FONDAZIONE ENI ENRICO MATTEI

NOTA DI LAVORO

20.2014

Climate Amenities and Adaptation to Climate Change: A Hedonic-Travel Cost Approach for Europe

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Climate Change and Sustainable Development
Series Editor: Carlo Carraro

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Keywords: Climate Change, Hedonic Prices, Travel Cost, Tourism, Europe

JEL Classification: L8, Q5

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This version: 13 December 2013

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Abstract

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1. Introduction

The economic literature has paid growing attention to the economic cost of climate change. Existing studies have generally focused on specific geographical areas and/or on sectors of activity which are deemed to be especially vulnerable to long-run climate variability, see in for instance Mendelsohn et al. (1994), Deschêne and Greenstone (2007), Barrios et al. (2010) and Dell et al. (2012). In principle these losses might be mitigated if economic agents *adapt* their behaviour to minimise the corresponding losses in welfare, especially if climatic conditions were to change dramatically in the coming decades as predicted by the scientific community, see Stern (2008). Ideally the modelling of adaptation strategies should be based on ex-ante observation of agents´ behaviour in order to identify possible variables of adjustment. In this paper we consider the specific case of tourism activities and investigate whether adaptation in tourism demand could eventually mitigate the effect of climatic change on welfare. Tourists make simultaneous decisions regarding their holiday destination and the time spent at these locations depending on the travel cost. The time that can be spent at a given destination is therefore a fundamental attribute of holiday destination choices in Lancaster (1966) sense.[1] One should therefore consider that holiday duration is also likely to be an important variable of adjustment if climate change is to alter regional climatic attributes in a significant way. Time therefore becomes "of the essence" when devising possibly adaptation strategies to climate change, at least in the case of tourism demand. Our analysis focuses on the European case for which we avail of detailed data on climate projections, accommodation and travel costs at a detailed regional level. Our findings suggest that the rise in temperature in preferred destination choices (i.e. southern EU) during the summer season is likely to yield significant welfare losses. We show explicitly that holiday duration can play a non-negligible role in terms of softening such adverse effect of climate change. As a result European tourists, especially those originating from Northern EU countries, are more likely to spend shorter (and more frequent) holidays and to diversify their destination choices in order to mitigate these losses. Our analysis is, to the best of our knowledge the first to consider time as factor of adaptation to climate change at such large geographical scale and based on detailed regional data.

[1] In his seminal contribution Becker (1965) also discusses the value of time as fundamental attribute of consumers´ behaviour. More recently, Connoly (2008) and Graff Zivin and Neidell (2010) provide empirical evidence suggesting that climate change might also alter the allocation of time between leisure and labour supply and bear significant economic consequences.

Climatic conditions represent a key input for the tourism industry and future alterations of these conditions are also likely to lead to non-negligible changes in its structure and performance, see Higham and Hall (2005). In the European case, future climate projections indicate that climatic conditions might become more favourable for tourism in the Northern regions and less so in the Southern regions, especially the Mediterranean regions, see Ciscar et al. (2011). Existing studies usually project a significant deterioration in the suitability of tourism during the summer months (the traditional holiday season in Europe) which would potentially benefit Northern European regions, Hamilton et al. (2005), Lise and Tol (2002), Amelung et al. (2007) and Berrittella et al. (2006).[2] Cross-country tourist flows in Europe have typically originated from the Northern regions towards the Southern regions due to the predominance of sun-related recreational activities, which represent the most common form of tourism.[3] Importantly, the net gains or losses induced by climate variations will depend on tourists´ valuation of climatic-related amenities which are also unlikely to be uniform across EU regions. The differences in climatic conditions between origin and destination regions as well as differences in the level of accessibility of destination regions are likely to lead to heterogeneous adaptation of tourists across EU regions. In particular one would expect inhabitants of Northern EU regions to have a different valuation of climatic conditions compared to their Southern counterparts since the latter generally enjoy more suitable climatic conditions in their region of residence or in neighbouring regions. A change in climatic conditions might in turn be valued differently by Northern and Southern tourists just because sun tourism-related amenities are more difficult to access for the former than for the latter. The adaptation of tourism demand will thus depend very much on the travel cost and the time needed to reach preferred holiday destinations together with other institutional or societal factors.[4]

Our analysis takes explicitly into account the cost of transport between regions of origin and destination. This in turn allows us to reflect possible difference in tourists´ adaptation to potential climate change scenarios depending on the travel cost between origin and destination and thus,

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[2] There are also numerous specific case-studies concerning European regions where site-specific vulnerability to climatic conditions is more easily identified, see, for instance, Maddison (2001), Maddison and Bigano (2003), Harrison et al. (1999) and Perry (2000).

[3] See Eurostat (2012). Our paper focuses on sun tourism which represents around 80% of total tourism activity, see Morris and Walls (2009).We do not consider alternative tourism activities such as winter tourism although this type of activity is also very likely to be altered by climate change.

[4] These other aspects could include for instance institutional arrangements on schools´ calendar year or the rise in age-old population which is less constrained in the timing of holidays. These other aspects are not considered in the study, however.

implicitly, on the relative weight of transport vs. accommodation cost in total tourists´ spending. We estimate hedonic price equations to derive the hedonic price index of tourism services and associated marginal willingness to pay (MWTP) for climatic amenities for each region of origin of tourists following the literature on recreational demand, see in particular Brown and Mendelsohn (1984), Englin and Mendelsohn (1991) and Pendleton and Mendelsohn (2000). Our transport cost estimations are based on the GIS-based model TRANS-TOOLS which covers intermodal transports and which, for the purpose of this study, has been calibrated specifically on tourists´ choices of transport modes and tourism-specific valuation of travel time, see Nielsen and Burgess (2008).[5] The cost of accommodation data are taken from a unique database on hotel prices at regional level obtained from the web hotel booking company hotelscombined. Based on these two sources of information we calculate an average price of tourism services for each region of origin of tourists by adding the average hotel price (at the destination region) to the estimated travel cost (between origin and destination region). In doing so we are therefore able to consider alternative holiday duration by varying the number of nights spent at the holiday destination. Our main results show that the climate dimension plays a significant (economically and statistically) role in explaining hedonic valuations of tourism services. We provide examples showing that the valuation of climate-related amenities also differs markedly depending on the region of origin of tourists and on the time duration of holidays. Using long-run climate model projections we show that potential adaptation in terms of holiday duration might cushion part of the loss in welfare due to climate change. Our results show in particular that European tourists are likely to prefer shorter holiday duration as a result of the global rise in temperatures. The rest of the paper is organised as follows. Section 2 describes our hedonic price model while Section 3 present the results of the hedonic price estimations. In Section 4 we analyse the possible adaptation responses to long-run climate change while Section 5 concludes.

