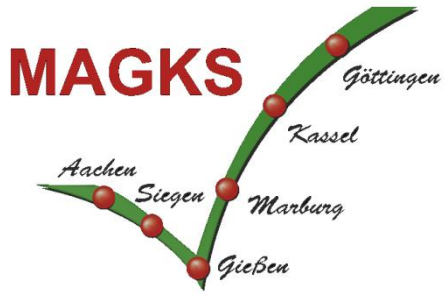

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July 2013

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Abstract

This paper empirically analyzes the determinants of individual tourism-related adaptation to climate change, i.e. the stated choice of alternative travel destinations due to increasing temperatures in the future. 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 micro-econometric analysis with binary probit models implies strong positive effects of a high awareness of climate change effects, increasing age as indicator for vulnerability of climate change, as well as a high adaptive capacity (measured by disposable financial resources) on this type of adaptation. The estimation results suggest no single significant effect of a high educational level or a high level of information on adaptation to climate change, but a positive interaction effect (which was, in contrast to former studies, estimated according to Ai and Norton 2003 and Norton et al. 2004). 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, micro-econometric analysis

JEL: Q54, Q58

1. Introduction

Climate change is in the meantime mostly considered as scientifically proven due to the observation of increased global average surface and ocean temperatures, widespread melting of snow and ice, and the rising global mean sea level (e.g. IPCC AR4 WGI 2007). 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 academic attention. The corresponding 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 Constello 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 et al. (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 an adaptation 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 van den 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 AR4 WGII (2007), the tourism industry is a sector which is likely to see substantial demand shifts due to the impacts of climate change. Therefore, 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). In the European Union (EU) the tourism industry generated in 2011 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 (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 AR4 WGII 2007; UNWTO et al. 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. Concerning 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 than 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. European Commission 2012). Furthermore, in 2011 German households have 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 particularly the determinants of tourism-related adaptation to climate change, which is measured by the stated choice of alternative travel destinations in the future due to increasing temperatures in the holiday region. Our micro-econometric 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, the vulnerability of climate change, and the adaptive capacity to cope with the impacts of global warming. 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 develops the hypotheses for our empirical analysis. Section 3 presents the data and the variables in our micro-econometric analysis. Section 4 discusses the estimation results and the final Section 5 draws some conclusions.

2. Background and hypotheses

The tourism industry is highly sensitive to the impacts of climate change (e.g. Aguiló et al. 2005; IPCC AR4 WGII 2007; 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 generally 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 AR4 WGII 2007; 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 AR4 WGII 2007; 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 due to rising temperatures (e.g. European Environment Agency 2005).

Although the overall effects of climate change on global tourism demand and therefore the economic consequences for the worldwide 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. In contrast, 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 AR4 WGII 2007; UNWTO et al. 2008; Scott et al. 2012).

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 AR4 WGII 2007; Hisali et al. 2011). Furthermore, adaptation measures are supposed to reduce the sensitivity to climate

change, alter the exposure to climate change, and increase the resilience or adaptive capacity to cope with the consequences of global warming (e.g. Yohe and Tol 2002). With respect to the determinants of tourism-related adaptation to climate change, we follow 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 van den Berg 2012) in order to make the results of our empirical study comparable to other analyses. Against this background, we consider four main groups of determinants of adaptation activities: Awareness of climate change effects, general risk aversion, vulnerability of climate change, and adaptive capacity.

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 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 AR4 WGII 2007). Accordingly, with increasing sensitivity and decreasing uncertainty about the (negative) consequences of climate change the propensity of households for adaptation activities in general and thus for tourism-related adaptation to climate change should increase. Therefore, 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). 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, besides 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 and destination loyalty are 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 the empirical analysis:

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

According to the definition of the IPCC AR4 WGII (2007), vulnerability is the degree to which a system or, as in our case, a household is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is therefore a function of the extent of climate change and variation to which a household is exposed. Yohe and Tol (2002) identify adaptation as a function of adaptive capacity and vulnerability, whereat vulnerability is defined as a function of the sensitivity and exposure of the household. Sensitivity and exposure reflect the likelihood that a household is affected (either adversely or beneficially) by the consequences of global warming (e.g. IPCC AR4 WGII 2007). While exposure refers to the degree to which a household experiences stress due to the effects of global warming, sensitivity refers to the degree to which the household is affected by that exposure such as differences in sensitivity to heat waves across age groups or populations with differing access to air conditioning (e.g. Mastrandrea et al. 2010). Certain groups of people are 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 (e.g. Bartlett 2008). Additional vulnerability of climate change arises 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 the empirical analysis:

Hypothesis 3: Tourists with a higher vulnerability of climate change are more likely to adapt their travel behavior due to global warming.

