe that their social environment makes no contribution and that the society expects them to make a contribution to climate protection, and to be highly educated.

Table 19 reports the parameter estimates (including robust z-statistics) from the bivariate binary probit models. In both countries, a perceived high contribution of carbon offsetting to climate protection has a significantly positive effect on *carbon offsetting*.[45] Being female is associated with a significantly higher willingness to offset carbon emissions in Germany and

[44] Since in both countries a high number of income data is missing, we omit the control variable for the income of the respondent. If we use single imputation methods for the income variable to reduce the number of missing observations, the estimation results are qualitatively equal to the estimation results without controlling for income. These results are not reported due to brevity but are available upon request.

[45] We also include this variable in the model explaining the willingness to pay a price premium for climate-friendly goods and find a significantly positive relationship in the USA.

a significantly lower willingness to pay higher prices for climate-friendly goods in the USA. German respondents with a higher educational level are significantly more willing to pay a *price premium* for climate-friendly goods, but this variable has no significant effect in the USA.

The free-rider rationale significantly decreases the willingness to offset carbon emissions in Germany and for both activities in the USA which is, especially for U.S. respondents, in line with our first hypothesis. In Germany and the USA, our estimation results suggest a strong significantly positive relationship between *warm glow motives* and both *carbon offsetting* and *price premium* confirming hypothesis 2. *Green identity*, as predicted in hypothesis 3, significantly increases the willingness to pay a price premium for climate-friendly goods but has no significant effect on the willingness to engage in carbon offsetting.

The impacts of social norms differ substantially in the two countries. While *no contribution of social environment* significantly decreases the readiness of German respondents to pay higher prices for climate-friendly goods and has no significant effect on *carbon offsetting*, in the USA the reverse is true. These findings only partly confirm hypothesis 4, since *no contribution of social environment* was expected to have a negative effect on both activities. *Expectation of society* has no significant effect on any of the two activities in Germany, but significantly increases the willingness to offset carbon emissions and to pay a price premium for climate-friendly goods in the USA. Thus, hypothesis 5 can only be confirmed for U.S. respondents. In hypothesis 6, *act as an example* was predicted to only increase the likelihood of *price premium* due to the better visibility of this activity. This hypothesis can be strongly confirmed in Germany and weakly confirmed in the USA, where the variable has an additional significantly positive effect on *carbon offsetting*. In both countries, environmental awareness measured by the variable *NEP scale* is a significant driver for both *carbon offsetting* and *price premium*, which is in line with the final hypothesis 7.

The multinomial logit analysis allows us to gain more insight into the relationship between the demand for carbon offsets and the willingness to pay higher prices for climate-friendly goods. Table 20 and Table 21 report the parameter estimates (including robust z-statistics) for

the two countries. Again *high contribution of carbon offsetting* is a significant driver for the readiness to engage in carbon offsetting. While the free-rider rationale has a significantly negative effect on *carbon offsetting but not price premium* as well as *carbon offsetting and price premium* in Germany, U.S. respondents are significantly less willing to pay a price premium and to engage in both activities. In both countries, the multinomial logit analysis confirms the significantly positive relationship between *warm glow motives* and the willingness to offset carbon emissions and to engage in both activities in Germany and between *warm glow motives* and all three categories in the USA. *Green identity* has a significantly positive effect on *price premium but not carbon offsetting* as well as *carbon offsetting and price premium* in Germany, but a weakly significantly negative effect on *carbon offsetting but not price premium* for U.S. respondents. These findings reflect the low acceptance of carbon offsetting among individuals with a green identity particularly in the USA.

The findings for the role of social norms are very similar to the estimation results from the binary probit models. In Germany, we find no significant effect of the two variables reflecting social norms. In the USA, the belief that the social environment does not contribute to climate protection is associated with a significantly lower willingness to engage in both activities. We also find a significantly positive relationship between *expectation of society* and *carbon offsetting but not price premium* as well as *carbon offsetting and price premium* for U.S. respondents. *Act as an example* is significantly associated with a higher willingness of German respondents to pay higher prices for climate-friendly goods and to carry out both measures, but significantly only increases the probability for the latter category in the USA. The *NEP scale* has a significantly positive effect on all three categories in both countries reinforcing the result from the binary probit models.

German respondents with a high educational level are more willing to pay higher prices for climate-friendly goods and to carry out both measures but the variable *highly educated* has no significant effect in the USA. Female respondents in Germany show a higher propensity to demand carbon offsets and to engage in both activities. In the USA, being female is associated with a lower willingness to pay higher prices for climate-friendly goods and to engage in

both activities. Interestingly, both methodological approaches reveal rarely any regional heterogeneity in the two countries. However, our findings broadly confirm our seven hypotheses and suggest substantial differences of the motivational impacts between the two climate protection activities as well as between respondents in Germany and the USA.

5.5 Summary and discussion

Voluntary climate protection activities play an important role for implementing new climate policy objectives and reducing the negative impacts of consumption on the climate. Understanding the determinants and motivation for voluntary climate protection activities is crucial since international climate policy has failed to make significant progress over the past years. This paper is the first to investigate a wide range of motives for voluntary climate protection activities. This analysis considers two consumption alternatives for making voluntary contributions to the public good climate protection which provide no additional co-benefits (like financial advantages or health benefits): Consuming conventional products and offsetting carbon emissions (i.e. directly donating to a public good) or paying higher prices for climate-friendly products or services (i.e. consuming an environmental impure public good). Our discussion of motivational factors focusses on feelings of warm glow, moral obligation, social norms, green identity, and signaling. We demonstrate analytically that impacts of these factors may vary across the two consumption alternatives.

Using data from representative surveys among more than 2000 participants from Germany and the USA, our empirical results strongly support our seven hypotheses in the two countries. The belief that one person on their own will not change anything regarding climate protection significantly reduces the willingness to offset carbon emissions and to pay higher prices for climate-friendly goods. Warm glow motives and the desire to set a good example have positive effects on the two consumption alternatives in both countries. The latter result might be attributed to the development that more and more suppliers of carbon offsets issue personalized certificates for supporters who offset a certain amount of carbon emissions and thereby enhance the visibility of this measure. A green identity enhances the willingness to pay higher

prices for climate-friendly goods in Germany, but decreases the willingness to demand carbon offsets in the USA. These findings reflect the profound skepticism towards carbon offsetting among environmental groups and parties, which obviously continues to dominate decisions for climate protection activities especially in the USA.

Social norms seem to be of much higher relevance in the USA, since the perceived expectation of the society to contribute to climate protection increases the propensity to demand carbon offsets and to pay higher prices for climate-friendly goods of U.S. respondents, but has no effect in Germany. In the USA, the population is widely separated in ideologically similar groups. Individuals identify far more closely with peers who have common concerns and interest or share similar world views and beliefs. Consequently, the behavior of individuals is strongly influenced by values and norms of their peers and "their" society.

Our descriptive results further suggest that decisions about climate protection activities involve substantial uncertainties. Individuals in both countries seem to be poorly informed about carbon offsetting, but also about environmental impure public goods, since a large proportion of respondents refused to answer the questions about their future willingness to take these climate protection activities. The provision of fundamental knowledge may reduce these uncertainties and eliminate existing reservations particularly towards carbon offsetting (e.g., UBA, 2010). Our findings regarding the determinants and motivations for climate protection activities might serve as basis for successful and targeted information campaigns.

Future research may investigate whether our results hold for other countries and apply such a wide range of motives to non-environmental consumption patterns such as fair-trade, Child-Labor-Free certified, or products combined with charitable purposes (e.g., Kotchen, 2006).

6. 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 USA. Considering carbon offsetting and seven other pro-environmental activities, our empirical evidence is consistent with the theoretical predictions and indicates generally a positive relationship between offsetting and other pro-environmental activities. This complementary relationship is even strengthened if offsetting is perceived to have some medium effectiveness. Our findings further suggest that offsetting may substitute certain clean consumption alternatives if individuals lay a sufficiently large weight on environmental preference or if offsetting is relatively effective in providing the public good climate protection. We find only little evidence supporting the concerns that the availability of carbon offsets might crowd out other pro-environmental activities.

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

JEL: H41, Q54

6.1 Introduction

While the economic literature provides numerous explanatory approaches why individuals make voluntary contributions to public goods, only a small body of literature is concerned with the interrelation between direct donations to public goods and the consumption of impure public goods. The demand for voluntary carbon offsets and their impact on pro-environmental activities proved to be an excellent framework to investigate this relationship (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 relatively 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).[46] 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.[47] That is, the environmental impact of the purchase of voluntary offsets may be ambiguous if offsetting substitutes other pro-environmental activities. In this paper, we theoretically and empirically investigate the existence of such substitution effects.

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 prefer-

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

[47] 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).

ences 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 presence (e.g., Kotchen, 2009b). In the context of green electricity consumption,[48] 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 (e.g., 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 USA 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.

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

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:[49] Donations of time and money were theoretically predicted to be 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. Introducing prices for otherwise "voluntary" prosocial activities, i.e. extrinsic motivation, has been found to potentially crowd out intrinsic motivation (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 6.2, 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 that complementarities between offsetting options

[49] 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 travel 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.

and using cleaner options to satisfy private consumption needs can only be expected for medium effectiveness of offsets in generating the public good (or feelings of warm glow from making a contribution to the public good climate protection). As long as the cleaner option is more expensive than the dirty alternative, full substitution away from the cleaner option is predicted when offsets become highly effective. 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 6.3 and 6.4 we examine the impact of individual purchases of carbon offsets on the probability to choose cleaner consumption alternatives.[50] 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 analyze the effect of offsetting purchases on the probability to use cleaner consumption alternatives 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. Using data from unique representative surveys among overall more than 2000 citizens in Germany and the USA,[51] 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 6.5 summarizes our theoretical and empirical findings and draws some important conclusions.

[50] 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.
[51] The EU and the USA are large emitters and supposed to play a key role in future international climate policy. The survey was conducted in Germany since this country is the largest economy in the EU.

6.2 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

$$u_i(c_i, x_i, y_i)$$

where c_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.[52] Here, $u_i(c_i, x_i, y_i)$ is an increasing and quasi-concave utility function.

Individuals can spend income w_i on the numeraire c_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 contributes to the public good at rate β_i^c and to the private characteristic at rate α_i^c, respectively. [53] Each dollar spent on direct donations g_i^o contributes 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

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

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.

[52] 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).

[53] 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.

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[54] 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 cases:

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

(A.2) $\alpha_i^c \geq 1, 1 - \frac{\beta_i^c}{\beta_i^o} > 0$: $\quad g_i^c = \frac{x_i}{\alpha_i^c}, \quad g_i^d = 0, \quad g_i^o = \max\left\{0, \frac{\alpha_i^c y_i - \beta_i^c x_i}{\beta_i^o \alpha_i^c}\right\}.$

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

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

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

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

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 a low effectiveness of offsets, case

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

(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.[55]

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)).

It is instructive to illustrate these cases in terms of the budget sets for consuming the characteristics (c_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 ($\beta_i^o \leq \beta_i^c$), 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 in (B.2) would be dominated by the right lower facet. We denote the optimal consumption levels without offsetting options by (c_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. It is, however, obvious that – for convex preferences – the consumption choice will not change if consumption without offsetting options (c_i^0, x_i^0, y_i^0) was in the interior of the lower right facet. That is, offsetting will continue *not* to be used. Only if (c_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 the upper right part of the budget frontier. In this range, the consumption patterns thus are similar to (A.2) as no dirty

[55] 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.

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 case below. Finally, in case (B.2) 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.

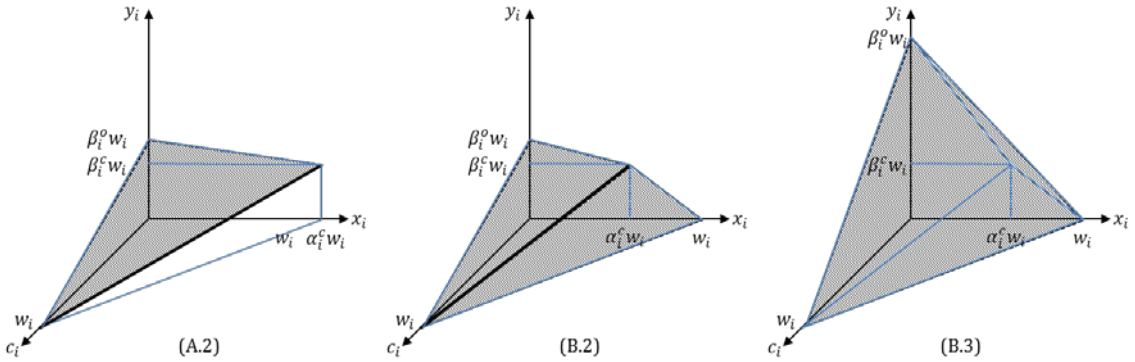

Figure 1: Illustration of budget sets.

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 (lower right facet of the budget frontier) or no consumption of the dirty good (upper left facet of budget frontier). 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 the upper left triangular facet 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:

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

and define the implicit prices for private and public characteristics as $p_x = \frac{1}{\alpha_i^c}\left(1 - \frac{\beta_i^c}{\beta_i^o}\right)$ 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 the clean good 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 crowd out other clean goods. Instead, both may be complementary. 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 $\alpha_i^c \leq 1$). 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.

6.3 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 USA aged 18 and older. The surveys were carried out simultaneously in May and June 2013 by the market research company GfK (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.[56] Based on the binary structure of the response options, we construct seven dummy variables that serve as dependent variables in our microeconometric analyses.[57]

[56] 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 Table 23 to 27 and are not reported for reasons of brevity but are available upon request.

[57] 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.[58]

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).[59] For measuring environmental preferences, we use six items from the New Environmental Paradigm (*NEP scale)* (Dunlap et al., 2000)[60] 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 22 reports some 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 USA 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 USA believe that reducing the consumption of meat or dairy products makes a high contribution to

[58] 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.
[59] A perceived high contribution of offsetting does not imply that offsets are perceived to be more effective than in providing the public good compared to the clean consumption alternatives.
[60] 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).

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 USA) and saving energy (in Germany). Accordingly, a large proportion of the respondents have already bought energy-efficient appliances (77 percent in Germany and 69 percent in the USA) and have already saved energy at home (88 percent in Germany and 80 percent in the USA), while reducing the number of flights (24 percent in Germany and 37 percent in the USA) and reducing the consumption of meat or dairy products (40 percent in Germany and 31 percent in the USA) 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.[61]

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 binary random effects probit models and thereby to control for unobserved heterogeneity. Seven additional binary variables identifying and control for each clean consumption alternative.

This approach incorporates individual-specific random effects in the error term 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 binary random effects probit models.[62] In order to check the robustness of our results when not controlling for unobserved heterogeneity, we also estimate single binary probit models for each

[61] 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.
[62] Test results are available upon request.

clean consumption alternative (with unstacked data). The results are qualitatively very similar to the parameter estimates obtained from the binary random effects probit models.[63]

To investigate further implications of our theoretical predictions, we include several two-way and three-way interaction terms in our models. We estimate average interaction effects across all observations following the approach of Ai and Norton (2003), Norton et al. (2004), as well as Cornelißen and Sonderhof (2009).[64] 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*[65]. 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 be-

[63] 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 binary random effects 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 23 and thus are not reported.

[64] 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.

[65] 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.

lieve 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*[20], 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*.

6.4 Estimation results

Our discussion of the empirical findings focuses on the estimation results from the binary random effects probit models with stacked data reported in Table 23. These results are robust when using single binary probit models for each pro-environmental activity (Table 24 and Table 25).[66] Including the binary variables that identify the clean consumption alternative allows us to examine differences in the probability to take these alternatives. Using *reducing the consumption of meat or dairy products* as the base activity, we find that only the propensity of German respondents to reduce the number of flights and the propensity of U.S. respondents to use energy from renewable sources are significantly smaller than the propensity to reduce the consumption of meat or dairy products.

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

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

For Germany and the USA, our estimation results suggest a strong significantly positive relationship between *offsetting* and the probability to use one of the clean consumption alternatives.[67] Interestingly, we find one significantly negative relation between offsetting and *saving energy at home* in Germany, while the significantly positive average discrete probability effect is highest for *using energy from renewable source*. The latter finding might be attributed to the similarities between the demand for offsets and renewable energies.

In both countries, the use of clean consumption alternatives is significantly positively related to environmental preferences measured by the variables *NEP scale* and *warm glow indicator* as well as *high contribution of clean good* (corresponding to large β_i^c in the theoretical model). Our estimation results also reveal a highly significantly positive effect of perceived financial advantages associated with the pro-environmental activity, 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)).[68] 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. This finding is consistent with our predictions for highly effective offsetting (case (B.3)) where individuals were predicted to revert to the dirty alternative.

Further implications of our theoretical predictions are reflected by the two-way and three-way interaction terms described in Section 6.3. Table 26 and Table 27 report the estimates (including z-statistics) of average interaction effects as well as average discrete probability effects of the interacted variables which are needed for the interpretation of the interaction effects.[69]

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

[67] 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 positively related to *reducing flights* in both countries (statistically significant at the 1% level).