2. The Hedonic price model

2.1 Model specification

Our approach follows the travel cost approach and hedonic valuation of recreational demand and related amenities, see in particular Brown and Mendelsohn (1984) and more recently Riera Font (2000) for an application in the case of tourism demand. Our aim is to analyse the correlation

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[5] In a recent contribution Cullinan (2011) develops a travel-cost spatial microsimulation model for modelling recreational demand in the West of Ireland also using GIS-based travel cost estimates.

between climatic conditions and the cost of holidays, which includes the accommodation cost (represented by the average hotel price in the region of destination) and the transport cost (represented by the bilateral transport cost estimated by the TRANS-TOOLS model). Using data on hotel price and estimated travel cost we can construct a variable measuring the cost of tourism services which embeds these two dimensions of the cost of holiday into one single indicator. Hence the cost of tourism services *Z* is defined as:

$$Z_j^i = P_j + t_{i,j} \tag{1}$$

where *i* and *j* denote, respectively, the regions of origin and destination of tourists, P_j is the average one-night hotel price in destination region *j* and $t_{i,j}$ is the average transport cost from region *i* to region *j*. The price estimated is therefore the sum of the travel time cost from the region of origin to the region of destination and of the accommodation cost represented by the price of a standard bedroom hotel in the destination region. We do not consider the cost of auxiliary goods linked to holiday stays (i.e. food, on-site transport cost, local recreational activities prices, etc.) as these are not available on a comparable basis across EU regions. These other aspects are considered separately through several control variables as will be explained below. Following the literature on recreational demand we estimate a separate regression for each region of origin, see Brown and Mendelsohn (1983). Therefore we assume that all tourists originating from a given origin region face similar travel cost in order to get to a specific destination region. The equation estimated is:

$$Z_j^i = \beta \cdot D \cdot C_j + \alpha \cdot X_j + \varepsilon_j \tag{2}$$

where *D* is a set of month-specific dummy variables interacted with a set of region-j specific climate variables C_j. The term X_j represents a set of non-climatic control variables, β and α are vectors of estimated elasticities specific to the interaction between the monthly dummies and the set of climatic variables, while ε is an error term which is assumed to have the usual independent and identically distributed (*iid)* properties. The elements of β are therefore represented by the month-specific elasticities estimated for each climatic variable. The set of climatic variables considered here includes temperature, wind speed, humidity and precipitation. The coefficients β can be interpreted as the *marginal willingness to pay* (MWTP) indicating the supplement (in percentage) an average tourist originating from a region *i* is willing to pay for a given percentage change in one specific climatic variable and for a given month. Since the equation (2) is estimated for each of the EU 285 regions of origin considered and four different holiday duration (i.e. one day, four -day, one week and two weeks), we thus obtain a set of 4 x 12 x 285 = 13680 monthly MWTPs for each climatic variables considered in the hedonic price equations.

A number of econometric issues arise when estimating such hedonic price equation. We only discuss some of these issues briefly. Usually economists assume that consumers´preferences are unobservable and that the prices observed indirectly reflect these preferences through the interplay of demand supply of tourism services. As noted by a number of authors, identification in estimating hedonic price functions is largely the result of considering Rosen (1974) framework second stage regression in terms of equating marginal cost and marginal utility derived from the consumption of a given amenity, see for instance Bishop and Timmins (2011) for a discussion. Because marginal prices are implicit rather than explicit the estimation of such model can become especially intricate. As suggested by Epple (1987), "*hedonic models raise identification and estimation issues beyond those normally confronted in simultaneous models*". In the context of the present study we do not elaborate on the logic of the demand-supply equilibrium which inherently leads to difficulties with the identification problem, see Ekeland et al. (2002). Another possible issue when estimating hedonic prices is the potential presence of spatial correlation which may lead to biased estimates when OLS is used. Such an issue has attracted attention recently in the hedonic and environment literature, see for instance Won Kim et al. (2003) and Maddison and Bigano (2003). In both cases the estimators used with a simple OLS regression might lead to biased estimates. The spatial dependence may appear in two forms. It can affect the estimated MWTPs directly and it can also affect the error term in the regression if the tourism price variable is influenced in some way by the spatial dimension. On the one hand, regions located nearby are more likely to offer similar climatic conditions. As a matter of fact tourism activities tend to be spatially clustered, especially when it comes to sun-tourism with location-specific attributes (e.g. beaches). It follows that *geographical distance* may be an important driver of spatial correlation and this might affect the coefficients estimated for the climatic explanatory variables. However, some distant regions may also offer similar level of climatic amenities, e.g. a Spanish and a Turkish region with Mediterranean climate but located far away. As a consequence, the geographical distance might not necessarily be the right spatial weight to be used, as it is usually done in the spatial econometrics literature see, for instance, Anselin et al. (2004). Since we use an origin to destination specification, two regions located far from each other (e.g. Turkish and Spanish coastal regions) can in fact be considered as close substitute for tourism destination if they offer similar level of amenities, in particular regarding weather conditions and if the transport cost with main origin regions (e.g. German or British regions) is similar. The degree of substitution is also likely to rise with the decrease in transport costs, especially with the development of charter-all included flights or low-cost air carriers. In such case the *cost of transport* rather than the *geographical distance* between regions of origin and region of destination is likely to be a more appropriate weight to correct for spatial correlation either in the explanatory variable or in the residuals. While the potential existence of spatial correlation might be relevant, we do not explicitly deal with it in the present study in order to keep it relatively short. In fact, dealing with spatial correlation issues would require using distance and possible travel-time matrices for all the 285 regions on a monthly basis would make such an exercise intractable and not really necessary for the purpose of the study. Instead our estimations take into account the transport cost directly to construct the dependent variable as described in (1) in order to consider possibly variation in the relative weight of travel cost on total holiday cost depending on the holiday duration.