The ability to adjust to climate change effects in order to reduce potential harm, to take advantage of these changes, or to cope with the consequences is called adaptive capacity (e.g. IPCC AR4 WGII 2007). The adaptive capacity is closely related to other commonly used concepts, like adaptability, coping ability, man-

agement capacity, stability, robustness, flexibility, and resilience (e.g. Smit and Wandel 2006). Adaptive capacity includes all indicators which influence the ability to adjust to new climate conditions (e.g. Smit and Wandel 2006), for example, human capital including education and information as well as the ability of decision makers to manage this information and the availability of resources (e.g. Yohe and Tol 2002; IPCC AR4 WGII 2007). Furthermore, choosing an alternative travel destination is generally associated with transaction costs, for example, in terms of fees for changing the booking. Therefore, households with higher income and particularly wealth (and thus disposable financial resources) could have a higher ability to adapt to climate change. This leads to the following hypothesis that is examined in the empirical analysis:

Hypothesis 4: Tourists with a higher adaptive capacity are more likely to adapt their travel behavior due to global warming.

3. 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. with respect to 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 micro-econometric analysis, the tourists were asked if they think to commonly choose alternative holiday destinations in the future (aside from winter sports journeys) due to increasing temperatures in the holiday region. This 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). Nevertheless, the corresponding variable is naturally a clear indicator 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 choose alternative holiday destinations in the future.

With respect to 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 consequences" 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 global warming 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. Finally, 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 "per-

sonal 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.

The next two groups of explanatory variables (in order to test hypotheses 2 and 3) concern the general risk aversion and the vulnerability of climate change. With respect to risk aversion, we consider 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 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 vulnerability, we consider the variable "age" of the respondent (in years) as perhaps most important indicator, the variable "number of children under 18 years" living in the household of the respondent, and the dummy variable "frequent journeys" that takes the value one if the respondent undertook at least four journeys with a duration of at least two days during the past two years.

With respect to the adaptive capacity as fourth group of explanatory variables (in order to test hypothesis 4), we examine 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 adaptive capacity 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 "highly educated times very well informed" of these two variables 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.

Besides these main explanatory variables, we include several control variables, namely the gender dummy variable "female" that takes the value one if the respondent is a woman, the regional dummy variable "Eastern Germany" that takes the value one if the respondent lives in Eastern Germany, and the occupation dummy variable "full-time employment" that takes the value one if the respondent is full-time employed. Table 1 reports several descriptive statistics (i.e. mean, median, standard deviation, minimum, maximum) for the dependent and the explanatory variables in the micro-econometric analysis. The main result is the fairly high relative frequency of more than 22% of tourists who stated to commonly choose alternative holiday destinations in the future due to increasing temperatures. 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 micro-econometric 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. The corresponding parameters are estimated by the maximum likelihood method (ML) (e.g. Greene 2012). In this respect, we consider heteroscedasticity-robust estimates of the standard deviations of the estimated parameters according to White

(1982) 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 interaction effects (with possible distorted conclusions if only the parameter of the interaction term is interpreted). It should be noted that the number of observations in this micro-econometric analysis decreases to 3217 tourists due to incomplete data for the dependent or the explanatory variables as it is obvious from Table 1. However, the corresponding descriptive statistics for this smaller group of observations are qualitatively almost identical to the values in Table 1 (these values are not reported due to brevity, but are available on request). All calculations and estimations were conducted with the statistical software package STATA.

4. Estimation results

Table 2 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 corresponding 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 times very well informed". The results are divided in five parts. While the first four parts refer to the estimation results for the indicators of the four main groups of explanatory variables, namely the awareness of climate change effects, risk aversion, the vulnerability of climate change, and the adaptive capacity, the fifth part considers the estimation results for the remaining control variables. Concerning the latter group of variables, Table 2 suggests 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).

With respect to the first main group of explanatory variables, 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 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 3, 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 64% from 18.11% if negative consequences of climate change for the living conditions are not expected to 29.79% 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 of adaptation explicitly refers to the stated choice of alternative holiday destinations due to increasing temperatures 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 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 of 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 2, however, no other risk aversion indicator has a single significant effect and no group of risk aversion variables has (on the basis of the results from corresponding Wald tests) a joint significant impact on tourism-related adaptation to climate change.

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 is certainly an indicator for vulnerability of climate change as discussed above, it can also decrease the adaptive capacity by increasing transaction costs of choosing alternative holiday destinations in the future due to increasing temperatures. 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 unambiguous strong positive impact at very low significance levels. The estimated average discrete probability effect implies an increase by 0.23 percentage points for each additional year. According to Table 3, this means that the estimated average probability of this type of adaptation increases from 17.13% for an 18 years old tourist to 32.78% for an 87 years old tourist. Overall, hypothesis 3 can be confirmed for this most important component of vulnerability of climate change.