[68] In the USA, financial advantages associated with an activity have significantly positive effects on all of the seven climate protection activities.

[69] 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.

interaction effect of *offsetting* with *medium effectiveness of offsetting* (corresponding to case (B.2) in the model) is positive and highly significantly different from zero. This finding implies that the complementary relationship between offsetting and other pro-environmental activities gets even larger if offsetting has a medium effectiveness in providing the public good.

For U.S. respondents, the two average three-way interaction effects and the average two-way interaction effect of *offsetting* with *medium effectiveness of offsetting* are highly significantly different from zero. The interaction effect of *offsetting* with *high contribution of offsetting* and *financial advantages of clean good* is significantly positive. While the significantly negative interaction effect of *offsetting* and *financial advantages of clean good* reduces the estimated complementary relationship between offsetting and other pro-environmental activities, the estimation result for the three-way interaction term with *high contribution of offsetting* confirms that offsetting and the clean consumption alternatives might be complementarily used if offsetting is perceived to be highly effective in providing the public good and the clean consumption alternative being highly effective in providing the private characteristic (case (A.2)). Similar to the results for German respondents, the significantly positive interaction effect of *offsetting* with *medium effectiveness of offsetting* reflects case (B.2) where offsetting with some medium effectiveness may further increase the consumption of the impure public good.[70] For case (B.3), our estimation results reveal a significantly negative interaction effect of *offsetting* with *high contribution of offsetting* and *ineffective clean good*. In this case, the high estimated average interaction effect inverts the complementary relationship between offsetting and the pro-environmental activities. 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 consumption alternatives are perceived to be relatively ineffective in providing the private characteristic.

[70] In contrast to the theoretical predictions, the interaction effect is significantly positive regardless of environmental preferences.

In addition, we find significantly negative interaction effects of *offsetting* and *NEP scale* as well as *offsetting* and *warm glow indicator* (only for U.S. respondents). Higher environmental preferences therefore reduce the estimated complementary relation between offsetting and pro-environmental activities and potentially convert it to a substitution effect. This finding is consistent with the idea of moral balancing. The consumption of clean alternatives is substantially higher for individuals with higher environmental preferences, such that offsetting is not needed to regain moral balance but gives these individuals a license to choose dirty consumption alternatives. 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.

6.5 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. This complementary relationship is even strengthened if offsetting is perceived to have some medium effectiveness. Our findings fur-

ther suggest that offsetting may substitute certain clean consumption alternatives if individuals lay a sufficiently large weight on environmental preference or if offsetting is relatively effective in providing the public good climate protection. In sum, we find only little evidence supporting the concerns that the availability of carbon offsets might crowd out other pro-environmental activities.

Future research could investigate whether our behavioral findings are robust on the basis of panel data. The analysis of revealed willingness to pay for carbon offsetting and other pro-environmental activities would also be interesting. It might further be useful to examine whether the analyses in this paper can be applied to other fields of private provisions of impure public goods and charitable giving like volunteer labor or blood and organ donations.

7. Adaptation vs. climate protection: Responses to climate change and policy preferences of individuals in China, Germany, and the USA

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Abstract: This paper investigates the interrelations between adaptation and climate protection efforts of individuals in a cross-country comparison. The empirical analyses are based on theoretical predictions derived from a subjective utility framework which demonstrates that, at the individual level, private adaptation and climate protection activities cannot be substitutes and are determined by different factors. Considering seven climate protection and four adaptation measures, these theoretical predictions are tested empirically using representative data from more than 3400 citizens in China, Germany, and the USA. The empirical findings are consistent with the theoretical predictions that the engagement in adaptation and climate protection activities tends to be positively related. While climate protection efforts are significantly driven by their benefits (e.g., financial advantages or feelings of warm glow), adaptation activities are significantly influenced by a higher income and the individual evaluation of the risk that negative consequences from climate change occur. There is also some evidence that a perceived lack of public engagement in climate protection is compensated by increased private adaptation and climate protection efforts. Preferences for public adaptation and climate protection are significantly determined by individuals' beliefs about the efforts of others, social norms, feelings of warm glow, and confidence in the effectiveness.

Keywords: Adaptation, climate protection, climate change, policy preferences

JEL: H41, Q54, Q58

7.1 Introduction

International climate policy has merely made little progress towards binding emission reduction targets involving the world's largest emitters such as China and the USA. Even if international climate negotiations are able to reach an agreement on the distribution of climate protection costs which all countries consider to be fair, the scientific society would doubt that such an agreement will lead to lasting climate stability (e.g., IPCC, 2013). Therefore, the respective actors cannot rely on climate protection activities only, but also need to turn towards adaptation measures to cope with the unpreventable impacts of global warming (e.g., Klein et al., 2005; Stern, 2008; Aakre and Rübbelke, 2010). The fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change emphasizes that "reliance on adaptation alone is likely to lead to a magnitude of climate change in the long run to which effective adaptation is no longer possible or only at very high social, economic and environmental costs" (e.g., IPCC, 2007a, p.748).

In contrast to the public good climate protection, adaptation to climate change is regarded as a private or club good. Benefits from investments in adaptation can be of exclusive use to the investor or to particular regions. This makes adaptation an attractive alternative and additional option for policy, industries, companies, and individuals to reduce climate-related damages and losses (e.g., Tol, 2005; Onuma and Arino, 2011; Barrett, 2011). Such adaptation measures that reduce the severity of potential climate-related losses might, however, diminish the incentive to engage in activities that reduce the risk of climate change, i.e. climate protection activities.[71] To date there is barely any empirical evidence regarding decisions for adaptation and climate protection activities taking account of potential interrelations between these responses to climate change. This study empirically investigates these interrelations at the individual level by exploring the determinants and motives of adaptation and climate protection efforts of citizens in three countries.

[71] This is comparable to a very important problem in the contract literature, i.e. "moral hazard", which describes the propensity of individuals to take less care in preventing loss if they don't have to bear the risk of these losses (e.g., Hirshleifer and Riley 1979).

At the policy level, theoretical predictions on the interrelation between adaptation and climate protection are ambiguous. While there is a broad consensus that efficient and cost-effective climate policy involves adaptation and climate protection strategies (e.g., Klein et al., 2005; Tol, 2005; Swart and Raes, 2007; IPCC, 2014), the option of adaptation may also aggravate the social dilemma of greenhouse gas reductions (e.g., Auerswald et al. 2011; Probst 2013). Regarding adaptation and climate protection as imperfect substitutes, Barrett (2011) shows that returns from adaptation and climate protection are interrelated and may lead to corner solutions where countries rely solely on adaptation in case of non-cooperation and solely on climate protection in case of cooperation. Differences in adaptive capacities may also reinforce welfare inequalities between rich and poor countries. Taking account of fairness considerations, Rübbelke (2011) shows that transfers to support adaptation in developing countries may reduce the perceived lack of fairness and increase the incentive to cooperate, while Ebert and Welsch (2012) demonstrate that improvements in the productivity of adaptation and adaptive capacity may lead to higher global emission levels.

Buob and Stephan (2011) develop a game theoretic framework and show that regions choose the strategy with lower marginal costs. Only relatively rich regions with poor environmental quality who account for the interdependence of adaptation and climate protection efforts use these measures as a common strategy. Kane and Shogren (2000) find that an exogenous increase in risk results in more adaptation efforts while the change in climate protection efforts depends on the marginal effectiveness of mitigation in reducing risk. The chance of receiving better information about climate change in the future may decrease climate protection efforts if adaptation is possible (e.g., Ingham et al., 2007).

The existing literature also provides some experimental evidence on the interrelation between adaptation and climate protection. Hasson et al. (2010) consider either-or decisions in an experimental setting and find no significant difference in choosing climate protection between low-vulnerability and high-vulnerability treatments. Probst (2013) finds that adaptation substitutes climate protection. Lower adaptation costs increase free-riding but to a lesser extent than theoretically predicted which may be attributed to risk preferences and inequity aversion.

This study is the first to provide survey-based empirical evidence on adaptation and climate protection efforts of individuals, preferences for the respective public activities, and their interrelation in a cross-country comparison. These analyses are based on theoretical predictions derived from a subjective utility framework that models climate change as a shock that potentially causes losses to a representative individual. The severity of these climate-related losses can be reduced by private adaptation measures, while risk reduction through private climate protection efforts is assumed to be marginal. The individual chooses adaptation and climate protection activities by maximizing her subjective expected utility. The comparative static results demonstrate that private adaptation and climate protection activities are determined by different factors. While climate protection efforts are predicted to be solely affected by their costs and benefits (e.g., financial advantages or feelings of warm glow), adaptation activities tend to be driven by income and the individual evaluation of the risk that negative consequences from climate change occur. These theoretical predictions are tested empirically using survey data from citizens in China, Germany, and the USA. China, the EU[72], and the USA are large emitters and supposed to play a key role in future international climate policy. The empirical results broadly confirm the theoretical prediction in the three countries and reveal a positive relationship between private adaptation and climate protection activities as well as private climate protection efforts and preferences for public climate protection activities.

The remainder of this paper is structured as follows: Section 7.2 derives theoretical prediction based on a subjective utility maximization problem of a representative individual under climate-related uncertainty. After the description of the surveys and the econometric approach in Section 7.3, Section 7.4 discusses the empirical findings. Section 7.5 summarizes the results and draws some conclusions.

[72] The survey was conducted in Germany since this country is the largest economy in the EU.

7.2 Theoretical predictions

Assume that a representative individual faces two states of the world: A moderate state and a bad state with negative consequences from climate change causing loss $l(a)$ (e.g., an extreme weather event causing damages). The severity of potential losses can be reduced by investments in adaptation measures a, i.e. $l_a < 0$ and $l_{aa} < 0$.[73] The individual assigns a probability to each state of the world which is interpreted as the individual's subjective evaluation of the risk that negative consequences from climate change occur.[74] This subjective risk perception $\pi(G, \theta, z)$ depends on exogenous factors θ[75] (e.g., Hasson et al., 2010) and individual-specific characteristics z (e.g., gender, education, income)[76]. While the total amount of climate protection efforts G reduces the actual probability of negative consequences from climate change and thereby potentially the individual's subjective risk perception, the effect of private climate protection efforts g on the mitigation of climate risks remains marginal and will thus not be considered in the following, i.e. $\pi_G < 0$ and $\pi_g = 0$ (e.g., Hoel, 1991; Kane and Shogren, 2000; Ebert and Welsch, 2012). The individual's payoffs, x_0 and x_1,[77] in the moderate and the bad state of the world are:

$$x_0 = w - c(G, \tau)a - pg + b(g)$$

$$x_1 = w - l(a) - c(G, \tau)a - pg + b(g)$$

where w is the individual's initial wealth and p is the price for private climate protection activities. Costs of private adaptation $c(G, \tau)$ are influenced by the actual probability of negative consequences from climate change[78] which is reduced by total climate protection efforts,[79] i.e. $c_G < 0$ (e.g., Buob and Stephan, 2011; Ingham et al., 2013), as well as other factors τ like

[73] Hereafter, subscripts denote first and second partial derivatives, i.e. $l_a \equiv \partial l/\partial a$ and $l_{aa} \equiv \partial^2 l/\partial a^2$.
[74] Using subjective risk perception takes into account that individuals may not be able comprehend information and parameters of actual loss probabilities properly (e.g., Kahneman and Tversky, 1979; Schoemaker and Kunreuther, 1979; Shogren, 1990; Botzen and v. d. Bergh, 2009).
[75] θ reflects natural processes that cause climatic changes, the uncertainty about the effects of climate protection, but also factors like media exposure of climate change and its consequences.
[76] These factors were found to determine risk aversion (e.g., Cicchetti and Dubin, 1994) as well as the decision for self-insurance and self-protection measures (e.g., Lewis and Nickerson, 1989).
[77] It is assumed that the individual is not fully insured, i.e. $l(a) > 0$, which implies that $x_0 > x_1$.
[78] Insurance companies, for instance, possess very good knowledge about actual risk probabilities and adjust insurance costs according to these probabilities.
[79] As discussed above, the effect of private climate protection efforts g is assumed to be marginal and is thus not considered.

administrative expenses (e.g., Lakdawalla and Zanjani, 2005). The function $b(g)$ represents co-benefits associated with the individual's climate protection efforts including material (e.g., financial advantages) as well as immaterial (e.g., feelings of warm glow or social approval) gains. These benefits increase with private climate protection efforts at a decreasing rate, i.e. $b_g > 0$ and $b_{gg} < 0$.

Denoting $u_0 \equiv u(x_0)$ and $u_1 \equiv u(x_1)$, the individual's expected utility can be written as

$$EU = \pi u_1 + (1 - \pi)u_0 \tag{6}$$

with $u' > 0$ and $u'' < 0$.[80] The individual chooses adaptation and climate protection efforts that maximize this subjective expected utility. The first order condition with respect to a is

$$\frac{\partial EU}{\partial a} = \pi u_1'(-l_a - c) + (1 - \pi)u_0'(-c) = 0. \tag{7}$$

That is, the individual balances marginal costs and benefits from adaptation across the two states of the world, such that the optimality condition for the choice of adaptation efforts can be written as

$$\frac{c}{-l_a} = \frac{\pi u_1'}{\pi u_1' + (1 - \pi)u_0'}.$$

The first order condition with respect to g is

$$\frac{\partial EU}{\partial g} = \big(b_g - p\big)[\pi u_1' + (1 - \pi)u_0'] = 0. \tag{8}$$

Since the term in squared brackets is strictly greater than zero, this condition can only hold if the price for climate protection activities equals marginal benefits, i.e. $p = b_g$. In the optimum, the decision to engage in climate protection is independent of the subjective risk perception.

[80] u' denotes the first order derivative $\partial u/\partial x$ and u'' the second order derivative $\partial^2 u/\partial x^2$. This also implies that $u_0' < u_1'$.

In order to explore how changes in the exogenous parameters c, p, π, G, and w affect the demand for private adaptation and climate protection, denote the optimal solutions to the utility maximization problem $a^*(\cdot)$ and $g^*(\cdot)$. Assuming the second order condition

$$|H| = \frac{\partial^2 EU}{\partial a^2}\frac{\partial^2 EU}{\partial g^2} - \left(\frac{\partial^2 EU}{\partial a \partial g}\right)^2 > 0$$

to hold whenever (7) and (8) hold, totally differentiating the first order conditions (7) and (8) yields

$$\frac{\partial^2 EU}{\partial a^2}da + \frac{\partial^2 EU}{\partial a \partial g}dg = -\frac{\partial^2 EU}{\partial a \partial c}dc - \frac{\partial^2 EU}{\partial a \partial p}dp - \frac{\partial^2 EU}{\partial a \partial \pi}d\pi - \frac{\partial^2 EU}{\partial a \partial G}dG - \frac{\partial^2 EU}{\partial a \partial w}dw$$

$$\frac{\partial^2 EU}{\partial a \partial g}da + \frac{\partial^2 EU}{\partial g^2}dg = -\frac{\partial^2 EU}{\partial g \partial c}dc - \frac{\partial^2 EU}{\partial g \partial p}dp - \frac{\partial^2 EU}{\partial g \partial \pi}d\pi - \frac{\partial^2 EU}{\partial g \partial G}dG - \frac{\partial^2 EU}{\partial g \partial w}dw.$$

with

$$\frac{\partial^2 EU}{\partial a^2} = (-l_{aa})\pi u_1' + \pi u_1''(-l_a - c)^2 + (1-\pi)u_0''(-c)^2 < 0,$$

which is negative by the second order sufficiency condition which is assumed to hold whenever (7) and (8) hold,

$$\frac{\partial^2 EU}{\partial a \partial g} = \left(b_g - p\right)(-c[\pi u_1'' + (1-\pi)u_0''] - l_a \pi u_1'') = 0$$

which is equal to zero by the first order condition (7), and

$$\frac{\partial^2 EU}{\partial g^2} = \left(b_g - p\right)^2[\pi u_1'' + (1-\pi)u_0''] + b_{gg}[\pi u_1' + (1-\pi)u_0'] < 0.$$

Cross partial derivatives with respect to p are

$$\frac{\partial^2 EU}{\partial g \partial p} = \left(b_g - p\right)(-g)[\pi u_1'' + (1-\pi)u_0''] - [\pi u_1' + (1-\pi)u_0'] < 0,$$

$$\frac{\partial^2 EU}{\partial a \partial p} = \pi u_1''(-l_a - c)(-g) + (1-\pi)u_0''(-c)(-g) = l_a \pi g u_1'' + cg[\pi u_1'' + (1-\pi)u_0''] < 0$$

$$\text{if } \frac{c}{-l_a} > \frac{\pi u_1''}{[\pi u_1'' + (1-\pi)u_0'']}.$$

Substituting the first order condition (7) and rearranging yields $\pi < 1$ (which is assumed) if $-u_0''/u_0' < -u_1''/u_1'$, i.e. the individual's absolute risk aversion (e.g., Pratt, 1964) regarding the bad state exceeds her absolute risk aversion regarding the good state of the world.