It is important to note that our hedonic price regressions cover only two years of data, i.e., 2010 and 2011 due to the availability of hotel price data for these years. Our regression can thus be considered as being of a cross-section nature. Such an approach is similar to the one adopted by Mendelsohn et al. (1994) and Albouy et al. (2013). In fact, unless one avail of data covering extreme weather events such as the hot summer of 2003 in Europe or the 2006 US heat wave covered in Graff and Neidell (2010) it is unlikely that even panel estimation would provide a better approximation of the MWTP. By running estimations over a two-year period and using monthly data we are able to capture the specific characteristics of the summer months, i.e. when sun-tourism is predominant in Europe, and their distinctive implications for holiday cost. Our estimates thus reflect of the seasonal nature of tourism, especially with regards to accommodation and travel costs. The following section provides more details on the data used.

2.2 Hotel prices

The data used comes from HotelsCombined (http://www.hotelscombined.com/) online hotel booking company and covers 53211 hotels in 285 EU NUTS2 regions, see Graph 1 for a description of hotels' location across the EU.[6] The hotel prices were made available to us on a monthly basis from January-2010 until August-2011. The data provides average hotel prices per month and city, which we further aggregated to the regional NUTS2 level in order to make it compatible with the available tourism flow data. In addition the data includes information on the number of hotels (covered by the sample) and star-category of the hotel. The original data are available on city-basis (i.e. NUTS3) and includes geographical coordinates of the hotels which we used for calculating weighted average price at NUTS2 level reflective of the geographical sub-regional hotel density based on the Eurostat city-level data. Overall the coverage is fairly good as the HotelsCombined database represents 26.3% of the total number of hotels in Europe when compared to the Eurostat figures for 2010. The coverage is especially good for countries with sizeable sun/beach tourism such as Cyprus (48.1%), Bulgaria (50.1%), Spain (43.7%), Greece (42.6%), Portugal (60.8%) and Croatia (78.7%). Importantly, the hotel prices database is skewed towards tourism-oriented regions and thus does not provide data for all regions (see Map 1). The information contained in the hotel price data was further checked by running simple OLS regression of the level (expressed in log) of each hotel price against the category of the hotel which is represented in the estimation by a set of dummy variables. Table 1 provides these results showing that, as expected, the star-category is a significant determinant of the hotel price which confirms prior expectation. In addition we checked whether hotel prices could possibly display a seasonal pattern. This was checked by running a regression on the hotel price level against a set of dummy variable specific to each month of the year. The results of these estimates displayed in Table 2 show that hotel prices are significantly larger during the summer month, thus reflecting the seasonal nature of hotel pricing. Finally it is important to note that this data is as announced in hotel websites for reservation. Therefore these data do not include price offered in tour-operator packages which may offer further discount. This could possibly result in our hotel price index being biased upward.

2.3 Travel cost estimations

The travel cost estimations used in this paper are obtained from the TRANS-TOOLS (TT) model, which is a European transport network model built upon the air, road, rail and waterways network of

[6] The NUTS (Nomenclature of Territorial Units for Statistics) of the EU statistical office EUROSTAT splits EU countries into sub-regional administrative divisions for statistical purposes. For more information, see http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction.

42 European countries, covering both passenger and freight transport[7]. A detailed explanation of the model can be found in Rich and Mabit (2011). Two key features of TRANS-TOOLS have been adapted in order to reflect tourists´ specific transport cost. First the survey data used to calibrate the model distinguishes tourists´ trip from other types of trip (i.e. business, private and work-commuting trips). Second regional data on hotel bed capacity taken from Eurostat was used to explain potential changes in tourist´ trips between origin and destination regions in order to reflect the pull effect associated to hotel bed capacity. Trans-tools includes both ticket cost and time spent during the entire trip (e.g. including queuing at the airport or train station) and covers all transport modes. The Appendix provides a description of the flowchart of the different building-blocks of TT. A representation of the road network and airports considered is provided in Map 2.

Trans-Tools results have been produced in order to match official transport activity statistics published yearly by the European Commission statistical office Eurostat. The reference year used in the model is 2005.[8] Within each trip purpose, TT follows a traditional 4-step modelling approach: trip generation, trip distribution, trip mode choice and trip route assignment. The trip generation evaluates the transport demand that each zone in the model generates or attracts (at the NUTS3 geographical level) and depends on the socio-economic characteristics of each zone, as well as on their specific economic and industrial structures. The trip distribution reflects the demand for transport between connected zones and depends on trade and travel patterns, as well as on the availability and specific costs of transport between each zone. The transport mode choice depends on the relative costs, speed and capacities of the various alternative means of transport. In the case of holiday trips, these are road (car and bus), railways and airplanes. The route assignment gives for each transport mode the links within the network where transport demand will be distributed and depends on costs, speed and capacities of the available route options. For the tourism trip purpose the main data is taken from the DATELINE survey which covers the holiday trips carried out across Europe in 2002, see Brög et al., (2003). Importantly, TRANS-TOOLS estimates take into account the

[7] TRANS-TOOLS (TOOLS for TRansport Forecasting ANd Scenario testing) has been developed in collaborative projects funded by the European Commission's DG MOVE and the European Commission Joint Research Centre (JRC). The model is owned by the European Commission and is based on IPR-free modules with an open GIS architecture. The JRC hosts the model and applies the model on behalf of the EC to study the impact of transport policies on an EU scale, for instance, to assess the level of congestion and of accessibility and the impact of (the pricing of) transport infrastructure. The concept of the TRANS-TOOLS model was first defined in 2004 and made fully operational after completion in June 2007 of the (funded by the European Union 6th Framework Program) TRANS-TOOLS project. The version 2.5.0 of the model is the one used in this study.

[8] Note that in order to make the travel cost estimates and hotel prices data compatible we deflated the monthly hotel price data in order to express them in 2005 euro values using EUROSTAT tourism monthly price index.

radical change in the air-transport with the entry of low-cost carriers since the early 2000s which are especially relevant for tourism Eurostat data was used to gather information about flights between European airports and local airport information concerning number of departures. Airport web-sites were used to identify connections operated by low budget lines, and add charter flights to tourist areas, see Rich et al. (2009) for more details.