With respect to the impact of adaptive capacity, the estimation results are 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 (we have also experimented with alternative bounds for the construction of the dummy variable for high income which leads to very similar estimation results), 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 adaptive capacity. Finally, one interesting estimation result refers to our further indicators for adaptive capacity. While a high educational level and a high level of information on possible adaptation activities to climate change do not lead to significant impacts, the average interaction effects of these two variables as well as the single interaction effects for each respondent according to Figure 1 are highly significant. 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 adaptive capacity. 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 adaptive capacity plays an important role so that hypothesis 4 can be confirmed.

5. 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 commonly choose alternative travel destinations in the future due to increasing temperatures in the holiday region. 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. The most favorite holiday destinations of German tourists in 2011 were Spain, Italy, and Turkey with a common market share of nearly 30% (e.g. Deutscher 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 corresponding 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 in response 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 particularly 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 micro-econometric 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 of risk aversion. Instead, age as indicator for vulnerability of climate change, and disposable financial resources as indicator of adaptive capacity 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 has to be supported by a high educational level with respect to tourism-related adaptation to climate change. Methodologically, it should be noted that we consider the consistent estimation of this interaction ef-

fects according to of Ai and Norton (2003) and Norton et al. (2004), which often leads to different results compared with the incorrect analysis of the parameter of the interaction term.

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.

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 our knowledge not available yet so that this analysis is left for future research. Another direction for further research is the analysis not only of German tourists, but an international comparison, for example, across several EU countries. A 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.

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Appendix: Tables and figure

Table 1: Descriptive statistics of the dependent and explanatory variables for overall 5370 observations

Variables	Number of observations (without missings)	Mean	Standard deviation	Minimum	Maximum
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
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
Vulnerability of climate change					
Age	5370	50.63	13.41	18	87
Number of children under 18 years	5316	0.38	0.77	0	5
Frequent journeys	5370	0.66	0.47	0	1
Adaptive capacity					
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

Table 2: ML 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 = 3217

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	0.21**	0.0590**
	(1.96)	(2.11)
Expected negative consequences	0.39***	0.1168***
	(7.76)	(7.86)
Member of environmental organization	0.15**	0.0460**
	(2.08)	(2.01)
Personal experience of heat waves	0.42***	0.1164***
	(6.88)	(7.50)
Personal experience of floods	0.02	0.0045
	(0.30)	(0.30)
Personal experience of heavy rain	-0.01	-0.0025
	(-0.11)	(-0.11)
Personal experience of storms	0.02	0.0063
	(0.32)	(0.32)
Risk aversion		
Risk aversion recreation and sports	0.03	0.0101
	(0.64)	(0.64)
Risk aversion financial investments	0.04	0.0108
	(0.72)	(0.72)
Vulnerability of climate change		
Age	0.01***	0.0023***
	(3.44)	(3.45)
Number of children under 18 years	0.03	0.0092
	(0.89)	(0.89)
Frequent journeys	-0.07	-0.0205
	(-1.27)	(-1.26)
Adaptive capacity		
High household income	-0.04	-0.0127
	(-0.78)	(-0.78)
Disposable financial resources	0.18***	0.0507***
	(2.96)	(3.06)
Highly educated	-0.01	-0.0027
	(-0.17)	(-0.17)
Very well informed	-0.11	-0.0306
	(-0.60)	(-0.62)
Highly educated times very well informed	0.47**	0.1487***
	(1.96)	(5.44)
Control variables		
Female	0.24***	0.0720***
	(4.13)	(4.02)
Eastern Germany	-0.15**	-0.0424**
	(-2.20)	(-2.28)
Full-time employment	-0.01	-0.0025
	(-0.15)	(-0.15)
Constant	-2.02***	
	(-9.72)	

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

Table 3: 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 = 3217

Explanatory variables	Estimates of average probability at minimum value of variable	Estimates of average probability at maximum value of variable
Expectated rising temperature	0.1845	0.2435
Expected negative consequences	0.1811	0.2979
Member of environmental organization	0.2336	0.2796
Personal experience of heat waves	0.1552	0.2716
Age	0.1713	0.3278
Disposable financial resources	0.2024	0.2531
Female	0.2190	0.2911
Eastern Germany	0.2476	0.2052

Figure 1: Single z-statistics for the interaction effect between the variables highly educated and very well informed across all 3217 observations with different estimates of probabilities in the binary probit model, dependent variable: tourism-related adaptation to climate change