Cross partial derivatives with respect to c are

$$\frac{\partial^2 EU}{\partial g \partial c} = (b_g - p)(-a)[\pi u_1' + (1-\pi)u_0'] = 0,$$

$$\frac{\partial^2 EU}{\partial a \partial c} = \pi u_1''(-l_a - c)(-a) + (1-\pi)u_0''(-c)(-a) = l_a \pi a u_1'' + ca[\pi u_1'' + (1-\pi)u_0''] < 0$$

which again holds if $-u_0''/u_0' < -u_1''/u_1'$.

Consider now the effects of changes in prices c for adaptation and p for climate protection:

$$\frac{\partial g^*}{\partial c} = \frac{\frac{\partial^2 EU}{\partial g \partial a} \cdot \frac{\partial^2 EU}{\partial a \partial c} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial c}}{|H|} = 0,$$

$$\frac{\partial a^*}{\partial c} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial g \partial c} - \frac{\partial^2 EU}{\partial g^2} \cdot \frac{\partial^2 EU}{\partial a \partial c}}{|H|} = \frac{-b_{gg}[\pi u_1' + (1-\pi)u_0'] \cdot \left[l_a \pi a u_1'' + ca[\pi u_1'' + (1-\pi)u_0'']\right]}{|H|} < 0$$

$$\frac{\partial g^*}{\partial p} = \frac{\frac{\partial^2 EU}{\partial g \partial a} \cdot \frac{\partial^2 EU}{\partial a \partial p} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial p}}{|H|}$$

$$= \frac{[(-l_{aa})\pi u_1' + \pi u_1''(-l_a - c)^2 + (1-\pi)u_0''(-c)^2][\pi u_1' + (1-\pi)u_0']}{|H|} < 0,$$

$$\frac{\partial a^*}{\partial p} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial g \partial p} - \frac{\partial^2 EU}{\partial g^2} \cdot \frac{\partial^2 EU}{\partial a \partial p}}{|H|} = \frac{-\left[b_{gg}[\pi u_1' + (1-\pi)u_0']\right]\left[l_a \pi g u_1'' + cg[\pi u_1'' + (1-\pi)u_0'']\right]}{|H|}.$$

The latter expression $\partial a^*/\partial p$ is negative if $-u_0''/u_0' < -u_1''/u_1'$. Making adaptation less costly may solely increase adaptation efforts, while lower costs for climate protection may increase both adaptation and climate protection efforts if the individual's absolute risk aversion (e.g., Pratt, 1964) regarding the bad state exceeds her absolute risk aversion regarding the good state of the world. Thus, private adaptation and climate protection efforts are not pre-

dicted to be substitutes,[81] but there might be a positive relationship between the engagements in both activities.

Prediction 1: Private adaptation activities are either positively or not related to private climate protection efforts.

Cross partial derivatives with respect to π are

$$\frac{\partial^2 EU}{\partial g \partial \pi} = (b_g - p)[u_1' - u_0'] = 0,$$

$$\frac{\partial^2 EU}{\partial a \partial \pi} = u_1'(-l_a - c) + cu_0' = -l_a u_1' + c(u_0' - u_1') > 0$$

$$\text{if } -\frac{c}{l_a} < \frac{u_1'}{u_1' - u_0'}.$$

Substituting the first order condition in (7) and rearranging yields $u_0^{'} > 0$ which is assumed. The effect of a change in the subjective risk perception on adaptation activities can be written as

$$\frac{\partial a^*}{\partial \pi} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial g \partial \pi} - \frac{\partial^2 EU}{\partial g^2} \cdot \frac{\partial^2 EU}{\partial a \partial \pi}}{|H|} = \frac{-b_{gg}[\pi u_1' + (1-\pi)u_0'] \cdot [u_1'(-l_a - c) + cu_0']}{|H|} > 0.$$

That is, an increase of the subjective risk perception is associated with an increase in adaptation efforts, while an increase in the subjective risk perception does not change the individual's climate protection activities since

$$\frac{\partial g^*}{\partial \pi} = \frac{\frac{\partial^2 EU}{\partial g \partial a} \cdot \frac{\partial^2 EU}{\partial a \partial \pi} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial \pi}}{|H|} = 0.$$

Prediction 2: Individuals with a higher subjective risk perception show a higher propensity to engage in private adaptation activities, while subjective risk perception has no effect on the propensity to take climate protection activities.

[81] In economic terms, private adaptation and climate protection would be substitutes if higher cost for adaptation reduced adaptation and increased climate protection efforts and vice versa (e.g., Ingham et al., 2013).

Cross partial derivatives with respect to G are

$$\frac{\partial^2 EU}{\partial g \partial G} = \big(b_g - p\big)[\pi_G u_1' - c_G \pi u_1'' - \pi_G u_0' - c_G(1-\pi)u_0''] = 0,$$

$$\frac{\partial^2 EU}{\partial a \partial G} = -l_a(\pi_G u_1' - c_G \pi u_1'') + c c_G[\pi u_1'' + (1-\pi)u_0''] - c_G[\pi u_1' + (1-\pi)u_0'] + c\pi_G(u_0' - u_1').$$

The sign of the latter expression is ambiguous. Now consider a change in the total climate protection efforts:

$$\frac{\partial a^*}{\partial G} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial g \partial G} - \frac{\partial^2 EU}{\partial g^2} \cdot \frac{\partial EU}{\partial a \partial G}}{|H|}$$

$$= \frac{-\Big[b_{gg}[\pi u_1' + (1-\pi)u_0']\Big]\,[-l_a(\pi_G u_1' - c_G \pi u_1'') + c c_G[\pi u_1'' + (1-\pi)u_0''] - c_G[\pi u_1' + (1-\pi)u_0'] + c\pi_G(u_0' - u_1')]}{|H|}.$$

The effect of G on adaptation activities is also ambiguous. On the one hand, an increase in the total amount of climate protection increases π which reduces the need to invest in adaptation. On the other hand, an increase in the total amount of climate protection decreases the costs of adaptation which makes this alternative more attractive. Hence, it is left to the empirical analyzes in the next two sections to determine this effect. Again, an increase in the total amount of climate protection does not change private climate protection efforts since

$$\frac{\partial g^*}{\partial G} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial a \partial G} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial G}}{|H|} = 0.$$

Assuming that the total amount of climate protection provides additional benefits for the individual, i.e. $b(g, G)$ with $b_G > 0$ and $b_{gG} < 0$, the cross partial derivative $\partial^2 EU / \partial g \partial G$ becomes

$$\frac{\partial^2 EU}{\partial g \partial G} = \big(b_g - p\big)[\pi_G u_1' + (b_G - c_G)\pi u_1'' - \pi_G u_0' + (b_G - c_G)(1-\pi)u_0''] + b_{gG}[\pi u_1' + (1-\pi)u_0'] < 0$$

The effect of a change in the amount of total climate protection efforts is then

$$\frac{\partial g^*}{\partial G} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial a \partial G} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial G}}{|H|} = \frac{-b_{gg}[\pi u_1' + (1-\pi)u_0'] \cdot b_{gG}[\pi u_1' + (1-\pi)u_0']}{|H|} < 0.$$

An increase in G may reduce private climate protection efforts if the individual draws additional benefits from G, for example, through an increase in environmental quality or due to preferences for reciprocity.[82] Conversely, this implies that private climate protection activities may also compensate a perceived lack in public climate protection efforts if the individual profits from public activities. The effect of G on adaptation activities remains ambiguous.

> *Prediction 3: Individuals who perceive the amount of total climate protection to be lower show a higher propensity to take climate protection activities if the total amount of climate protection provides additional benefits for them.*

Cross partial derivatives with respect to w are

$$\frac{\partial^2 EU}{\partial g \partial w} = \big(b_g - p\big)[\pi u_1'' + (1-\pi)u_0''] = 0,$$

$$\frac{\partial^2 EU}{\partial a \partial w} = (-l_a - c)\pi u_1'' + (1-\pi)u_0''(-c) = -l_a \pi u_1'' - c[\pi u_1'' + (1-\pi)u_0''] > 0$$

$$\text{if } \frac{c}{-l_a} > \frac{\pi u_1''}{[\pi u_1'' + (1-\pi)u_0'']}.$$

Substituting the first order condition in (7) and rearranging again yields $\pi < 1$ if $-u_0''/u_0' < -u_1''/u_1'$. The effect of an exogenous change in initial wealth on private adaptation activities is

$$\frac{\partial a^*}{\partial w} = \frac{\frac{\partial^2 EU}{\partial a \partial g} \cdot \frac{\partial^2 EU}{\partial g \partial w} - \frac{\partial^2 EU}{\partial g^2} \cdot \frac{\partial^2 EU}{\partial a \partial w}}{|H|} = \frac{-b_{gg}[\pi u_1' + (1-\pi)u_0'](-l_a \pi u_1'' - c[\pi u_1'' + (1-\pi)u_0''])}{|H|}$$

which is positive if $-u_0''/u_0' < -u_1''/u_1'$. This implies that the individual increases her adaptation efforts with increasing wealth if her absolute risk aversion (e.g., Pratt, 1964) regarding the bad state exceeds her absolute risk aversion regarding the good state of the world. In con-

[82] This finding is the same if the individual had to pay a tax $t(G)$ which finances the increase in G.

trast, an exogenous change in initial wealth does not affect private climate protection efforts, i.e.

$$\frac{\partial g^*}{\partial w} = \frac{\frac{\partial^2 EU}{\partial g \partial a} \cdot \frac{\partial^2 EU}{\partial a \partial w} - \frac{\partial^2 EU}{\partial a^2} \cdot \frac{\partial^2 EU}{\partial g \partial w}}{|H|} = 0.$$

Prediction 4: Individuals with higher income show a higher propensity to engage in private adaptation, while income has no effect on private climate protection activities.

Climate protection efforts of individuals are predicted to be unaffected by subjective risk perception and changes in wealth, but determined by additional co-benefits and costs of these efforts. Individuals' incentive to invest in adaptation is predicted to be higher the higher the subjective risk perception and initial wealth.[83] These findings suggest that quite different factors influence the individual's responses to climate change and that climate protection efforts are, at the individual level, not crowded out by the option to invest in adaptation measures.

From a policy perspective it may also be important to gain insights into the relationship between private and public responses to climate change since implementing and achieving climate policy objectives broadly depends on the acceptance and participation of citizens. The next two sections empirically investigate the interrelation between private adaptation activities and climate protection efforts of individuals and their preferences for public adaptation and climate protection. The microeconometric analyses comprise two parts in order to draw meaningful conclusions: (i) Analysis of the determinants and motives of private adaptation and climate protection activities as well as the impact of adaptation activities on voluntary climate protection efforts and (ii) identification of the determinants of individual preferences for public adaptation and climate protection including the impact of private activities on these preferences.

[83] The presented model is also suitable to analyze preferences for public adaptation if $c(a)$ is interpreted as a tax to finance these public adaptation activities. Thus, public adaptation may be positively related to private activities (e.g., air conditioning in public buildings and at home) while both may also be substitutes (e.g., public financial compensation and insurance against damage by natural forces).

7.3 Data and variables

The data for these analyses were collected in May and June 2013 by the market research company GfK (Gesellschaft für Konsumforschung). In Germany and the USA, the sample was drawn from representative GfK Online Panels. Respondents were invited via email to attend a self-administered interview in a web-based online environment. In China, participants were recruited by employees of GfK China in eleven core regions and were invited to centrally located test studios.[84] In the test studios respondents answered the survey questions without any interference by the interviewers who were thoroughly briefed. Survey questions were carefully pretested and the completion of the survey required about 30 minutes on average in all three countries. In total, 1430 Chinese, 1005 German, and 1010 U.S. citizens aged 18 and older completed the questionnaire.

Among others, the questionnaire covered a wide range of climate protection activities which respondents had already engaged in: Buying energy-efficient appliances, saving 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. In the first part of the microeconometric analysis, the dependent variables g_{ij} are dummies indicating that respondent i ($i = 1, \dots, n$) has already engaged in one of the climate protection activities j ($j = 1, \dots, 7$) which serves as a proxy for respondents' private climate protection efforts. The underlying unobservable latent variable is

$$g_{ij}^{*} = \beta_j \pi_i + \gamma_j a_i + \delta_j' b_{ij} + \lambda_j' z_i + \varepsilon_{ij} \text{ with } g_{ij} = 1 \text{ if } g_{ij}^{*} > 0 \qquad (9)$$

where π_i and a_i are dummy variables indicating the respondent's subjective risk assessment and adaptation activities, b_{ij} is a vector of explanatory variables capturing potential co-benefits from the climate protection activities, and z_i is a vector of explanatory variables including beliefs, preferences, and characteristics of the respondent. By treating the responses to each climate protection activity as a separate sample and arranging (i.e. stacking) these samples as a panel dataset over the seven activities for each country, binary random effects probit

[84] Due to lacking internet access in rural areas, an online survey is likely to lead to a systematic bias in China.

models can be applied to analyze the general probability of engaging in one of the climate protection activities. This approach is suitable to control for individual-specific random effects in the error term ε_{ij} which are constant over the climate protection activities and are assumed to be uncorrelated with the explanatory variables.[85]

The unobservable latent variable of the propensity that respondent i ($i = 1, \dots, n$) has already engaged in one of the adaptation activities is

$$a_i^* = \beta_j \pi_i + \lambda_j' z_i + \nu_{ij} \text{ with } a_i = 1 \text{ if } a_i^* > 0. \quad (10)$$

This equation is estimated using common binary probit models. Since decisions for private adaptation and climate protection activities might be made concurrently, equations (4) and (5) are estimated simultaneously.[86] To check the robustness of the results and detect further differences between individuals, random effects probit models are also estimated separately using the maximum likelihood method for the whole sample, for respondents who have already engaged in adaptation activities, and for respondents who have not yet engaged in adaptation activities.[87]

For the analysis of the preferences for public activities, respondents were asked how strongly the following two responses should be pursued by public authorities in their home country: Mitigation of climate change (e.g. advancement of renewable energy or energy-efficient technologies) and adaptation measures regarding the consequences of climate change (e.g. provide protection against natural events like the building of dams, safeguarding of traffic routes). The dependent variables y_i are measured on a symmetric scale with five ordered response levels (i.e. "very weakly", "rather weakly", "neither weakly nor strongly", "rather strongly", and "very strongly") and are analyzed by applying ordered probit models. The underlying latent variable y_i^* can be written as

[85] As a robustness check, the estimation of single binary probit models for each climate protection activity confirms the findings from the random effects probit models. The results are not reported for reasons of brevity but are available upon request.

[86] The simultaneous estimation incorporates higher-dimensional cumulative normal distributions and requires the application of simulated maximum likelihood (SML) using Geweke, Hajivassiliou, and Keane (GHK) algorithm. The simultaneous estimation of the two probabilities allows for potential dependencies between the preferences for adaptation and climate protection and accounts for possible correlations between the dependent variables in the error terms.

[87] All estimations relied on robust estimations of the standard deviation of the parameter estimates.

$$y_i^* = \beta\pi_i + \gamma a_i + \theta g_i + \delta' b_i + \lambda' z_i + \varepsilon_i \text{ with } y_i = m \text{ if } \kappa_{m-1} < y_i^* < \kappa_m \qquad (11)$$

with κ_m $(m = 1, \dots, 5)$ as the upper bound threshold for the discrete level y_i. Equation (11) is estimated in a bivariate ordered probit model to allow for correlations in the respective error terms between the preferences for public adaptation and climate protection measures.

The survey included four questions on private adaptation activities which respondents had already taken: Climate control in their home (e.g. air-conditioning, sunblind, green roof), flood prevention measures in their home (e.g. backflow trap, waterproof external plaster), purchasing insurances to protect themselves against weather factors (e.g. storms, heavy rain events), and changing their travel habits due to weather impacts (e.g. choosing different travel periods or destinations due to high temperatures or missing snow reliability). The main explanatory variable *adaptation* (a_i) indicates that a respondent has already taken one of the four adaptation activities.[88] For the analyses of policy preferences, the binary variable *climate protection* denotes that a respondent has already engaged in one of the seven climate protection activities and the variables *number of adaptation activities* and *number of climate protection activities* count the number of measures a respondent has already taken.[89]

As a proxy for the subjective risk perception (π), the binary variable *negative consequences* reflects the respondent's belief that climate change has roughly equally positive and negative, rather negative, or very negative consequences for her personal living conditions. Perceptions of the climate protection efforts of others are captured by the binary variables *little effort of home country* and *little effort of most countries* and thereby by the belief that the respondent's home country does too little for climate protection or that most countries do too little for cli-

[88] I also used the single adaptation activities as explanatory variables in equation (9) and dependent variables a_{ik} $(k = 1, \dots, 4)$ in equation (10). Estimation results are very similar to those reported in the next section and are not reported for reasons of brevity but are available upon request.