The modeling of the transportation cost takes into account the frequency, traffic congestion and tourism-specific pattern of travel flows and is made using a nested logit estimation model. The passenger demand model is specific to short-distance movements (below 100km) and long-distance (equal or greater than 100km). The former considers four alternative modes (rail, bus, car passenger and car driver) for a tour *n*, whereas long-distance considers air travel as well. Importantly, each transport mode and destination choice accounts for accessibility linked to induced traffic and thus accounts for seasonal peaks in travel flows which are especially relevant during the summer season. The Appendix 2 provides more details on the different estimation stage and the structure of the Trans-Tools model used to obtain our bilateral transport cost estimates. It is important to note that Trans-Tools provides travel cost estimation at the geographical NUTS3 level. When building our transport cost matrices at NUTS2 level, we thus include the average cost of transport between each EU NUTS2 regions based on the NUTS3 estimates using weighted-population data. This in turn allows us to measure within-NUTS2 transportation cost as an average of the NUTS3 cost estimates in the same way as previously explained for the hotel price data. The Trans-Tools estimated were also adjusted in order to add up to Eurostat country-level totals by origin and destination country. To adjust the national trips with a holiday purpose we have not considered intra-zonal trips (the ones with origin and destination in the same NUTS3 region, assuming that they will not lead to hotel overnights) and have used the ratios for national and international tourism flows available from Eurostat for each country instead (for Cyprus, Malta and Luxembourg we consider intra-zonal trips as they are comprised of only one zone). Once the TT trips are adjusted we aggregate the costs across modes and across the NUTS3 in each NUTS2 region using TT adjusted trips and TT shares across modes, the latter not being affected by the adjustment for a given origin and destination region. Hence, to produce a cost matrix at NUTS2 level we also have to construct a trip matrix at the same level of regional detail and that adds up to Eurostat tourism trips figures based on total number of bednights observed at regional level.

2.3.2 The valuation of tourism services

Before calculating our tourism cost estimator Z_j^i we checked whether the transport cost and hotel price monthly variation displayed specific seasonal pattern. Figure 1 provides selected examples of the evolution of the transport cost and hotel price indicators for four EU regions. We selected two well-known sun-tourism regions, the Málaga province in Spain and the Hersonissos province in Greece and two other regions, South Manchester from the UK and Bielefeld from Germany which are arguably not sun-tourism destinations. As discussed earlier the transport cost is significantly higher than the hotel price given that the transport cost includes a wide range of factors while the hotel price concerns only the average price of a standard-single room in a given destination regions. Hotel prices have a clear seasonal pattern in the two Spanish and Greek regions with peaks during the summer months. The same does not seem to hold for the other two regions considered, namely Bielefeld and South Manchester where no seasonal pattern emerge. The seasonal pattern is also to some extent apparent for the transport cost from the latter two regions to Málaga and Hersonissos, although the time span is maybe too short in order to draw too many conclusions in this respect.[9] Overall, therefore, our indicator on transport cost and holiday price reflect the seasonal nature of tourism demand, especially so in regions traditionally chosen as holiday destination. Figure 2 provides a more general illustration by comparing our tourism cost indicator Z_j^i between two groups of regions: on the one hand the Mediterranean and Adriatic regions which are traditional sun-tourism destinations, and on the other hand the North and Baltic regions. Overall the difference in seasonality appears to be more pronounced when moving from short stays (which in Figure 2 corresponds to the top two panels) to long stays (the two bottom panels). This feature is not surprising to the extent that the accommodation share of the total holiday cost increases for long stays. In addition the cost of holidays tends to be higher for holidays in traditional summer holiday regions when sun-tourism demand reaches its peak. Given the seasonal pattern of holiday cost depicted in Figure 1 and 2 one would expect the tourism cost indicator Z_j^i to reflect the preferences (or marginal willingness to pay) for the climatic conditions prevailing in the regions of destination j for a given region of origin i. The hedonic price estimations presented in the following section attempt to analyse the correlation between the cost of holiday variable depicted in Figure 2 and the climatic conditions in the EU regions.

3 Hedonic price estimations

3.1 Climatic data

[9] Transport costs are in particular more directly affected by other factors such as fuel prices.

The climate scenarios used in this study are based on the EU-financed ENSEMBLES project, see van der Linden and Mitchell (2009).[10] These scenarios and model runs were driven by the SRES A1B emission scenario prepared under the auspice of the Intergovernmental Panel for Climate Change of the United Nations, see Nakicenovic and Swart (2000). The climatic variables were taken from the KNMI-RACMO2-ECHAM5-r3 climatic model run in order to ensure consistency in the geographical breakdown of the climatic data used for the regressions and the long-term projections (running until 2100). The KNMI-RACMO2-ECHAM5-r3 run was preferred over the alternative model/scenarios as it provides a wider set of climatic variables.[11] It is important to note that climate model runs may present significant errors (biases) when compared to real observed data, in particular in the case of temperature and precipitations. Consequently, the climate runs originally obtained from the ENSEMBLES project were corrected for biases in temperature and precipitation by Dosio and Paruolo (2011), and Dosio et al. (2012). Four climatic variables were selected in order to encompass the widest variety of regional climatic conditions deemed to be relevant for tourism demand, namely, the average temperature, precipitations, wind speed and humidity level.[12] Table 3 summarizes the long-term (2100) projection of the temperature variable during the four seasons by broad geographical areas following the grouping used in Ciscar et al. (2011). The projected rise in temperatures affects all geographical areas and seasons. The rise is especially pronounced in relative terms during the winter season, with significantly hotter winters in Central European regions. The summer season is the other season most affected by climatic change. Considering more specifically the traditional sun-tourism season, i.e. the summer season, the rise in temperature is on average above 10%. Long-run temperature projections are typically the most reliable ones in terms of climate, see Dosio and Paruolo (2011) for instance. Our long-run projection will thus be made by considering changes in this variable only while the other climatic variables (i.e. rainfall, windspeed and humidity) will be given their monthly average values of the years 2010-2011, which is the period considered in our baseline results on the hedonic price index.

[10] See http://ensembles-eu.metoffice.com/index.html for a description of the ENSEMBLES project.

[11] Barrios and Ibañez Rivas (2013) provide results considering additional climate and model runs, namely the METO-HC-HadRM3Q0-HadCM3Q0, DMI-HIRHAM5-ECHAM5 and the MPI-REMO-E4 runs from the ENSEMBLES database. Results were are similar to the ones reported here.

[12] Initially the set of climatic variables considered to estimate equation (2) included: maximum daily temperature (°C) minimum daily relative humidity (%) mean daily temperature (°C) mean daily relative humidity (%) Total daily precipitation (mm), total daily hours sunshine, average daily wind speed (in m/s or km/h) and daily afternoon water vapour pressure, Daily mean water vapour pressure. However, since variables enter separately into the regression co-linearity problems forced us to retain only a sub-sample of these variables in the final estimations.