[89] The variable *number of climate protection activities* only includes the five activities which were reported by all respondents. The questions *for reduce car use* and *reduce the number of flights* were filtered, i.e. only citizens who reported a positive number of kilometers or a positive number of flights could answer these questions so that the number of observations is considerably lower in this case. Hence, the variable *number of climate protection activities* only includes the five activities which were reported by all respondents (i.e. buy energy-efficient appliances, save energy at home, reduce the consumption of meat or dairy products, use or purchase energy from renewable sources, and buy a fuel-efficient car).

mate protection (i.e. G is believed to be small). For China, these two variables are not included since the underlying questions were not asked there.

Four additional binary variables cover respondent's financial, social, and psychological benefits from the climate protection activities (b). *Financial advantage from activity* reflects the respondent's belief that a certain climate protection activity provides rather financial advantages for her personally, *expectation of social environment* and *no contribution of social environment* cover the respondent's rewards from norm compliant behavior, and *warm glow* indicates that contributing to climate protection makes her feel good. The dummy *high contribution of activity* indicates that a certain climate protection activity is perceived to contribute rather a lot or a lot to climate protection and thereby serves as a proxy for a lower price of the climate protection activity (p).[90]

Lacking confidence in the effectiveness of climate protection activities may discourage individuals from engaging in climate protection activities. The index variable *lack of confidence* reflects the respondent's belief that climate change can still be effectively limited by climate protection measures, that one person on their own will not change anything anyway (reflecting the awareness that $\pi_g = 0$), or both. In Germany and the USA, the binary variables *liberal*, *conservative*, and *green* reflect the respondent's political attitudes. The binary variable *communist* indicates that a Chinese respondent is a member of the communist party. Table 2 in the Appendix provides a full list of explanatory variables (including several socio-economic and regional control variables) and their definitions. The binary random effects probit models include seven additional binary variables to identify and control for each climate protection activity.

7.4 Estimation results

Table 28 reports some descriptive statistics of the dependent and explanatory variables for the samples of 1430 Chinese, 1005 German, and 1010 U.S. respondents. On average, the proba-

[90] An increase in the effectiveness of offsets is equivalent to a reduction in their price.

bilities of buying energy efficient appliances, saving energy at home, and using renewable energy are highest in Germany. Chinese respondents report the highest average propensity to reduce meat or dairy products, to buy a fuel-efficient car, and to reduce car use and the number of flights. The average numbers of adaptation (2.30 for Chinese, 0.79 for German, and 1.44 for U.S. respondents) and climate protection activities (3.29 for Chinese, 2.88 for German, and 2.38 for U.S. respondents) which respondents have already engaged in are highest in China. In all three countries, a very large proportion of individuals has already taken climate protection activities (96 percent in China, 94 percent in Germany, and 88 percent in the USA), while the average engagement in at least one of the four adaptation measures is considerably lower (89 percent in China, 51 percent in Germany, and 69 percent in the USA).[91]

Average preferences for adaptation and climate protection efforts by public authorities are very similar in the three countries. Respondents rated climate protection slightly higher than adaptation, whereas German respondents rated both responses slightly higher compared to the other two countries. This is surprising since not even half of the respondents in China and only one third of the respondents in Germany and the USA believe that climate change has rather or very negative consequences for their personal living conditions and more than three quarters of the respondents in each country lack confidence in the effectiveness of climate protection activities.

7.4.1 Private climate protection activities

Tables 29 to 31 report the estimation results for the general probability of engaging in one of the seven climate protection and in one of the four adaptation activities in the three countries. The first two columns in each table refer to the approach where the binary random effects probit models for the climate protection activities and binary probit models for *adaptation* are estimated simultaneously. The latter three columns contain the results from the binary random

[91] The Global Climate Risk Index (CRI) published by Germanwatch measures to what extent countries have been affected by the impacts of weather-related loss events (see https://germanwatch.org/de/download/8551.pdf). In the period from 1993 to 2012, the lowest risk is measured for Germany followed by the USA and China. These differences in risk might be the reason for the varying average engagements in adaptation in the three countries.

effects probit models, first for the whole sample, followed by respondents who have not yet engaged in adaptation activities, and then for respondents who have already engaged in adaptation activities.

In all three countries, adaptation is significantly positively related to the probability of engaging in one of the seven climate protection activities. But there are some groups of individuals who significantly reduce their climate protection efforts if they engage in adaptation: Older people living in China as well as Chinese and U.S. respondents who perceive negative consequences from climate change. Even though there is no indication that adaptation and climate protection efforts are negatively related, which is in line with prediction 1, the engagement in adaptation may reduce the incentive to take climate protection activities for certain subgroups of individuals.

In line with prediction 2, expecting negative consequences from climate change significantly raises the probability of adaptation activities in China and the USA, while this variable has no significant effect on the probability of engaging in climate protection. Only Chinese and U.S. respondents who have not yet engaged in adaptation are significantly more likely to take one of the climate protection activities. In Germany, the belief that climate change has negative consequences for the personal living conditions has no significant effect on adaptation or climate protection efforts in any of the models.

The belief that the home country does too little for climate protection is associated with a significantly higher probability of taking adaptation measures in Germany and of engaging in climate protection for U.S. respondents who have not yet taken adaptation measures. The belief that most states do too little for climate protection significantly increases German respondents' climate protection efforts if they have not yet engaged in adaptation and U.S. respondents' likelihood to take adaptation measures.[92] In line with prediction 3, this finding implies that individuals compensate for a perceived lack of other's engagement in climate protection with higher efforts in either adaptation or climate protection activities.

[92] As mentioned before, these two variables are not included for China since the underlying questions were not asked in the Chinese survey.

In all three countries, financial advantages associated with the climate protection activity seem to be the most important driver for climate protection activities. Peer behavior represents an additional considerable factor for climate protection efforts. The perception that the social environment does not contribute to climate protection significantly discourages Chinese and German respondents except for those who have already engaged in adaptation. The belief that the social environment expects a contribution to climate protection significantly motivates respondents in China and the USA, especially if they have already engaged in adaptation activities.[93] Feelings of warm glow are a highly significant motive to take climate protection activities for German respondents, but also for Chinese respondents who have not yet engaged in adaptation activities. The effectiveness of a climate protection activity in providing climate protection, as indicated by the dummy variable *high contribution of activity*, further significantly increases the likelihood that respondents in all three countries engage in climate protection activities. Consistent with the theoretical modeling, climate protection efforts are strongly motivated by benefits from these activities and lower costs.

A lack of confidence significantly discourages U.S. respondents to engage in climate protection especially if they have already taken adaptation measures, while this variable has no significant effect in China and Germany. In line with prediction 4, a higher income significantly increases the probability to have already engaged in adaptation for Chinese and German respondents, while income has no effect on climate protection efforts. The estimation results further reveal that female (with the exception of the significantly negative effect in China), older, and highly educated (except in Germany) respondents are significantly more likely to engage in adaptation measures, but also some regional heterogeneity. Socio-demographic and regional factors seem to be of minor importance for private climate protection efforts.

[93] The significantly negative sign of the parameter estimate of the variable *expectation of the social environment* for U.S. respondents who have not yet engaged in adaptation activities seems to be counterintuitive. Some unobserved characteristics of these respondents might prevent them from doing anything in response to climate change.

7.4.2 Preferences for public adaptation and climate protection

Tables 32 to 34 report the estimation results for policy preferences in the bivariate ordered probit models. The estimated correlation in the error terms between preferences for adaptation and climate protection efforts by public authorities is significantly positive in all three countries and highest in the USA (0.50 in China, 0.38 in Germany, and 0.58 in the USA) suggesting a positive interrelation between the preferences for public adaptation and climate protection activities.

The relationship between private and public activities is quite heterogeneous in the three countries. Respondents in all three countries who engage in private climate protection are significantly more likely to have higher preferences for public climate protection activities. This finding implies a positive interrelation between private climate protection efforts and preferences for public activities. In Germany, the private engagement in climate protection additionally significantly increases the preferences for public adaptation, while a higher number of adaptation activities has an additional significantly negative effect on Chinese respondents' preferences for public climate protection. The belief that climate change has negative consequences for the own living conditions decreases preferences for public adaptation in China, but increases the preferences for public climate protection in Germany. In China, these findings may be attributed to the high average number of private adaptation activities of Chinese individuals, but also to the perception that public authorities already engage intensively in adaptation.[94] In Germany, the negative consequences from climate change are much more moderate. German individuals, therefore, exhibit the lowest average number of private adaptation activities among the three countries and seem to rely much more on public activities to cope with future negative consequences resulting from climate change.

In Germany, the perceptions that the home country and most states do too little for climate protection have significantly positive effects on the preferences for public climate protection. The belief that most states do too little for climate protection significantly increases U.S. re-

[94] China spent more than 200 billion yuan on public adaptation during the past two decades (see http://en.ndrc.gov.cn/newsrelease/201311/P020131108611533042884.pdf).

spondents' preferences for both measures. In both countries, the perceived lack of climate protection efforts of others tends to be compensated with private activities (as discussed in Section 7.4.1) but also with higher preferences for public engagement in climate protection (in both countries) and in adaptation (only in Germany).

Peer behavior seems to influence not only private activities but also preferences for public efforts. In all three countries, the perception that the social environment does not contribute to climate protection is associated with significantly lower preferences for public climate protection. Chinese respondents who state that their social environment expects them to make a contribution to climate protection are significantly more likely to have higher preferences for both public activities. In China and the USA, feelings of warm glow significantly increase preferences for both public activities, but in Germany only for public climate protection. As expected, a lack of confidence regarding the effectiveness of climate protection is associated with lower preferences for public climate protection in all three countries, and in Germany also with lower preferences for adaptation.

Being a member of the communist party in China is associated with significantly higher preferences for adaptation, identifying with green politics in Germany significantly increases preferences for climate protection, and U.S. liberals have significantly higher preferences for both. The estimation results also reveal considerable differences between the three countries concerning the socio-economic and regional characteristics. While a higher income, being female, older, and highly educated are significant determinants of private adaptation activities, these factors only partly influence preferences for public adaptation efforts. Preferences for public climate protection activities, however, are hardly determined by socio-demographic characteristics.

7.5 Summary and conclusions

This study is the first to provide survey-based evidence on the preferences for adaptation to climate change and climate protection and their interrelation at the individual level. The em-

pirical analyzes are based on theoretical predictions derived from a subjective utility framework which demonstrates that, at the individual level, private adaptation and climate protection activities cannot be substitutes and are determined by different factors. These predictions are tested using unique data from three key players in international climate policy, i.e. China, Germany (as the largest economy in the EU), and the USA.

The empirical findings strongly support the theoretical predictions that the private engagements in adaptation and climate protection are positively related. While the expectation of negative consequences from climate change (as a proxy for the subjective risk perception) and individual characteristics (like income, education, gender, and age) significantly influence adaptation activities, these factors have no significant effects on climate protection efforts. Financial advantages and a high effectiveness in providing climate protection seem to be the most important drivers for climate protection activities in all three countries. Feelings of warm glow and benefits from norm compliant behavior seem to further motivate these activities in China and Germany. There is also some evidence that a perceived lack of public engagement in climate protection is compensated by increased private adaptation and climate protection efforts.

These results also confirm findings from the existing literature, for example, the predictions from the model provided by Kane and Shogren (2000) that an exogenous increase in risk leads to higher adaptation efforts, while a change in climate protection efforts depends on the marginal effectiveness of mitigation in reducing risk, but also the experimental evidence in Hasson et al. (2010) who find no significant difference in choosing climate protection between low-vulnerability and high-vulnerability treatments.

Regarding policy preferences, the empirical findings indicate a positive relationship between private and public climate protection efforts. In the three countries, preferences for public adaptation and climate protection seem to be mainly driven by individual beliefs about the climate protection efforts of others, social norms, feelings of warm glow, and the confidence in the effectiveness (in the case of climate protection). Individual characteristics that signifi-

cantly determine these preferences differ significantly between Chinese, German, and U.S. respondents.

Future research could investigate whether the findings in this study are robust in other countries. Future studies may also use panel data to gain deeper insights into the interrelation between these two potential responses to climate change. Future research could also allow for other private adaptation and climate protection activities as well as for a richer set of items capturing the factors that determine these activities. New experimental settings may also account for potential trade-offs between private adaptation and climate protection efforts.

Appendix A: Tables

Table 1: Description of dependent variables

Variables	Description
Buying energy-efficient appliances	1 if the respondent has already bought energy-efficient appliances, 0 otherwise.
Saving energy at home	1 if the respondent has already taken actions to save energy at home, 0 otherwise.
Reducing meat or dairy products	1 if the respondent has already reduced the consumption of meat or dairy products, 0 otherwise.
Using energy from renewable sources	1 if the respondent has already used or purchased energy from renewable sources, 0 otherwise.
Buying a car with lower fuel consumption	1 if the respondent has already bought a car with lower fuel consumption, 0 otherwise.
Reducing car use	1 if the respondent has already reduced car use, 0 otherwise.
Reducing flights	1 if the respondent has already reduced the number of flights, 0 otherwise.

Table 2: Description of explanatory variables

Variables	Description
Adaptation	1 if respondent has already taken at least one of the four adaptation activities (i.e. climate control in their home, flood prevention measures in their home, purchase of insurances to protect themselves against weather factors, and change travel habits due to weather impacts), 0 otherwise.
Climate protection	1 if respondent has already engaged in at least one of the seven climate protection activities (i.e. buying energy-efficient appliances, saving 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), 0 otherwise.
Number of climate protection activities	Takes values from zero to five by counting the climate protection activities which a respondent has already engaged in and which were reported by all respondents (i.e. buy energy-efficient appliances, save energy at home, reduce the consumption of meat or dairy products, use or purchase energy from renewable sources, and buy a fuel-efficient car).
Number of adaptation activities	Takes values from zero to four by counting the adaptation activities which a respondent has already engaged in (i.e. climate control in their home, flood prevention measures in their home, purchase of insurances to protect themselves against weather factors, and change travel habits due to weather impacts).
Offsetting	1 if the respondent already engaged in offsetting, 0 otherwise.
High contribution of (carbon) 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 carbon offsetting in protecting the climate?” with the five ordered response categories: “Very ineffective”, “rather ineffective”, “neither effective nor ineffective”, “rather effective”, and “very effective”.
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.

Table 2: Description of explanatory variables (continued)

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.
High contribution of activity / 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 (from activity)	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	1 if the respondent agreed rather strongly or very strongly to the statement "it makes me feel good to contribute 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".
Warm glow indicator / motives	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".
Free-rider rationale	1 if the respondent agreed rather strongly or very strongly to the statement "regarding climate protection one person on their own will not change anything anyway", 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".
Green identity	1 if the respondent agreed rather strongly or very strongly to the statement "I identify myself closest with green politics", 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".
No contribution of social environment	1 if the respondent agreed rather strongly or very strongly to the statement "my family, friends or colleagues do not contribute 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".
Expectations of social environment	1 if the respondent agreed rather strongly or very strongly to the statement "my family, friends or colleagues expect me to contribute 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".
Expectation of society	1 if the respondent agreed rather strongly or very strongly to the statement "society expects me to contribute to climate protection", 0 otherwise.
Act as an example	1 if the respondent agreed rather strongly or very strongly to the statement "I want to set an example for others by making a contribution to climate protection", 0 otherwise.

Table 2: Description of explanatory variables (continued)

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.
Negative consequences	1 if respondent believes that climate change has equally positive and negative, rather negative, or very negative consequences for his or her personal living conditions, 0 otherwise. The underlying question is "in your opinion, what consequences does climate change have for your personal living conditions" with the five ordered response categories: "very negative consequences", "rather negative consequences", "roughly equally positive and negative consequences", "rather positive consequences", and "very positive consequences".
Little effort of home country	1 if the respondent agreed rather strongly or very strongly to the statement "my home country does too little for 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".
Little effort of most countries	1 if the respondent agreed rather strongly or very strongly to the statement "most countries do too little for 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".
Lack of confidence	Additive indicator using the following two items: – "do you think that we can still effectively limit climate change by climate protection measures?" – "regarding climate protection one person on their own will not change anything anyway". The underlying question to the second item 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 answered the first question with "yes" and agreed to the second statement rather or very strongly. The two dummy variables were then added up. Accordingly, the variable takes values from 0 to 2.
Communist	1 if a Chinese respondent stated to belong to the communist party.
Conservative	1 if a German or U.S. respondent agreed rather strongly or very strongly to the statement "I am conservative", 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)

Green	1 if a German or U.S. respondent agreed rather strongly or very strongly to the statement "I identify myself closest with green politics", 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".
Liberal	1 if a German or U.S. respondent agreed rather strongly or very strongly to the statement "I am liberal", 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".
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.
High individual income	1 if the individual net income of the respondent is above median category of the sample (i.e. at least ¥ 5,000 in China, € 2,000 in Germany and $ 2,500 in the USA), 0 otherwise.
Highly educated	1 if the respondent's highest level of education is at least secondary (Senior Middle School in China, Abitur in Germany, College degree in the U.S.), 0 otherwise.
Number of own children	Number of own children of the respondent.
Living together with a partner	1 if the respondent lives together with his or her partner, 0 otherwise.
Regional dummies for China	Beijing, Shanghai, Guangzhou, Shenyang, Wuhan, Chengdu, Shijiazhuang, Hefei, Lanzhou, Yinchuan, and Quanzhou take the value 1 if respondent lives in the corresponding region in China, 0 otherwise.
Regional dummies for Germany	North, East, South, and West take the value 1 if the respondent lives in a northern (eastern, southern, western) state of Germany, 0 otherwise.
Western Germany	1 if the respondent lives in Western Germany, 0 otherwise.
Regional dummies for the USA	Northeast, Midwest, South, and West take the value 1 if the respondent lives in the corresponding region in the USA, 0 otherwise.

Table 3: Descriptive statistics

Variables	Number of observations (without missings)	Mean	Standard deviation	Mini-mum	Maxi-mum
Tourism-related adaptation to climate change	4737	0.22	0.42	0	1
Awareness of climate change effects					
Expected rising temperatures	5110	0.89	0.31	0	1
Expected negative consequences	4656	0.51	0.50	0	1
Member of environmental organization	5345	0.12	0.33	0	1
Personal experience of heat waves	5310	0.72	0.45	0	1
Personal experience of floods	5354	0.54	0.50	0	1
Personal experience of heavy rain	5337	0.85	0.36	0	1
Personal experience of storms	5327	0.80	0.40	0	1
Frequent journeys	5370	0.66	0.47	0	1
General risk aversion					
Risk aversion recreation and sports	5353	0.35	0.48	0	1
Risk aversion financial investments	5118	0.46	0.50	0	1
Health risk associated with climate change					
Age	5370	50.63	13.41	18	87
Number of children under 18 years	5316	0.38	0.77	0	5
Available means to cope with the impacts of climate change					
High household income	4587	0.43	0.50	0	1
Disposable financial resources	5114	0.74	0.44	0	1
Highly educated	5332	0.43	0.50	0	1
Very well informed	5256	0.04	0.20	0	1
Control variables					
Female	5370	0.32	0.47	0	1
Eastern Germany	5370	0.19	0.40	0	1
Full-time employment	5295	0.61	0.49	0	1

Notes: Descriptive statistics of the dependent and explanatory variables for overall 5370 observations

Table 4: Estimation results in the binary probit model

Explanatory variables	ML estimates of parameters (z-statistics)	Estimates of average marginal, discrete, and interaction effects (z-statistics)
Awareness of climate change effects		
Expected rising temperatures	0.22**	0.062**
	(2.06)	(2.229)
Expected negative consequences	0.39***	0.117***
	(7.77)	(7.870)
Member of environmental organization	0.16**	0.048**
	(2.18)	(2.106)
Personal experience of heat waves	0.42***	0.117***
	(6.90)	(7.513)
Personal experience of floods	0.01	0.003
	(0.18)	(0.183)
Personal experience of heavy rain	-0.01	-0.003
	(-0.13)	(-0.134)
Personal experience of storms	0.03	0.009
	(0.48)	(0.484)
Frequent journeys	-0.08	-0.024
	(-1.48)	(-1.472)
General risk aversion		
Risk aversion recreation and sports	0.04	0.013
	(0.83)	(0.826)
Risk aversion financial investments	0.03	0.009
	(0.62)	(0.622)
Health risk associated with climate change		
Age	0.01***	0.002***
	(3.62)	(3.632)
Number of children under 18 years	0.03	0.010
	(0.95)	(0.955)
High household income	-0.05	-0.013
	(-0.82)	(-0.822)
Disposable financial resources	0.17***	0.049***
	(2.85)	(2.936)
Highly educated	-0.01	-0.002
	(-0.12)	(-0.120)
Very well informed	-0.12	-0.034
	(-0.66)	(-0.687)
Highly educated × very well informed	0.47**	0.149**
	(1.96)	(1.97)
Control variables		
Female	0.23***	0.072***
	(4.10)	(4.000)
Eastern Germany	-0.14**	-0.040**
	(-2.06)	(-2.121)
Full-time employment	-0.01	-0.003
	(-0.18)	(-0.182)
Constant	-2.03***	
	(-9.81)	

Notes: Maximum Likelihood estimates of parameters, estimates of average marginal and discrete probability effects, as well as estimates of interaction effects in the binary probit model, dependent variable: tourism-related adaptation to climate change, number of observations = 3232. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 5: Estimates of average probabilities

Explanatory variables	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
Expected rising temperature	0.184	0.247
Expected negative consequences	0.184	0.301
Member of environmental organization	0.236	0.284
Personal experience of heat waves	0.158	0.275
Age	0.171	0.336
Disposable financial resources	0.207	0.256
Female	0.222	0.294
Eastern Germany	0.250	0.210

Notes: Estimates of average probabilities at minimum and maximum values of explanatory variables (i.e. 18 and 87 years for age, zero and one for the dummy variables) with a significant effect in the binary probit model, dependent variable: tourism-related adaptation to climate change, number of observations = 3232

Table 6: Item responses on distributional justice

		China	Germany	USA	Test for differences
Q7: In your opinion, how strongly should the following rules be considered when allocating costs in order to reduce global warming? *(very weakly - rather weakly - neither weakly nor strongly - rather strongly - very strongly)*					
a) Every country has to bear costs according to the emissions it causes (hence countries causing higher emissions have a higher share of the costs) [ACCOUNTABILITY]	rather strongly & very strongly	0.71	0.82	0.69	cg***; gu***
b) Every country has to bear costs according to its economic strength (hence richer countries have a higher share of the costs) [CAPABILITY]		0.66	0.61	0.52	cg**; cu***; gu***
c) Every country is allowed to produce the same amount of emissions per capita (hence countries with currently high emissions per capita have higher costs) [EGALITARIAN]		0.54	0.49	0.52	-
d) Every country is allowed to produce the same share of global emissions as in the past (hence the proportional reduction of emissions is the same for every country) [SOVEREIGNTY]		0.44	0.18	0.37	cg***; cu**; gu***

Notes: Item responses on distributional justice across countries (as shares of valid answers). * (**, ***) indicate statistical significance at 10% (5%, 1%) level at two-sided individual z-tests for differences across-countries. c, g, and u stand for China, Germany and the USA, respectively; for example, cg*** means that the difference in the response shares between China and Germany is statistically significant at $p<0.01$.

Table 7: Item responses on justification of climate policy

		China	Germany	USA	Test for differences
Q8: Do you think that we can still effectively limit climate change by climate protection measures?					
	yes	0.89	0.63	0.72	cg***; cu***; gu***
Q9: In your opinion, should climate change be limited by human activities?					
	yes	0.91	0.93	0.66	cu***; gu***
Q10: The scientific findings are too uncertain to serve as the basis for climate negotiations					
	yes	0.39	0.35	0.38	-
Q11: How successful do you think the international agreements reached so far are in combating climate change? *(very unsuccessful - rather unsuccessful - neither unsuccessful nor successful - rather successful - very successful)*					
	rather successful & very successful	0.56	0.09	0.26	cg***; cu***; gu***
Q12: How important do you consider future international agreements are for combating climate change? *(very unimportant - rather unimportant - neither important nor unimportant - rather important - very important)*					
	rather important & very important	0.77	0.87	0.73	cg***; cu*; gu***
Q13: How strongly do you agree with the following statement? *(very weakly - rather weakly - neither weakly nor strongly - rather strongly - very strongly)*					
All countries can benefit from international climate agreements.	rather strongly & very strongly	0.65	0.69	0.64	cg*; gu**
Q14: How important do you consider the following issues to be for international climate negotiations? *(very unimportant - rather unimportant - neither important nor unimportant - rather important - very important)*					
a) Comprehensive quantitative targets to reduce global greenhouse gas emissions?	rather important & very important	0.86	0.87	0.75	cu***; gu***
b) Measures to reduce global greenhouse gas emissions?		0.87	0.89	0.77	cu***; gu***
c) Adaptation measures to the consequences of climate change (e.g., dams for flood protection)		0.75	0.80	0.73	cg**; gu***

Notes: Item responses on justification of climate policy across countries (as shares of valid answers). * (**, ***) indicate statistical significance at 10% (5%, 1%) level at two-sided individual z-tests for differences across-countries.

Table 8: Item responses on perceptions of trust

		China	Germany	USA	Test for differences
Q15: This question concerns your personal perception of international climate negotiations and agreements. How strongly do you agree with the following statements? *(very weakly - rather weakly - neither weakly nor strongly - rather strongly - very strongly)*					
a) Commitments made at international climate negotiations will not be kept anyhow	rather strongly & very strongly	0.32	0.67	0.48	cg***; cu***; gu***
b) The richer (industrialized) countries should show they can successfully reduce emissions first before the poorer (developing) countries have to do so		0.75	0.49	0.50	cg***; cu***
c) Governments use international climate negotiations to pacify their citizens instead of reducing global greenhouse gas emissions		0.53	0.67	0.50	cg***; gu***
d) Climate negotiations are used to publicly denounce the industrialized countries		0.50	0.33	0.42	cg***; cu***; gu***
Q16: How strongly do you agree with the following statements? *(very weakly - rather weakly - neither weakly nor strongly - rather strongly - very strongly)*					
a) The richer (industrialized) countries use international climate negotiations to push through their own economic interests vis-a-vis other countries.	rather strongly & very strongly	0.57	0.63	0.50	cu***; gu***
b) The poorer (developing) countries use international climate negotiations to push through their own economic interests vis-a-vis other countries.		0.48	0.36	0.38	cg***; cu***
c) All countries have the same opportunities to represent their interests at international climate conferences.		0.71	0.39	0.50	cg***; cu***; gu***

Notes: Item responses on perceptions of trust in climate policy across countries (as shares of valid answers). * (**, ***) indicate statistical significance at 10% (5%, 1%) level at two-sided individual z-tests for differences across-countries.

Table 9: Sample Demographics for China

Total	N = 1430 (unweighted)	% (weigthed)
Gender		
female	713	50
male	717	50
Age		
18-29	379	23
30-47	684	47
48-66	349	28
67+	18	1
Education		
below secondary	333	25
secondary and higher	1078	75
Household income in Yuan*		
<4000	124	10
4000 - < 5000	105	8
5000 - < 10000	363	28
10000 - < 15000	326	24
15000 - < 25000	247	16
>25000	195	15
Region		
Beijing	220	3
Shanghai	234	3
Guangzhou	182	19
Shenyang	112	9
Wuhan	109	11
Chengdu	89	16
Shijiazhuang	89	13
Hefei	87	11
Lanzhou	141	5
Yinchuan	86	1
Quanzhou	81	7

* net income after tax and social security contributions

Table 10: Sample Demographics for Germany

Total	N=1005 (unweighted)	% (weigthed)
Gender		
female	494	51
male	511	49
Age		
18-29	192	18
30-47	478	31
48-66	306	39
67+	29	12
Education		
below secondary	452	50
secondary and higher	548	50
Household income in €*		
<1500	164	22
1500 - < 3000	323	42
3000 - < 6000	287	32
6000 - < 10000	40	4
> 10000	8	1
Region		
East	215	21
West	790	79

* net income after tax and social security contributions

Table 11: Sample Demographics for the USA

Total	N=1010 (unweighted)	% (weigthed)
Gender		
female	476	52
male	534	48
Age		
18-29	100	19
30-47	385	33
48-66	412	34
67+	113	14
Education		
below secondary	321	32
secondary and higher	685	68
Household income in US$*		
<2000	124	10
2000 - <4000	468	35
4000 - <7500	61	38
7500 - < 12500	121	8
> 12500	109	9
Region		
Northwest	204	21
Midwest	230	20
South	354	37
West	222	22

* net income after tax and social security contributions

Table 12: Item responses on climate change and climate policy

		China	Germany	USA	Test for differences
Q1: How important do you consider the following global challenges to be? *(very unimportant - rather unimportant - neither important nor unimportant - rather important - very important)*					
Combating climate change	rather important & very important	0.94	0.85	0.64	cg***; cu***; gu***
Q2: Which of the following statements about global climate change are you most likely to agree with?					
a) Global climate change is already occurring	yes	0.89	0.81	0.79	cg***; cu***
b) Global climate change is not happening now, but it will occur in the future	yes	0.11	0.15	0.13	cg**
c) Global climate change is not going to occur at all	yes	0.01	0.05	0.09	cg***; cu***; gu***
Q3: What, in your opinion, is the main cause of climate change?					
a) Natural processes	yes	0.03	0.02	0.10	cu***; gu***
b) Human activities	yes	0.43	0.25	0.30	cg***; cu***
c) Natural processes as well as human activities	yes	0.54	0.72	0.60	cg***; cu**; gu***
Q4: In your opinion, what consequences does climate change have? *(very negative - rather negative - roughly equally positive and negative - very positive - rather positive)*					
a) for present day generation	rather negative & very negative	0.45	0.50	0.45	cg*
b) for future generations		0.60	0.85	0.57	cg***; gu***
Q5: How well informed do you feel about these climate conferences? *(very badly - rather badly - neither well nor badly - rather well - very well)*					
	rather well & very well	0.36	0.22	0.27	cg***; cu***; gu**
Q6: How well do you think your personal position is represented at international climate negotiations? *(very badly - rather badly - neither well nor badly - rather well - very well)*					
	rather well & very well	0.48	0.13	0.28	cg***; cu***; gu***

Notes: Item responses on climate change and climate policy across countries (as shares of valid answers). * (**, ***) indicate statistical significance at 10% (5%, 1%) level at two-sided individual z-tests for differences across-countries; c, g, and u stand for China, Germany and the USA, respectively; for example, cg*** means that the difference in the response shares between China and Germany is statistically significant at $p<0.01$.

Table 13: Number of respondents and mean for all variables

Variables	Both countries		USA		Germany	
	Number of respondents	Mean	Number of respondents	Mean	Number of respondents	Mean
Planned climate protection activities						
Energy savings	1,938	0.84	965	0.81	973	0.87
Energy-efficient appliances	1,921	0.81	952	0.78	969	0.84
Fuel-efficient car	1,844	0.69	915	0.67	929	0.71
Renewable energy	1,832	0.56	890	0.50	942	0.62
Less meat or dairy products	1,903	0.46	939	0.42	964	0.50
Perceived justification	1,569	0.80	698	0.73	871	0.86
Perceived procedural trust	1,776	0.10	855	0.13	921	0.07
Perceived procedural justice	1,758	0.42	858	0.49	900	0.36
Effectiveness of activity						
Energy savings	1,888	0.61	924	0.61	964	0.61
Energy-efficient appliances	1,892	0.62	926	0.63	966	0.61
Fuel-efficient car	1,874	0.62	918	0.61	956	0.63
Renewable energy	1,824	0.64	875	0.60	949	0.67
Less meat or dairy products	1,795	0.30	847	0.25	948	0.35
Financial advantage of activity						
Energy savings	1,875	0.79	919	0.76	956	0.81
Energy-efficient appliances	1,870	0.67	914	0.73	956	0.62
Fuel-efficient car	1,789	0.63	877	0.66	912	0.61
Renewable energy	1,692	0.39	813	0.50	879	0.29
Less meat or dairy products	1,730	0.38	833	0.39	897	0.37
Environmental awareness	1,833	3.58	905	3.07	928	4.08
Identification with green politics	1,845	0.26	907	0.21	938	0.30
Age	2,015	44.83	1,010	48.51	1,005	41.13
Female	2,015	0.51	1,010	0.53	1,005	0.49
Number of children	2,015	1.14	1,010	1.32	1,005	0.95
Living together	2,008	0.62	1,006	0.62	1,002	0.63
High education	2,006	0.61	1,006	0.68	1,000	0.55
USA	2,015	0,50				
West			1,010	0.22	1,005	0.79
Midwest			1,010	0.23		
Northeast			1,010	0.20		
South			1,010	0.35		