3.2 Control variables used in the estimations

Since we focus on sun tourism we need to control for sun-related amenities and, in particular the availability and quality of bathing sites as sun-tourism is essentially related to water-related activities and bathing in particular. For this reason we include a dummy variable specific to each sea basin and the dominant water type (i.e. lake, river or sea) for bathing in the region of destination given that sun-tourism is mostly associated with bathing and water-related leisure activities, (Source: European Environment Agency). The other non-climatic data used are the longitude and latitude of the destination region, the share of employment in tourism-related services (in % of total employment), the density hotels (per head of population) at the destination region, the level of GDP per capita and variables indicating the availability of transport infrastructure and accessibility.[13] Whenever these data were not available on a regional basis we used country-wide figures instead. A variable concerning the hotel density (per head of population) was also included using EUROSTAT data. The *Hotelscombined* database was used to measure the share of four (or more) -star hotels in the region reflecting the nature of tourism supply. The level of GDP per capita in the destination region to capture indirectly the cost of living in the destination region (measured in PPS, source: Eurostat). The level of transport infrastructure and accessibility is measured by the average distance (in km) to the nearest international airport and the road density measured in km of road per square km.

3.3 Estimation results of Hedonic price equation.

3.3.1 General results

The estimation of Equation (2) is made by region of origin of tourists (i.e. 285 NUTS2 regions) following standard practice for the estimation of recreational demand based on the travel cost approach. For each EU region of origin we therefore observed region-of-destination characteristics regarding their climatic conditions and control for the set of variables described earlier which could also potentially influence tourists´ demand. Each climatic variable is estimated in interaction with a month-specific dummy variable. We include the square term of each climatic variable also interacted with the monthly dummies in order to capture potential non-linearity in the effect of climate on

[13] The sector considered is "Wholesale and retail trade, transport, accommodation, and food services activities" which is the sector most directly linked to the Tourism industry. This data was available at NUTS2 level.

holiday cost.[14] The period covered by the regressions is the 2010-August 2011 period for which the hotel price data was available. The hedonic price equation is estimated for four alternative holiday duration, namely one day, four day, one week and two weeks resulting in 285 x 4=1140 regression runs. Given the very large number of regressions performed a detailed account of each region-specific estimations cannot be provided in a standard way. Table 5 instead provides the (pooled) estimations of the hedonic price for the different holiday duration running these four regressions for all EU regions considered together in order to illustrate the results obtained *on average*. As indicated earlier each climatic variable (i.e. temperature, humidity, precipitations and wind speed) is interacted with a month dummy variable in order to capture the specific seasonal effect of climatic conditions on the marginal willingness to pay (MWTP). The other control variables are included at the bottom of Table 5. The first variable of interest is the temperature variable. As indicated in Table 5, this variable is usually positive and significant for the summer months, thus reflecting the seasonal pattern of holiday choices coinciding with temperature conditions which are appropriate for sun-tourism activities. For the other months the MWTP for temperature is negative (and in many instances significant) excepting in two cases: for the months of May and the two- week duration where it is positive and statistically significant; and the one-day stay during the month of January. The effect of the temperature variable is also negative and significant for the one-day stays and the month of August. This effect could simply reflect the fact that this month is traditionally the month when longer holidays are taken. The full effect of the temperature variable must take into account the possibility of a non-linear impact of this variable, i.e., beyond a given threshold, the effect of an increase in temperature and thus the MWTP for a one-degree temperature rise may change. This effect is indicated by the square terms of the temperature variable interacted with the monthly dummy variables, i.e. the *sq_Temperature* variables in Table 5. These variables appear in most cases to be positive and significant, with a few exceptions. These exceptions are the month of April (for holiday durations of at least two week), May (for holiday durations of at least four days), June (for holiday duration of at least two weeks) and July (for all holiday durations). In order to account for the full effect of the temperature variable one must consider together the coefficient and standard

[14] The non-linear effect is captured by the inclusion of a square term which is arguably the simplest way of capturing non-linearity in estimated coefficients. More sophisticated method could have been used as well such as using higher exponents, spline regressions or even threshold estimators à la Hansen. While these alternative approaches would in principle provide a more refined and maybe more accurate way of capturing non-linearity, we have opted for a more rudimentary approach in order to facilitate interpretation of the results given the very large number of regressions are performed. We leave the use of these alternative approaches to future extensions of this work which could possibly focus on a limited number of regions.

errors estimated for both the linear and non-linear cases. This can be done simply by calculating the full MWTP for temperature for a given month *m* as

$$MWTP_{m} = \beta_{1,m} + 2 * \beta 2_{,m} . \ln(Temperature\_{m}) \qquad (3)$$

Where $\beta_{1,m}$ and $\beta_{2,m}$ are the coefficients estimated on the linear and square terms of the Temperature variable, respectively. The full MWTP depends on the value taken by the Temperature variable. Setting this value at its (monthly) average level of the sample estimate we obtain the following (full) MWTP for the summer months and the holiday durations of one day: 0.2 for June, 0.29 for July and 0.13 for August. How can these results be interpreted? Consider for instance two hypothetical holiday destinations with exactly identical characteristics and differing among them only in terms of average temperature. Let assume for instance that the average temperature is 10% higher in one of these two regions. The above results would indicate that an average tourist would be ready to pay 20% more to take his/her short-term holidays during the month of June in this particular region, 29% more during the month of July and 13% more during the month of August. Considering the same estimations for non-summer months yields different results. For instance, for the month of January one obtains a MWTP of -3%, for the month of April -5% and for the month of October -10%. In these months therefore, the MWTP is negative but also generally lower in absolute terms during the summer months.

Considering the other climatic variables, one can observe that precipitations tend to display a negative MWTP while its square terms display more mixed results with generally lower coefficients in absolute terms. The latter result would suggest that the potential non-linear effect of this variable is less straightforward than for the temperature variable.[15] The other climatic variables, i.e. wind speed and humidity, have also a less straightforward interpretation, especially because it is unclear what their optimum level is in combination with the temperature and rain variables. The rest of control variables provide valuable information as well, although these are only meant to capture the characteristics of each region in relation to sun-tourism activities. For instance the share of employment in the service sector is positively correlated with the holiday cost indicator for short-holidays only. This could possibly indicate that long holidays are less demanding in terms of local

[15] One can note also that the effect of the precipitation variable is positive and significant for the December month. This result could simply reflect the effect of winter tourism.

services availability. The share of 4-(or more) star hotels and the level of GDP per capita are always positively related to the holiday cost, on the other hand. Other variables such as the hotel density or the density of transport infrastructure represented by the distance to international airport display mixed results depending on the holiday duration. Interestingly the road density is negatively related to the holiday cost, possibly indicating that an easier transport access tends to lower the cost of holiday. The rest of control variables concerning the sea regions and the bathing activity prevailing in a given region of destination suggest that the Mediterranean destinations and the coastal areas are the most valued holiday destinations, in line with prior expectations.