Table 14: Estimation results in the binary random effects probit models

Explanatory variables	Combined-countries model	Single-country model: USA	Single-country model: Germany
Planned climate protection activities			
Energy savings	1.24***	1.27***	1.25***
	(16.42)	(10.96)	(12.45)
Energy-efficient appliances	1.12***	1.12***	1.15***
	(15.60)	(9.82)	(12.22)
Fuel-efficient car	0.62***	0.78***	0.54***
	(9.40)	(7.32)	(6.29)
Renewable energy	0.28***	0.30***	0.26***
	(4.31)	(2.92)	(3.07)
Perceived justification	0.34***	0.35**	0.36***
	(3.66)	(2.53)	(2.87)
Perceived procedural trust	0.00	-0.04	0.09
	(0.03)	(-0.28)	(0.57)
Perceived procedural justice	-0.26***	-0.35***	-0.14
	(-3.62)	(-2.99)	(-1.59)
Effectiveness of activity	0.34***	0.10	0.46***
	(6.02)	(1.01)	(6.59)
Financial advantage of activity	0.41***	0.64***	0.26***
	(7.63)	(7.30)	(3.88)
Environmental awareness	0.05**	0.06*	0.04
	(2.37)	(1.73)	(1.64)
Identification with green politics	0.33***	0.25*	0.37***
	(4.16)	(1.83)	(3.93)
Age	-0.00	-0.00	-0.01
	(-1.44)	(-0.94)	(-1.43)
Female	0.14*	0.12	0.14*
	(1.95)	(1.02)	(1.68)
Number of children	0.04	0.03	0.04
	(1.32)	(0.72)	(1.04)
Living together	0.13*	0.09	0.17*
	(1.78)	(0.80)	(1.86)
High education	0.16**	0.14	0.16*
	(2.16)	(1.14)	(1.82)
Northeast		-0.17	
		(-1.10)	
Midwest		-0.11	
		(-0.75)	
West		-0.28*	0.23**
		(-1.88)	(2.28)
USA	-0.06		
	(-0.73)		
Constant	-0.71***	-0.57**	-0.92***
	(-4.20)	(-2.10)	(-3.94)
Number of observations	6,195	2,643	3,552
Number of respondents	1,315	568	747

Notes: Maximum likelihood estimates (z-statistics) of the parameters in binary random effects probit models, determinants of the general propensity to adopt one of the five climate protection activities. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 15: Estimation results in multivariate binary probit models for both countries

Explanatory variables	Energy savings	Energy-efficient appliances	Fuel-efficient car	Renewable energy	Less meat or dairy products
Perceived justification	0.50***	0.47***	0.48***	0.38***	0.11
	(3.95)	(3.81)	(4.20)	(3.36)	(0.97)
Perceived procedural trust	-0.03	0.10	0.02	0.33**	0.06
	(-0.16)	(0.66)	(0.15)	(2.28)	(0.45)
Perceived procedural justice	-0.54***	-0.23**	-0.26***	-0.23***	-0.07
	(-5.19)	(-2.33)	(-2.88)	(-2.59)	(-0.87)
Effectiveness of activity	0.16*	-0.14	0.10	0.28***	0.65***
	(1.68)	(-1.41)	(1.10)	(3.04)	(7.26)
Financial advantage of activity	0.33***	0.15*	0.29***	0.18**	0.30***
	(3.23)	(1.65)	(3.40)	(2.09)	(3.56)
Environmental awareness	0.07**	0.05*	0.04	0.01	0.04
	(2.36)	(1.87)	(1.34)	(0.52)	(1.54)
Identification with green politics	-0.14	0.10	0.03	0.44***	0.40***
	(-1.28)	(0.91)	(0.33)	(4.54)	(4.24)
Age	-0.00	-0.00	0.00	-0.01***	-0.00
	(-1.10)	(-0.62)	(0.88)	(-4.14)	(-1.32)
Female	0.20*	0.09	-0.01	-0.01	0.21**
	(1.95)	(0.96)	(-0.16)	(-0.07)	(2.47)
Number of children	0.01	0.04	-0.00	0.05	0.00
	(0.24)	(0.89)	(-0.05)	(1.26)	(0.13)
Living together	0.20*	0.24**	0.18*	0.18*	0.06
	(1.91)	(2.32)	(1.95)	(1.95)	(0.73)
High education	0.16	0.10	0.24**	0.21**	-0.02
	(1.53)	(0.94)	(2.56)	(2.33)	(-0.26)
USA	0.14	-0.02	0.13	0.00	0.06
	(1.29)	(-0.24)	(1.35)	(0.04)	(0.63)
Constant	0.23	0.32	-0.43**	0.05	-0.56***
	(1.01)	(1.44)	(-2.06)	(0.22)	(-2.74)
Number of observations			1,052		

Notes: Simulated maximum likelihood estimates (z-statistics) of the parameters in multivariate binary probit models, determinants of the adoption of five climate protection activities separately, combined-countries model for the USA and Germany. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 16: Estimation results in multivariate binary probit models for the USA

Explanatory variables	Energy savings	Energy-efficient appli-ances	Fuel-efficient car	Renewable energy	Less meat or dairy products
Perceived justification	0.50***	0.53***	0.46***	0.37**	0.16
	(2.75)	(3.08)	(2.73)	(2.35)	(0.99)
Perceived procedural trust	-0.25	0.09	-0.02	0.42**	-0.04
	(-1.17)	(0.39)	(-0.08)	(2.27)	(-0.22)
Perceived procedural justice	-0.63***	-0.39***	-0.38**	-0.21	-0.02
	(-4.06)	(-2.62)	(-2.54)	(-1.49)	(-0.15)
Effectiveness of activity	0.12	-0.60***	-0.05	0.12	0.37**
	(0.84)	(-3.76)	(-0.35)	(0.82)	(2.51)
Financial advantage of activity	0.27*	0.33**	0.33**	0.38***	0.37***
	(1.82)	(2.29)	(2.50)	(3.12)	(2.85)
Environmental awareness	0.12**	0.15***	0.12**	0.01	0.00
	(2.57)	(3.08)	(2.52)	(0.15)	(0.03)
Identification with green politics	-0.28	0.01	-0.09	0.35**	0.31**
	(-1.61)	(0.08)	(-0.57)	(2.21)	(2.00)
Age	-0.00	-0.00	0.00	-0.02***	-0.00
	(-0.48)	(-0.25)	(0.06)	(-3.43)	(-0.90)
Female	0.28*	0.04	0.04	-0.04	0.24*
	(1.84)	(0.24)	(0.28)	(-0.29)	(1.87)
Number of children	0.01	0.05	0.00	0.06	0.01
	(0.19)	(0.84)	(0.06)	(1.27)	(0.16)
Living together	0.10	0.20	0.23	-0.11	-0.06
	(0.66)	(1.32)	(1.59)	(-0.77)	(-0.46)
High education	-0.13	0.01	0.45***	0.14	0.15
	(-0.80)	(0.07)	(3.03)	(0.96)	(1.11)
Northeast	-0.42**	-0.01	-0.10	0.01	-0.16
	(-2.11)	(-0.05)	(-0.55)	(0.08)	(-0.91)
Midwest	-0.27	-0.28	0.00	-0.25	-0.16
	(-1.28)	(-1.48)	(0.02)	(-1.43)	(-0.93)
West	-0.47**	-0.48***	-0.04	-0.12	-0.06
	(-2.39)	(-2.62)	(-0.20)	(-0.67)	(-0.38)
Constant	0.81**	0.49	-0.43	0.51*	-0.37
	(2.34)	(1.49)	(-1.31)	(1.66)	(-1.22)
Number of observations			448		

Notes: Simulated maximum likelihood estimates (z-statistics) of the parameters in multivariate binary probit models, determinants of the adoption of five climate protection activities separately, single-country models for the USA. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 17: Estimation results in multivariate binary probit models for Germany

Explanatory variables	Energy savings	Energy-efficient appliances	Fuel-efficient car	Renewable energy	Less meat or dairy products
Perceived justification	0.60***	0.53***	0.48***	0.38**	0.10
	(3.27)	(2.98)	(2.85)	(2.32)	(0.59)
Perceived procedural trust	0.10	0.06	0.05	0.26	0.26
	(0.39)	(0.25)	(0.23)	(1.17)	(1.23)
Perceived procedural justice	-0.45***	-0.05	-0.17	-0.16	-0.01
	(-3.12)	(-0.32)	(-1.39)	(-1.36)	(-0.10)
Effectiveness of activity	0.15	0.11	0.21*	0.34***	0.80***
	(1.17)	(0.83)	(1.78)	(2.86)	(6.83)
Financial advantage of activity	0.30**	0.06	0.29**	0.08	0.25**
	(2.17)	(0.47)	(2.57)	(0.67)	(2.16)
Environmental awareness	0.05	0.00	0.01	0.03	0.07**
	(1.35)	(0.13)	(0.27)	(0.86)	(2.25)
Identification with green politics	-0.07	0.18	0.07	0.40***	0.39***
	(-0.48)	(1.18)	(0.54)	(3.16)	(3.16)
Age	-0.01**	-0.01	0.00	-0.02***	-0.01
	(-2.01)	(-0.96)	(0.29)	(-3.09)	(-1.38)
Female	0.12	0.07	-0.06	0.03	0.20*
	(0.83)	(0.48)	(-0.52)	(0.26)	(1.77)
Number of children	0.05	0.07	0.03	0.07	0.02
	(0.73)	(0.97)	(0.54)	(1.14)	(0.44)
Living together	0.24*	0.24*	0.09	0.32***	0.16
	(1.68)	(1.66)	(0.68)	(2.63)	(1.29)
High education	0.30**	0.16	0.09	0.26**	-0.12
	(2.12)	(1.10)	(0.71)	(2.19)	(-1.05)
West	0.12	0.03	0.19	0.35***	0.41***
	(0.74)	(0.21)	(1.38)	(2.59)	(2.96)
Constant	0.32	0.41	-0.34	-0.39	-1.01***
	(0.94)	(1.11)	(-1.10)	(-1.26)	(-3.24)
Number of observations			604		

Notes: Simulated maximum likelihood estimates (z-statistics) of the parameters in multivariate binary probit models, determinants of the adoption of five climate protection activities separately, single-country model for Germany. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 18: Descriptive statistics

Variables	Germany			USA		
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation
Carbon offsetting	572	0.55	0.50	549	0.57	0.50
Price premium	762	0.54	0.50	760	0.37	0.48
Free-rider rationale	959	0.34	0.47	931	0.35	0.48
Warm glow motives	957	0.66	0.47	934	0.60	0.49
Green identity	938	0.30	0.46	907	0.21	0.41
No contribution of social environment	912	0.19	0.39	872	0.29	0.45
Expectation of society	944	0.32	0.47	916	0.44	0.50
Act as an example	961	0.40	0.49	931	0.47	0.50
NEP scale	928	4.08	1.82	905	3.07	1.91
High contribution of carbon offsetting	892	0.54	0.50	778	0.49	0.50
Highly educated	1,000	0.55	0.50	1,006	0.68	0.47
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
Number of own children	1,005	0.95	1.12	1,010	1.32	1.39
Western Germany	1,005	0.79	0.41			
West				1,010	0.22	0.41
Northeast				1,010	0.20	0.40
Midwest				1,010	0.23	0.42

Notes: Descriptive statistics of dependent and explanatory variables for overall 1,005 observations in Germany and 1,010 observations in the USA

Table 19: Estimation results in the bivariate probit models for Germany and the USA

Explanatory variables	Germany		USA	
	Carbon offsetting	Price premium	Carbon offsetting	Price premium
Free-rider rationale	-0.44***	-0.06	-0.37**	-0.56***
	(-2.83)	(-0.42)	(-2.11)	(-3.32)
Warm glow motives	0.69***	0.56***	0.45**	0.54**
	(3.85)	(3.16)	(2.17)	(2.31)
Green identity	0.13	0.60***	-0.05	0.40**
	(0.82)	(4.03)	(-0.23)	(2.27)
No contribution of social environment	0.04	-0.34*	-0.36**	-0.16
	(0.24)	(-1.94)	(-1.99)	(-0.91)
Expectation of society	0.16	-0.11	0.57***	0.31*
	(1.08)	(-0.74)	(3.31)	(1.76)
Act as an example	0.21	0.48***	0.53***	0.32
	(1.34)	(3.11)	(2.64)	(1.46)
NEP scale	0.10**	0.16***	0.11**	0.11**
	(2.41)	(3.84)	(2.42)	(2.30)
High contribution of carbon offsetting	0.91***	0.13	0.57***	0.52***
	(6.52)	(0.90)	(3.35)	(3.16)
Highly educated	-0.01	0.53***	0.17	0.22
	(-0.09)	(3.57)	(0.91)	(1.30)
Age of respondent	0.01	0.01	-0.01	-0.01
	(1.10)	(1.37)	(-1.32)	(-1.06)
Female	0.39***	-0.01	-0.05	-0.44***
	(2.66)	(-0.07)	(-0.29)	(-2.73)
Number of own children	-0.02	-0.08	0.02	0.01
	(-0.30)	(-1.19)	(0.38)	(0.13)
Western Germany	0.08	0.03		
	(0.54)	(0.22)		
West			0.21	0.22
			(0.99)	(1.05)
Northeast			0.14	0.10
			(0.61)	(0.47)
Midwest			-0.11	-0.06
			(-0.54)	(-0.31)
Constant	-1.74***	-1.87***	-0.79**	-1.02***
	(-4.69)	(-4.93)	(-2.06)	(-2.93)
Observations	427		372	

Notes: Maximum likelihood estimates (robust z-statistics) of parameters in the bivariate binary probit models in Germany and the USA. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 20: Estimation results in the multinomial logit model for Germany

Explanatory variables	Price premium but not carbon offsetting	Carbon offsetting but not price premium	Carbon offsetting and price premium
Free-rider rationale	-0.20	-1.16***	-0.77**
	(-0.55)	(-2.65)	(-2.28)
Warm glow motives	0.63	0.92**	1.67***
	(1.56)	(2.06)	(4.08)
Green identity	1.26***	0.20	1.11***
	(3.06)	(0.42)	(2.98)
No contribution of social environment	-0.70	0.22	-0.35
	(-1.57)	(0.49)	(-0.96)
Expectation of society	-0.37	0.25	0.06
	(-0.93)	(0.63)	(0.18)
Act as an example	0.80**	0.27	0.97***
	(2.06)	(0.62)	(2.67)
NEP scale	0.40***	0.25**	0.37***
	(3.88)	(2.38)	(3.69)
High contribution of carbon offsetting	0.05	1.84***	1.51***
	(0.15)	(4.83)	(4.90)
Highly educated	1.57***	0.21	0.88***
	(3.70)	(0.52)	(2.62)
Age of respondent	0.03*	0.02	0.03**
	(1.78)	(1.37)	(1.98)
Female	-0.19	0.74*	0.59*
	(-0.44)	(1.87)	(1.65)
Number of own children	-0.19	-0.07	-0.19
	(-1.06)	(-0.37)	(-1.16)
Western Germany	-0.26	-0.07	0.12
	(-0.69)	(-0.18)	(0.37)
Constant	-4.72***	-4.25***	-5.27***
	(-4.89)	(-3.89)	(-5.57)
Observations		427	

Notes: Maximum likelihood estimates (robust z-statistics) of parameters in the multinomial logit model for Germany, base category: neither carbon offsetting nor price premium. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 21: Estimation results in the multinomial logit model for the USA

Explanatory variables	Price premium but not carbon offsetting	Carbon offsetting but not price premium	Carbon offsetting and price premium
Free-rider rationale	-0.90*	-0.38	-1.27***
	(-1.81)	(-0.94)	(-3.43)
Warm glow motives	1.30*	0.87*	1.18***
	(1.87)	(1.70)	(2.67)
Green identity	-0.04	-0.98*	0.18
	(-0.06)	(-1.72)	(0.41)
No contribution of social environment	0.12	-0.50	-0.83**
	(0.21)	(-1.13)	(-2.16)
Expectation of society	0.11	0.85*	1.21***
	(0.20)	(1.92)	(3.38)
Act as an example	-0.45	0.34	1.09**
	(-0.75)	(0.63)	(2.38)
NEP scale	0.44***	0.35***	0.32***
	(3.21)	(3.39)	(3.38)
High contribution of carbon offsetting	0.80	0.84**	1.50***
	(1.56)	(1.97)	(4.07)
Highly educated	0.61	0.42	0.55
	(1.13)	(1.00)	(1.50)
Age of respondent	-0.02	-0.02	-0.02
	(-1.04)	(-1.50)	(-1.51)
Female	-0.98*	0.04	-0.73**
	(-1.70)	(0.09)	(-2.07)
Number of own children	-0.07	0.01	0.07
	(-0.33)	(0.10)	(0.59)
West	0.17	0.07	0.42
	(0.28)	(0.15)	(0.87)
Northeast	0.45	0.36	0.28
	(0.72)	(0.65)	(0.51)
Midwest	-1.01	-0.75	-0.29
	(-1.50)	(-1.56)	(-0.65)
Constant	-2.29**	-1.61**	-2.09**
	(-2.04)	(-1.97)	(-2.51)
Observations		372	

Notes: Maximum likelihood estimates (robust z-statistics) of parameters in the multinomial logit model for the USA, base category: neither carbon offsetting nor price premium. * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level.