3.3.2 Regional results

The great variety of climate conditions across European regions calls for a closer inspection of region-specific results. In order to provide a snapshot of these region-specific results we calculated kernel density of the estimated MWTP for the temperature variable. Figures 3 provides these kernel densities of the MWTPs for the month of January, April, July and October and for each holiday duration, one-day, four-day, one-week and two weeks, considering the linear effect of temperature (graphs on the left hand side) as well as its non-linear effect represented by the square term (graphs on the right hand side) of the temperature variable. The x-axis indicates the range of estimated values for the MWTPs while the y-axis provides the density of these estimates, i.e., their frequency across the 285 regions of origin of tourists. The first salient feature is that the estimated MWTPs are more skewed when moving from short to long holiday duration. This suggests that the estimated effect of temperature becomes also more homogenous across regions for longer holidays. In fact the very short holiday duration display a large heterogeneity of results across regions of origin suggesting that, in this case, the hedonic valuation of temperature depends very much of the region of origin of tourists. It must be noted that in the long holiday duration case a greater weight is given to the accommodation cost vs. the transport cost. It is therefore not surprising to see that the estimated MWTPs become more homogenous given that hotel prices remain identical, independently of the region of origin of the tourists. Given the prevalence of more than 4-day holiday duration observed in Europe (see Table 4), the actual distribution of the MWTPs are more likely to be concentrate around specific values rather than being dispersed as indicated by the one-day kernel density curve.

The shape of the kernel density curve corresponding to the linear effect of temperature suggests that high temperatures are generally associated with positive MWTPs during the month of July. Considering long holidays more specifically, the estimated marginal willingness to pay for an extra degree of temperature according to the linear effect is concentrated around 25% and 50% for the one-week and two-week holiday respectively. For the 4-day holiday duration the MWTP ranges between 0 and 25%, approximately. The net effect of one extra-degree temperature depends very much on the actual temperature level in a specific month, however. As discussed earlier, the marginal effect of one extra-degree temperature on tourists´ satisfaction is likely to decrease and even to decline once hot temperature becomes a dis-amenity. This is to some extent reflected in the right-hand side panel of Figure 3 corresponding to the estimated coefficient of the square term of the temperature variable. In this case most estimations turn out to be negative suggesting that, conditional on reaching a certain (yet undetermined) level, the effect of an extra degree of temperature turns out to be negative. An opposite pattern can be observed for the MWTP for an extra-degree of temperature in January and October which are not the month traditionally chosen for sun-tourism. In these cases the estimated coefficients for the linear and non-linear terms tend to be negative and positive respectively. These results would indicate that the MWTP for enjoying one degree extra-temperature tends to be higher once a given level of temperature has been reached. A similar interpretation could be made for the month of April although the differences in estimated coefficients are less clear-cut in this case.[16] These results bring two main messages concerning the effect of temperature on the hedonic value of tourism services. First the estimations across regions of origin become more homogenous when one moves from short to long holiday duration suggesting that the choices of destination for sun-tourism becomes more homogenous for long-holiday. Second, during the summer months the MWTP for higher temperature is non-linear: it is first positive and then becomes negative suggesting that after reaching a given level, temperature is considered as a dis-amenity rather than an amenity.[17] The opposite holds true for the other months of the year.

In order to get a more concrete idea of the estimated MWTP one needs to consider the marginal effect of the temperature for a specific region of origin and destination in order to take into account the actual value taken by the temperature variable. In order to do so we considered two specific

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[17] The kernel density for the other summer months are not reported here since they displayed very similar patterns.

regions: Brussels and Andalusia, the latter being a traditional tourist destination of European tourists. Table 6 provides the estimated MWTP for these two regions on a bilateral basis and for the climatic attributes combining the linear and non-linear effect of each climatic variables for the months of January and July. Considering first the temperature variable, we find that the net marginal effect of higher temperature during the month of January is always positive although decreasing when moving from short to long holiday duration. The resulting MWTP appear to be much lower now compared to the results plotted in Figure 3 suggesting that the positive and negative effects of higher temperature tend to compensate each other, at least for the particular cases considered here. The net effect of temperature during the month of July appears first to be positive for the short holiday although it decreases sharply when moving from short to long holidays. For instance, in July tourists from the Brussels region would be ready to pay between 0.51% and 2.48% more for an extra-degree of temperature in Andalusia during the month July. However, conditional on reaching a given temperature level, a one degree increase in temperature yields a negative MWTP of between -0.33% and -1.24% for longer duration thus suggesting that the effect of temperature on the hedonic value of holiday is non-linear. The other climatic variables also display changing signs although the non-linearity is less salient than for the temperature variable. Precipitations turn out to be negative or positive during the month of January while being always negative for the month of July. Wind speed display in most case negative MWTP while humidity is either always positive (in January) or negative (in July).

4. Adaptation to climate change.

In order to investigate the impact of climate change on tourists´ welfare we use the long-run projection of the KNMI-RACMO2-ECHAM5-r3 model-run at the NUTS2 regional level. While the long-run climate projections run until 2100, we omitted the last five years of these projections given the notorious end-of-sample bias of climate projections, see in particular Dosio et al. (2012). As mentioned earlier, our long-run projections concern the temperature variable only, taking all other variable at their monthly average value for 2010-2011. In order to determine the MWTP based on the model (2) estimated for each region of origin we proceed in two steps. First we calculate the base value of the MWTP estimated at the average value of the temperature variable during the period 2010-2011 for each month of the year. To do so, we calculate the weighted average of each region of origin MWTP for the temperature variable including its square value as in equation (3) taking as weight the average bilateral tourist flows observed for the period 2010-2011. Analytically, this amounts to calculate the following weighted average monthly MWTPs for the temperature variable as follows (omitting the month subscript):

$$MWTP_i = \sum_j w_{i,j}.MWTP_{i,j}(temp_j) \quad (4)$$

where the MWTPs are obtained from the estimation of equation (3) evaluated for the values of the temperature variable as projected by the KNMI-RACMO2-ECHAM5-r3 model-run. The term $w_{i,j}$ represents the average monthly share of the bilateral tourists flow from region *i* to region *j* in the total flow of tourists to region *j* observed during the period 2010-2011 and $temp_j$ is the average temperature observed in the destination region *j* for each specific month. The role of the weights $w_{i,j}$ is relevant given that it determines the influence of the region of destination climatic condition in the MWTP estimated for a given region of origin. This of course means that we assume that the origin/destination distribution of tourists remains fixed at its 2009-2011 values, see Table 7. The rise in Southern EU temperature during the summer season is of special relevance since Northern/Central European and British citizens traditionally represent the bulk of foreign tourists in this region. Figure 4 for instance shows that the British, German, Belgian and Dutch tourists spend predominantly their holiday abroad during the summer season. French or Spanish tourists´ destinations are more balanced between home and foreign destination. British and German tourists are thus likely to be most directly affected by the rise in temperature in Southern EU regions. For instance 26% of all tourists visiting Spain in July 2010 were German according to our bednight data and 23% were British, while 24% of all tourists visiting Portugal were British during the same period. For instance if British tourists move predominantly to the Spanish coast during the summer season and if temperature is projected to increase significantly in this area over the long-run (as indicated in Table 3), then one would naturally expect a negative impact on British tourists welfare.

There is no reason to expect that tourists from Northern and Central European region would remain passive in case temperature would rise as predicted by the scientific community. Two possible adaptation scenarios are possible: a change in the frequency and duration of holidays and a change in destination region. These two scenarios face different constraints, however. In terms of frequency and duration the most important constraint is institutional. The holiday habits are determined by the work and school calendar years whereby July and August have traditionally been the traditional holiday months. In the long-run a change in these parameters could reasonably be foreseen although the change in temperature alone might not be sufficient and other factors such as population ageing (with retired people being arguably less constrained) and/or a change in the leisure/working hours distribution might also play a significant role. The possible change in destination faces a different constraint. For instance it would be difficult to find the same level of sun-related amenities in Northern European regions compared to Southern Mediterranean regions even with the predicted rise in temperature. A more likely change may thus come from a change in holiday duration and the possibility for tourists to spread their holiday more evenly during the year including shorter and more frequent holidays. Our previous analysis concerning the estimated MWTP for the temperature variable provides some indication regarding the way tourists may adapt both their holiday duration and holiday frequency throughout the year. Figure 3 suggested indeed that tourists would tend to prefer shorter holidays during the month of July since temperatures during this month display a lower MWTP. As shown in Figure 3 such evolution could also be observed to some extent for the month of April, although in a much less pronounced manner. The extent to which either the linear positive or non-linear negative effect of temperature would eventually dominate in the long-run can only be checked by calculating the expression of the MWTP as in equation (3) which combines these two elements.

Figure 5 provides the values of the MWTPs for a selected sample of regions and from 2012 up to 2095. As a matter of illustration we report results for selected capital regions included in our sample.[18] EU-wide results are discussed below. For each scenario the average MWTPs for the short (one and four days) and long (one and two weeks) holidays are considered taking as weights the country-level figures reported in Table 7.[19] According to these figures long holidays abroad are especially predominant in Northern-central European countries and the British Isles. Given our previous results, one would thus expect that tourists originating from these regions to spend shorter holiday in their preferred (i.e. Southern EU) destinations during the summer months. By contrast Portuguese or Spanish tourists would tend to spend longer holidays and to do more so abroad and/or out of the summer season. These hypotheses are considered in our long-run projections by modifying the relative weight of short vs. long holidays. The continuous blue line in Figure 5 represents the central scenarios. The dotted red (dashed green) lines plot the MWTPs for scenarios

[18] Note that the names of these regions used in Figure 5 correspond to the names of the capital cities and not the administrative names of the NUTS2 regions in order for the reader to identify more easily the geographical area these regions correspond to.
[19] Note that our projection of the MWTP are filtered using the Hodrick-Prescott (1996) filter with a smoothing factor of 129600) in order to account for the seasonal effect of the temperature variable and to improve the graphical representation of our results.

where longer (shorter holiday) would be preferred. In the central scenario the relatively weight of short vs. long holiday is assumed to remain unchanged and fixed at its 2010-2011 value. In the two other scenarios we assume an annual increment of +0.1% of the relative weight of each holiday duration type as from 2015 on. In these cases we assume that the relative weight of short-holiday (green dashed line) or alternatively that the relative weight of long-holiday (red-dotted line) increases continuously for each month compared to the same month a year earlier. [20] If these alternative MWTP curve fall below the central scenario (i.e. unchanged weight of short vs. long holiday) then this indicate that the corresponding scenario becomes less plausible given that it would yield lower welfare levels, assuming all other factors (in particular the origin/destination structure and the other explanatory variables) remain unchanged. The results of these projections are reported in Figure 5. The results overall suggest that the temperature rise expected to take place in Europe would have a very heterogeneous impact across European regions. For instance the tourists from the two Southern European regions of Lisbon and Madrid would find themselves better off by choosing longer holidays. Given the expected rise in temperature in Spain and Portugal one would also expect that tourists from these regions would prefer long holidays in cooler regions. Interestingly enough, a similar pattern can also be found in Northern European regions of Stockholm and Helsinki. In these cases however, the summer season in these countries is likely to become more suitable for spending holidays there. Given the predominance of short holidays in their home country, one would expect tourists from these regions to spend longer holidays at home rather that abroad. Apart from these two cases, tourists from all the other regions considered in Figure 5 would find themselves better off by spending shorter rather than longer holidays.

Whether shorter or longer holidays are more likely to prevail depends of the relative number of tourists in each region. In order to provide more general results results we have thus projected the MWTP for the five geographical areas (where the number of tourists´ bednight is used as weighting factor) and also for the EU as a whole. These results are provided in Figure 6. These additional projections confirm previous hypothesis, i.e., tourists are likely to prefer shorter rather than longer holidays duration in order to cushion for the negative effect of global warming on welfare. This result can be observed in all geographical areas and also for the EU as whole. Interestingly, the Southern and Northern European regions as a whole (and not only the capital regions as previously)

[20] Note that the year 2015 is chosen arbitrarily. A different year could have been considered without modifying the interpretation of the results of our long-run projections. Equally arbitrary is the change in the distribution of short vs. long holidays. Here again, results with different changes would yield the same conclusions as the ones discussed here.

yield a similar preference for shorter holidays thus illustrating the cross-regional heterogeneity in results.