Table 22: Descriptive statistics

Variables	Germany			USA		
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation
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
Buying energy-efficient appliances	969	0.77	0.42	952	0.69	0.46
financial advantages	956	0.62	0.49	914	0.73	0.44
high contribution	966	0.61	0.49	926	0.63	0.48
Saving energy at home	973	0.88	0.33	965	0.80	0.40
financial advantages	956	0.81	0.39	919	0.76	0.43
high contribution	964	0.61	0.49	924	0.61	0.49
Reducing meat or dairy products	964	0.40	0.49	939	0.31	0.46
financial advantages	897	0.37	0.48	833	0.39	0.49
high contribution	948	0.35	0.48	847	0.25	0.43
Using energy from renewable sources	942	0.37	0.48	890	0.23	0.42
financial advantages	879	0.29	0.45	813	0.50	0.50
high contribution	949	0.67	0.47	875	0.60	0.49
Buying a car with lower fuel consumption	929	0.46	0.50	915	0.38	0.48
financial advantages	912	0.61	0.49	877	0.66	0.47
high contribution	956	0.63	0.48	918	0.61	0.49
Reducing car use	805	0.52	0.50	739	0.57	0.50
financial advantages	928	0.62	0.48	896	0.64	0.48
high contribution	958	0.63	0.48	925	0.59	0.49
Reducing flights	547	0.24	0.43	371	0.37	0.48
financial advantages	834	0.56	0.50	805	0.55	0.50
high contribution	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

Notes: Descriptive statistics of dependent and explanatory variables for overall 1,005 observations in Germany and 1,010 observations in the USA

Table 23: Estimation results in binary random effects probit models

Explanatory variables	Germany	USA
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

Notes: Maximum Likelihood estimates (z-statistics) of parameters in binary random effects probit models for Germany and the USA, dependent variable: use of one of the seven pro-environmental activities. * (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level.

Table 24: Estimation results in binary probit models for Germany

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

Notes: Maximum Likelihood estimates (z-statistics) of parameters in binary probit models for Germany, dependent variables: use of one of the seven pro-environmental activities. * (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level.

Table 25: Estimation results in binary probit models for the USA

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

Notes: Maximum Likelihood estimates (z-statistics) of parameters in binary probit models in the USA, dependent variables: use of one of the seven pro-environmental activities. * (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level.

Table 26: Average discrete probability and interaction effects in Germany[i]

Variables and interaction terms	Binary random effects probit model	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	0.06**	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 × 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 × 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 × 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)							

Notes: Estimates (z-statistics) of average discrete probability effects and average interaction effects in Germany. * (**, ***) means that the appropriate effect is different from zero at the 10% (5%, 1%) significance level.

Table 27: Average discrete probability and interaction effects in the USA[i]

Variables and interaction terms	Binary random effects probit model	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 × 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 × 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 × 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)							

Notes: Estimates (z-statistics) of average discrete probability effects and average interaction effects in the USA * (**, ***) 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.

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Table 28: Number of respondents and mean for all variables

Explanatory variables	China		Germany		USA	
	Respondents	Mean	Respondents	Mean	Respondents	Mean
Climate protection	1,418	0.96	982	0.94	975	0.88
Buying energy-efficient appliances	1,413	0.80	969	0.84	952	0.78
Saving energy at home	1,413	0.80	973	0.87	965	0.81
Reducing meat or dairy products	1,400	0.63	964	0.50	939	0.42
Using renewable energy	1,395	0.44	942	0.62	890	0.50
Buying a fuel-efficient car	1,374	0.75	929	0.71	915	0.67
Reducing car use	916	0.77	805	0.62	739	0.62
Reducing flights	1,049	0.66	547	0.36	371	0.47
Adaptation by public authorities	1,390	3.98	889	4.01	747	3.81
Mitigation by public authorities	1,390	4.15	890	4.23	754	3.99
Adaptation	1,416	0.89	977	0.51	965	0.69
Number of adaptation activities	1,315	2.30	820	0.79	807	1.44
Number of climate protection activities	1,347	3.29	890	2.88	829	2.38
Negative consequences	1,387	0.44	879	0.34	725	0.32
Little effort of home country			955	0.38	913	0.45
Little effort of most states			961	0.78	909	0.60
Financial advantages from activity						
Buy energy-efficient appliances	1,419	0.79	966	0.61	926	0.63
Save energy at home	1,404	0.73	956	0.81	919	0.76
Reduce meat or dairy products	1,340	0.43	897	0.37	833	0.39
Use energy from renewable sources	1,340	0.63	879	0.29	813	0.50
Buy a fuel-efficient car	1,348	0.70	912	0.61	877	0.66
Reduce car use	1,340	0.43	897	0.37	833	0.39
Reduce flights	1,331	0.55	834	0.56	805	0.56
High contribution of activity						
Buy energy-efficient appliances	1,402	0.70	956	0.62	914	0.73
Save energy at home	1,418	0.77	964	0.61	924	0.61
Reduce meat or dairy products	1,393	0.42	948	0.35	847	0.25
Use energy from renewable sources	1,406	0.83	949	0.67	875	0.60
Buy a fuel-efficient car	1,406	0.81	956	0.63	918	0.61
Reduce car use	1,393	0.42	948	0.35	847	0.25
Reduce flights	1,394	0.63	944	0.62	854	0.50
No contribution of social environment	1,384	0.24	912	0.19	872	0.29
Expectation of social environment	1,381	0.69	935	0.19	896	0.26
Warm glow	1,398	0.91	957	0.66	934	0.60
Member of communist party	1,430	0.30				
Being conservative			954	0.24	940	0.41
Identifying with green politics			938	0.30	907	0.21
Being liberal			937	0.43	939	0.29
Lack of confidence	1,319	0.49	839	0.78	743	0.83
High individual income	1,369	0.62	827	0.51	872	0.60
Age	1,430	39.26	1,005	41.13	1,010	48.51
Female	1,430	0.50	1,005	0.49	1,010	0.53
Number of own children	1,430	0.86	1,005	0.95	1,010	1.32
Living with a partner	1,420	0.78	1,002	0.63	1,006	0.62
Beijing	1,430	0.15				
Shanghai	1,430	0.16				
Guangzhou	1,430	0.13				
Shenyang	1,430	0.08				
Wuhan	1,430	0.08				
Chengdu	1,430	0.06				
Shijiazhuang	1,430	0.06				
Hefei	1,430	0.06				
Lanzhou	1,430	0.10				
Yinchuan	1,430	0.06				
North			1,005	0.17		
East			1,005	0.20		
South			1,005	0.30	1,010	0.35
West			1,005	0.33	1,010	0.22
Northeast					1,010	0.20
Midwest					1,010	0.23

Table 29: Estimation results for China

Explanatory variables	Binary random effects model and binary probit model		Binary random effects probit models		
	Climate protection activities	Adaptation	Whole sample	If adaptation = 0	If adaptation = 1
Adaptation	2.05***		1.10***		
	(16.04)		(11.87)		
Negative consequences	-0.09	0.09**	-0.08	0.78***	-0.14**
	(-0.99)	(2.18)	(-1.26)	(2.97)	(-2.14)
Financial advantages from activity	0.25***		0.26***	0.02	0.29***
	(3.06)		(6.15)	(0.10)	(6.56)
No contribution of social environment	-0.15		-0.15**	-0.92***	-0.06
	(-1.59)		(-2.35)	(-3.93)	(-0.90)
Expectation of social environment	0.18**		0.19***	-0.08	0.22***
	(2.02)		(2.94)	(-0.37)	(3.36)
Warm glow	0.08		0.09	0.80***	0.04
	(0.68)		(1.09)	(2.85)	(0.45)
High contribution of activity	0.39***		0.40***	0.39**	0.41***
	(4.26)		(8.59)	(2.30)	(8.41)
Lack of confidence	-0.01		-0.01	0.18	-0.00
	(-0.16)		(-0.22)	(1.00)	(-0.06)
Member of communist party	0.13*	0.25***	0.18***	0.16	0.17***
	(1.70)	(6.26)	(3.12)	(0.71)	(2.95)
High individual income	0.02	0.09**	0.04	0.04	0.05
	(0.28)	(2.34)	(0.69)	(0.17)	(0.76)
Highly educated	-0.04	0.18***	-0.01	0.01	0.01
	(-0.41)	(4.25)	(-0.07)	(0.03)	(0.09)
Age	-0.00	0.00***	-0.00	0.01	-0.01**
	(-1.22)	(2.65)	(-1.33)	(0.75)	(-2.06)
Female	0.04	-0.06*	0.03	-0.12	0.04
	(0.57)	(-1.81)	(0.65)	(-0.64)	(0.79)
Number of own children	0.12*	0.17***	0.14***	0.74***	0.11**
	(1.69)	(4.21)	(3.04)	(3.76)	(2.35)
Living with a partner	0.03	-0.05	0.03	-1.08***	0.13
	(0.24)	(-0.82)	(0.42)	(-3.88)	(1.62)
Shanghai	-0.15	0.09	-0.14	0.08	-0.17*
	(-1.15)	(1.43)	(-1.47)	(0.27)	(-1.74)
Guangzhou	-0.19	0.13**	-0.18*	0.32	-0.20**
	(-1.39)	(2.03)	(-1.78)	(0.89)	(-2.02)
Shenyang	-0.17	0.13*	-0.16	-0.06	-0.16
	(-1.07)	(1.78)	(-1.41)	(-0.15)	(-1.40)
Wuhan	-0.08	0.01	-0.09	-0.14	-0.10
	(-0.47)	(0.10)	(-0.71)	(-0.30)	(-0.78)
Chengdu	0.12	0.13	0.14	0.96**	0.02
	(0.69)	(1.62)	(1.11)	(2.21)	(0.14)
Shijiazhuang	-0.11	0.34***	-0.07	-0.17	-0.12
	(-0.66)	(3.75)	(-0.54)	(-0.39)	(-0.97)
Hefei	-0.20	0.26***	-0.17	0.03	-0.24*
	(-1.14)	(2.98)	(-1.37)	(0.06)	(-1.90)
Lanzhou	-0.09	0.01	-0.09	0.23	-0.16
	(-0.61)	(0.11)	(-0.83)	(0.71)	(-1.41)
Yinchuan	-0.09	0.50***	-0.03	0.19	-0.04
	(-0.53)	(5.13)	(-0.24)	(0.37)	(-0.37)
Quanzhou	-0.17	0.27***	-0.13	-0.63	-0.09
	(-0.95)	(3.14)	(-0.99)	(-1.15)	(-0.72)
Constant	-2.11***	0.54***	-1.41***	-2.41***	-0.23
	(-8.47)	(5.88)	(-7.91)	(-4.08)	(-1.41)
Number of observations	9,373	9,373	7,735	671	7,064
Number of respondents			1,224	115	1,109

Notes: Simulated maximum likelihood and maximum likelihood estimates (z-statistics) of the parameters for China. Parameter estimates of dummy variables for single activities are not reported. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

Table 30: Estimation results for Germany

Explanatory variables	Binary random effects model and binary probit model		Climate protection activities in binary random effects probit models		
	Climate protection activities	Adaptation	Whole sample	If adaptation = 0	If adaptation = 1
Adaptation	1.04***		0.45***		
	(13.40)		(6.86)		
Negative consequences	0.08	0.02	0.09	-0.04	0.15
	(0.62)	(0.35)	(0.89)	(-0.27)	(1.15)
Little effort of home country	0.06	0.12***	0.09	0.09	0.09
	(0.75)	(3.00)	(1.33)	(0.78)	(1.05)
Little effort of most states	0.06	0.06	0.08	0.27**	-0.09
	(0.58)	(1.28)	(0.91)	(1.99)	(-0.86)
Financial advantages from activity	0.40***		0.42***	0.59***	0.32***
	(5.04)		(7.41)	(6.66)	(4.27)
No contribution of social environment	-0.19*		-0.20**	-0.45***	-0.02
	(-1.89)		(-2.39)	(-3.49)	(-0.15)
Expectation of social environment	-0.03		-0.03	0.12	-0.07
	(-0.29)		(-0.35)	(0.90)	(-0.73)
Warm glow	0.27***		0.28***	0.31***	0.25***
	(2.97)		(3.70)	(2.59)	(2.63)
High contribution of activity	0.38***		0.40***	0.27***	0.48***
	(4.56)		(6.71)	(2.92)	(6.10)
Lack of confidence	-0.03		-0.03	-0.03	-0.03
	(-0.52)		(-0.67)	(-0.42)	(-0.57)
Being conservative	-0.14	-0.02	-0.15**	-0.02	-0.26***
	(-1.54)	(-0.45)	(-1.99)	(-0.18)	(-2.72)
Identifying with green politics	0.17*	-0.05	0.16**	0.13	0.15
	(1.88)	(-1.33)	(2.21)	(1.16)	(1.64)
Being liberal	0.08	0.02	0.09	0.17*	0.02
	(1.06)	(0.67)	(1.40)	(1.72)	(0.20)
High individual income	-0.02	0.39***	0.07	-0.01	0.10
	(-0.28)	(9.63)	(1.03)	(-0.06)	(1.09)
Highly educated	0.07	-0.00	0.07	0.05	0.06
	(0.84)	(-0.01)	(1.06)	(0.50)	(0.65)
Age	0.01	0.01***	0.01**	0.01	0.01**
	(1.44)	(5.52)	(2.51)	(1.40)	(2.22)
Female	-0.01	0.24***	0.05	0.05	0.09
	(-0.08)	(6.21)	(0.78)	(0.48)	(1.00)
Number of own children	0.01	-0.02	0.01	-0.02	0.03
	(0.34)	(-1.29)	(0.25)	(-0.44)	(0.77)
Living with a partner	0.11	0.23***	0.18**	0.12	0.27***
	(1.33)	(5.79)	(2.50)	(1.08)	(2.86)
North	0.01	0.27***	0.08	-0.05	0.17
	(0.12)	(4.95)	(0.85)	(-0.31)	(1.43)
East	0.09	0.12**	0.12	0.20	0.06
	(0.86)	(2.44)	(1.40)	(1.53)	(0.51)
South	0.03	0.20***	0.08	-0.04	0.19*
	(0.28)	(4.46)	(0.96)	(-0.33)	(1.79)
Constant	-1.72***	-0.95***	-1.71***	-1.52***	-1.39***
	(-6.80)	(-9.40)	(-8.61)	(-4.81)	(-5.47)
Number of observations	5,047		3,644	1,654	1,990
Number of respondents			592	270	322

Notes: Simulated maximum likelihood and maximum likelihood estimates (z-statistics) of the parameters for Germany. Parameter estimates of dummy variables for single activities are not reported. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

Table 31: Estimation results for the USA

Explanatory variables	Binary random effects model and binary probit model		Climate protection activities in binary random effects probit models		
	Climate protection activities	Adaptation	Whole sample	If adaptation = 0	If adaptation = 1
Adaptation	1.87***		1.32***		
	(10.87)		(11.35)		
Negative consequences	-0.19	0.42***	-0.10	0.22	-0.23*
	(-1.15)	(9.88)	(-0.91)	(0.91)	(-1.86)
Little effort of home country	0.17	-0.04	0.17	0.61**	0.04
	(0.94)	(-0.91)	(1.45)	(2.06)	(0.36)
Little effort of most states	0.04	0.08*	0.06	0.18	-0.05
	(0.23)	(1.80)	(0.52)	(0.68)	(-0.41)
Financial advantages from activity	0.75***		0.78***	0.66***	0.79***
	(4.88)		(9.94)	(4.11)	(8.78)
No contribution of social environment	-0.06		-0.06	-0.22	0.07
	(-0.38)		(-0.55)	(-0.86)	(0.59)
Expectation of social environment	0.03		0.04	-0.94***	0.26**
	(0.20)		(0.32)	(-3.10)	(2.06)
Warm glow	-0.11		-0.11	0.12	-0.22
	(-0.55)		(-0.89)	(0.42)	(-1.58)
High contribution of activity	0.20		0.21**	0.25	0.19**
	(1.17)		(2.50)	(1.35)	(1.97)
Lack of confidence	-0.12		-0.13*	-0.07	-0.19**
	(-1.15)		(-1.79)	(-0.50)	(-2.26)
Being conservative	-0.16	0.22***	-0.12	-0.10	-0.16
	(-1.10)	(5.17)	(-1.21)	(-0.42)	(-1.36)
Identifying with green politics	0.31	0.57***	0.42***	0.43	0.33**
	(1.56)	(9.75)	(3.26)	(1.24)	(2.39)
Being liberal	-0.23	-0.02	-0.23**	-0.11	-0.28**
	(-1.32)	(-0.51)	(-2.04)	(-0.42)	(-2.20)
High individual income	-0.09	-0.00	-0.10	-0.29	-0.08
	(-0.64)	(-0.06)	(-0.97)	(-1.31)	(-0.71)
Highly educated	-0.12	0.38***	-0.05	-0.00	-0.01
	(-0.74)	(8.78)	(-0.41)	(-0.02)	(-0.11)
Age	-0.00	0.01***	0.00	0.02**	-0.00
	(-0.12)	(8.88)	(0.52)	(2.17)	(-0.14)
Female	-0.02	0.11***	-0.00	-0.19	-0.00
	(-0.16)	(2.58)	(-0.01)	(-0.86)	(-0.02)
Number of own children	0.03	-0.03*	0.02	0.03	0.01
	(0.53)	(-1.95)	(0.63)	(0.41)	(0.28)
Living with a partner	0.20	0.04	0.21**	0.31	0.17
	(1.32)	(0.98)	(2.01)	(1.36)	(1.46)
West	0.50***	-0.41***	0.44***	0.12	0.54***
	(2.64)	(-7.64)	(3.26)	(0.42)	(3.50)
Midwest	0.03	-0.05	0.02	0.03	-0.01
	(0.15)	(-1.01)	(0.14)	(0.10)	(-0.07)
Northeast	0.17	-0.08	0.16	0.13	0.16
	(0.89)	(-1.47)	(1.20)	(0.47)	(1.10)
Constant	-2.21***	-0.77***	-2.13***	-2.83***	-0.51*
	(-5.56)	(-8.00)	(-8.24)	(-5.35)	(-1.78)
Number of observations	4,837		3,063	874	2,189
Number of respondents			517	150	367

Notes: Simulated maximum likelihood and maximum likelihood estimates (z-statistics) of the parameters for the USA. Parameter estimates of dummy variables for single activities are not reported. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

Table 32: Estimation results in bivariate ordered probit models for China

Explanatory variables	Adaptation		Climate protection	
Adaptation	0.11		-0.10	
	(0.99)		(-0.89)	
Climate protection	0.03		0.44**	
	(0.19)		(2.55)	
Number of adaptation activities		0.04		-0.08**
		(1.37)		(-2.35)
Number of pro-environmental activities		0.00		0.10***
		(0.09)		(3.25)
Negative consequences from climate change	-0.40***	-0.43***	-0.08	-0.13
	(-4.74)	(-4.99)	(-0.98)	(-1.56)
No contribution of social environment	0.04	0.02	-0.13*	-0.17**
	(0.55)	(0.19)	(-1.71)	(-2.13)
Expectation of social environment	0.33***	0.30***	0.24***	0.21**
	(4.24)	(3.74)	(3.05)	(2.48)
Warm glow	0.36***	0.33***	0.42***	0.39***
	(3.75)	(3.20)	(4.32)	(3.78)
Lack of confidence	-0.08	-0.09	-0.10*	-0.11*
	(-1.48)	(-1.59)	(-1.78)	(-1.84)
Member of communist party	0.17**	0.20***	0.11	0.10
	(2.56)	(2.99)	(1.52)	(1.34)
High individual income	0.14*	0.16**	-0.02	0.01
	(1.87)	(2.09)	(-0.31)	(0.11)
Highly educated	-0.23**	-0.21**	0.03	0.05
	(-2.47)	(-2.15)	(0.27)	(0.49)
Age	0.00	0.00	-0.00	-0.00
	(0.52)	(0.48)	(-0.16)	(-0.26)
Female	0.03	0.02	0.02	0.03
	(0.50)	(0.37)	(0.35)	(0.38)
Number of own children	0.15**	0.15**	0.06	0.05
	(2.49)	(2.35)	(1.00)	(0.77)
Living with a partner	-0.12	-0.16	-0.08	-0.12
	(-1.22)	(-1.56)	(-0.87)	(-1.17)
Shanghai	-0.27**	-0.35***	-0.10	-0.13
	(-2.28)	(-2.87)	(-0.81)	(-0.98)
Guangzhou	-0.10	-0.13	-0.17	-0.20*
	(-0.79)	(-0.97)	(-1.44)	(-1.68)
Shenyang	-0.13	-0.15	-0.29**	-0.32**
	(-0.89)	(-0.96)	(-2.07)	(-2.17)
Wuhan	-0.24*	-0.27*	-0.38**	-0.37**
	(-1.69)	(-1.77)	(-2.43)	(-2.21)
Chengdu	-0.21	-0.27*	-0.05	-0.05
	(-1.38)	(-1.74)	(-0.33)	(-0.34)
Shijiazhuang	-0.13	-0.14	-0.07	-0.06
	(-0.86)	(-0.90)	(-0.42)	(-0.34)
Hefei	-0.23	-0.25	-0.16	-0.19
	(-1.51)	(-1.60)	(-1.16)	(-1.31)
Lanzhou	0.05	0.05	0.08	0.05
	(0.40)	(0.40)	(0.58)	(0.39)
Yinchuan	-0.12	-0.11	0.13	0.15
	(-0.86)	(-0.76)	(0.88)	(1.01)
Quanzhou	-0.39**	-0.39**	-0.12	-0.09
	(-2.48)	(-2.33)	(-0.70)	(-0.50)
Number of respondents	1,206	1,134	1,206	1,134

Notes: Maximum likelihood estimates (z-statistics) of the parameters in bivariate ordered probit models for China. The dependent variable is the respondents' assessment of how strongly adaptation and climate protection should be pursued by public authorities. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

Table 33: Estimation in bivariate ordered probit models for Germany

Explanatory variables	Adaptation		Climate protection	
Adaptation	0.01		0.16	
	(0.06)		(1.48)	
Climate protection	0.55**		0.67***	
	(2.55)		(3.00)	
Number of adaptation activities		-0.05		-0.03
		(-0.90)		(-0.47)
Number of pro-environmental activities		0.09*		0.14***
		(1.78)		(2.84)
Negative consequences from climate change	-0.25	-0.31	0.82***	0.49**
	(-1.02)	(-1.26)	(3.85)	(2.30)
Little effort of home country	-0.11	-0.11	0.28**	0.22*
	(-1.08)	(-0.99)	(2.54)	(1.85)
Little effort of most states	0.23*	0.18	0.54***	0.55***
	(1.73)	(1.23)	(3.93)	(3.76)
No contribution of social environment	-0.23*	-0.08	-0.27*	-0.29*
	(-1.88)	(-0.64)	(-1.93)	(-1.94)
Expectation of social environment	0.06	0.03	0.09	0.03
	(0.43)	(0.23)	(0.66)	(0.23)
Warm glow	0.00	-0.04	0.40***	0.33***
	(0.03)	(-0.29)	(3.59)	(2.68)
Lack of confidence	-0.20***	-0.24***	-0.23***	-0.26***
	(-2.84)	(-3.27)	(-3.19)	(-3.38)
Being conservative	0.09	0.08	-0.10	-0.04
	(0.84)	(0.69)	(-0.89)	(-0.30)
Identifying with green politics	-0.07	-0.16	0.30**	0.27**
	(-0.62)	(-1.34)	(2.50)	(2.14)
Being liberal	0.05	0.02	0.11	0.08
	(0.54)	(0.20)	(1.08)	(0.66)
High individual income	-0.16	-0.21*	-0.30**	-0.28**
	(-1.57)	(-1.86)	(-2.54)	(-2.23)
Highly educated	-0.12	-0.11	-0.06	-0.06
	(-1.13)	(-0.93)	(-0.54)	(-0.53)
Age	0.01**	0.01**	-0.00	-0.00
	(1.98)	(1.99)	(-0.27)	(-0.13)
Female	0.29***	0.23**	-0.08	-0.12
	(2.87)	(2.10)	(-0.74)	(-1.01)
Number of own children	-0.03	-0.03	0.03	0.01
	(-0.52)	(-0.63)	(0.48)	(0.23)
Living with a partner	-0.01	-0.12	0.12	0.13
	(-0.07)	(-0.99)	(1.11)	(1.11)
North	0.13	0.17	-0.03	0.00
	(0.96)	(1.12)	(-0.20)	(0.01)
East	0.15	0.26*	0.11	0.16
	(1.20)	(1.86)	(0.82)	(1.14)
South	0.05	0.18	0.17	0.17
	(0.38)	(1.39)	(1.26)	(1.17)
Number of observations	544	458	544	458

Notes: Maximum likelihood estimates (z-statistics) of the parameters in bivariate ordered probit models for Germany. The dependent variable is the respondents' assessment of how strongly adaptation and climate protection should be pursued by public authorities. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

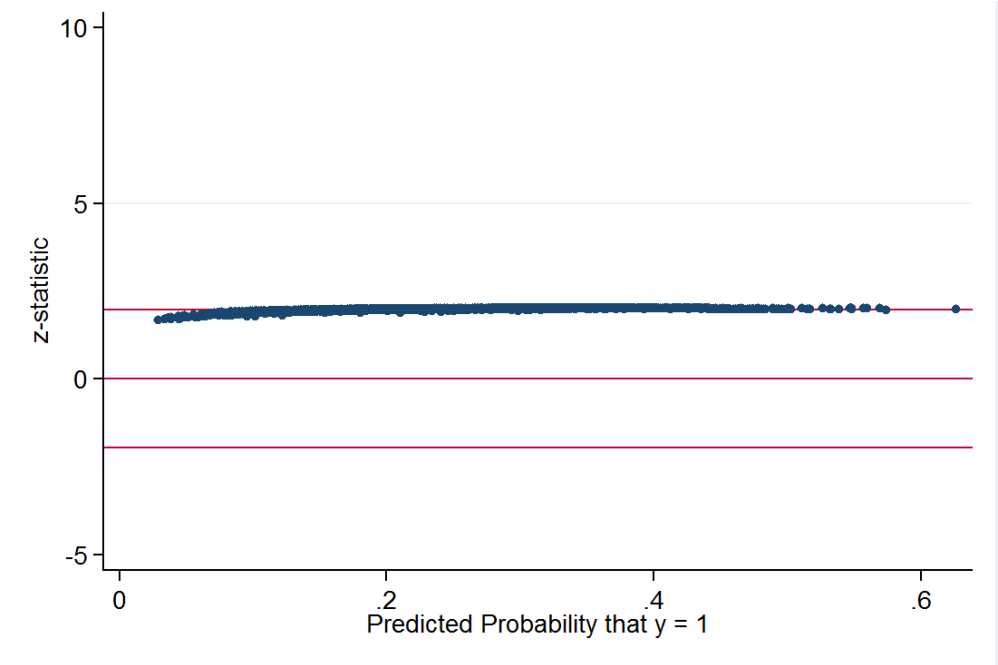
Table 34: Estimation results in bivariate ordered probit models for the USA

Explanatory variables	Adaptation		Climate protection	
Adaptation	-0.01		-0.00	
	(-0.04)		(-0.01)	
Climate protection	0.09		0.39*	
	(0.48)		(1.95)	
Number of adaptation activities		0.09		0.04
		(1.61)		(0.73)
Number of pro-environmental activities		-0.05		0.06
		(-0.92)		(1.10)
Negative consequences from climate change	-0.26*	-0.22	-0.06	-0.05
	(-1.86)	(-1.52)	(-0.39)	(-0.30)
Little effort of home country	-0.00	0.06	0.14	0.20
	(-0.00)	(0.42)	(1.01)	(1.32)
Little effort of most states	0.39***	0.36**	0.51***	0.43***
	(2.91)	(2.48)	(3.62)	(2.87)
No contribution of social environment	-0.10	-0.05	-0.28**	-0.26*
	(-0.69)	(-0.32)	(-2.06)	(-1.75)
Expectation of social environment	0.10	0.04	-0.07	-0.04
	(0.70)	(0.29)	(-0.50)	(-0.26)
Warm glow	0.41***	0.35**	0.69***	0.77***
	(3.15)	(2.53)	(4.99)	(5.36)
Lack of confidence	0.07	0.06	-0.20**	-0.19**
	(0.84)	(0.60)	(-2.42)	(-2.20)
Being conservative	0.03	0.06	-0.05	-0.03
	(0.26)	(0.48)	(-0.37)	(-0.22)
Identifying with green politics	0.12	0.13	0.34**	0.18
	(0.77)	(0.72)	(2.09)	(0.94)
Being liberal	0.28**	0.32**	0.24*	0.25*
	(2.20)	(2.31)	(1.78)	(1.70)
High individual income	0.08	0.03	0.17	0.20
	(0.65)	(0.19)	(1.37)	(1.58)
Highly educated	0.13	0.23*	-0.06	-0.01
	(1.01)	(1.66)	(-0.43)	(-0.05)
Age	0.01	0.01	0.01	0.01
	(1.41)	(1.56)	(1.29)	(1.21)
Female	0.20*	0.19	0.15	0.19
	(1.72)	(1.53)	(1.35)	(1.55)
Number of own children	-0.10**	-0.11***	-0.02	-0.05
	(-2.43)	(-2.73)	(-0.48)	(-1.10)
Living with a partner	-0.00	-0.05	-0.16	-0.24*
	(-0.00)	(-0.40)	(-1.30)	(-1.77)
West	-0.04	-0.05	-0.17	-0.18
	(-0.24)	(-0.30)	(-1.11)	(-1.07)
Midwest	-0.16	-0.23	-0.14	-0.19
	(-1.11)	(-1.47)	(-0.91)	(-1.13)
Northeast	0.08	0.07	0.18	0.16
	(0.51)	(0.45)	(1.14)	(0.95)
Number of observations	412	353	412	353

Notes: Maximum likelihood estimates (z-statistics) of the parameters in bivariate ordered probit models for the USA. The dependent variable is the respondents' assessment of how strongly adaptation and climate protection should be pursued by public authorities. * (**, ***) means that the parameter is different from zero at the 10% (5%, 1%) significance level.

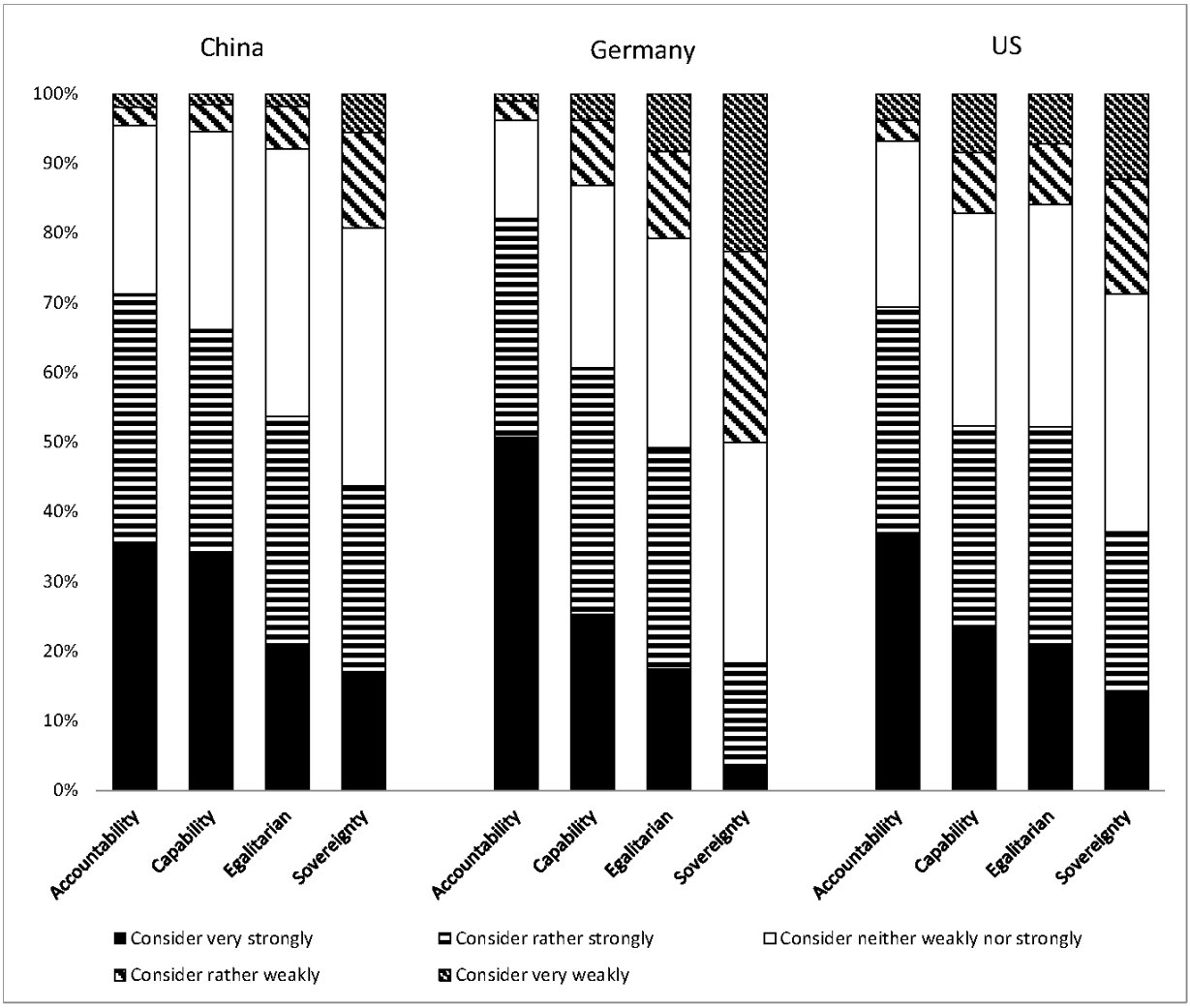
Appendix B: Figures

Figure 2: Z-statistics of interaction effects



Notes: Single z-statistics for the interaction effect between the variables highly educated and very well informed across all 3232 observations with different estimates of probabilities in the binary probit model, dependent variable: tourism-related adaptation to climate change

Figure 3: Perceptions of distributive justice principles across countries



Notes: Shares per answer category in % of total

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