5. **Summary and conclusion**

In this paper we investigate the impact of climatic change on tourism demand in European regions using a hedonic price framework. We derive region-specific estimates of the impact of climate change based on tourists flows between European regions taking into account regions' specific characteristics regarding the nature of (and degree of specialisation in) tourism activities and related vulnerability to potential climate change scenarios. We base our long-term projections on hedonic price estimations combining detailed hotel price information with tourism-specific travel cost estimations for each pair of EU region. Such an approach allows us to estimate different valuations of climate amenities depending on the distance travelled by tourists which in turn are used to further differentiate the valuation of climatic conditions depending on the time duration of holidays. Based on this approach we can draw alternative adaptation strategies to climate change. Our approach thus explicitly models possible adaptation scenarios to climate change based on observed data. Our long-run climatic projection focus on temperature as the driver of climate change since other climatic variables are arguably more difficult to predict, especially when considering a detailed regional dimension as in our study. Our findings suggest that on average, European tourists are more likely to spend shorter holidays given the dis-amenity associated with long holiday spells during the summer season. While this result appears to be robust across European, in some cases we find that longer holidays could be preferred depending on regional-specific circumstances.

Our results are rather intuitive given that the time spent during holidays is an obvious complement to other holiday characteristics such as destination choices. It is therefore not surprising to consider that individuals might adapt the time spent during their holiday as a way to minimise potential adverse effects of climate change. More generally one could extrapolate our reasoning to other economic activities, be it consuming or producing, as a way to cope with extreme variations in climatic conditions. It is important to note that our results are limited in a number of ways, however. First our hedonic price estimates only reflect the tourism related to hotel occupation only without accounting for other possible accommodation modes. In addition our hypotheses regarding the possible shift in destination choices are limited since we do not estimate a tourism demand function directly whereby possible substitution effects between destination choices could be devised. Finally we consider only intra-European tourism while climate change is arguably a global phenomenon. While EU citizens still predominantly spend their holidays in Europe, a more global perspective would be warranted in order to draw more general conclusions from our approach. These issues shall be considered in future research.

6. References

Albouy, D., W.F. Graf, R. Kellogg and H. Wolff, (2013), "Climate amenities, climate change, and American Quality of Life", *NBER Working Paper* 18925, National Bureau of Economic Research, Cambridge.

Amelung, B., S. Nicholls and D.Viner (2007), "Implications of Global Climate Change for Tourism Flows and Seasonality" *Journal of Travel Research* 45(3): 285-296.

Won Kim, C., T. T.Phipps, and L. Anselin (2003). Measuring the benefits of air quality improvement: a spatial hedonic approach. *Journal of environmental economics and management* 45(1), 24-39

Barrios, S., L. Bertinelli and E. Strobl (2010), "Trends in Rainfall and Economic Growth in Africa: A Neglected Cause of the African Growth Tragedy", *Review of Economics and Statistics* 92(2): 350-366.

Barrios, S., and J.N. Ibañez Rivas (2013), "Tourism demand, climatic conditions and transport costs: An integrated analysis for EU regions", *Institute for Prospective and Technological Studies, Scientific and Policy Report* 80898, Joint Research Centre, European Commission, Seville.

Becker, G. (1965), "A theory of the Allocation of Time", *Economic Journal* 75 (299): 493-517.

Berrittella, M., A. Bigano, R. Roson, and R.S.J. Tol (2007), "A general equilibrium analysis of climate change impacts on tourism", *Tourism Management* 27(5): 913–924.

Bishop, K. C. and C. Timmins, (2011), "Hedonic prices and implicit markets: Estimating marginal willingness to pay for differentiated products without instrumental variables", *NBER working paper* 17611.

Brög, W. E. Erl and B. Schulze (2003), DATELINE Design and Application of a Travel Survey for Long-distance Trips Based on an International Network of Expertise, Project Report, Brussels, European Commission.

Brown, G. and R. Mendelsohn (1984), "The Hedonic Travel Cost Method", *Review of Economics and Statistics* 66: 427-433.

Carr, L. and R. Mendelsohn (2003), "Valuing Coral Reefs: A Travel Cost Analysis of the Great Barrier Reef" *Ambio* 32: 353-357.

Cassell, E. and R. Mendelsohn, (1985), "The Choice of Functional Forms for Hedonic Price Equations: Comment", *Journal of Urban Economics* 18: 135-142.

Ciscar, J.C., A. Iglesias, L. Feyen, L. Szabó, D. Van Regemorter, B. Amelung, R. Nicholls, P. Watkiss, O. B. Christensen, R. Dankersc. L. Garrote, C. M. Goodess, A. Hunt, A. Moreno, J. Richards, and A. Soria, (2011), "Physical and economic consequences of climate change in Europe", *Proceedings of the National Academy of Science* 108(7): 2678-2683.

Cullinan, J. (2011). A spatial microsimulation approach to estimating the total number and economic value of site visits in travel cost modelling. *Environmental and Resource Economics* 50(1): 27-47.

Deschenes, O., and M. Greenstone, (2007), "The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather." *American Economic Review* 97(1): 354-385.

Dell, M., Jones, B. F., Olken, B. A., (2012) "Temperature shocks and economic growth: Evidence from the last half century", *American Economic Journal: Macroeconomics* 4(3): 66-95.

Dosio A., P. Paruolo, and R. Rojas R. (2012), "Bias correction of the ENSEMBLES high resolution climate change projections for use by impact models: analysis of the climate change signal", Journal of Geophysical Research 117: 1-24.

Dosio A and Paruolo P (2011). Bias correction of the ENSEMBLES high-resolution climate change projections for use by impact models: Evaluation on the present climate, J. Geophys. Res., 116, D16106, DOI: 10.1029/2011JD015934.

Ekeland, I., J.T Heckman and L. Nesheim, (2002), "Identifying hedonic models", *American Economic Review* 92(2), Papers and Proceedings.

Englin, J. and R. Mendelsohn. (1991), "A Hedonic Travel Cost Analysis for Valuation of Multiple Components of Site Quality: The Recreation Value of Forest Management", *Journal of Environmental Economics and Management* 21: 275-290.

Eurostat (2012), Tourism in Europe: Results for 2011, Statistics in Focus 2012.

Graf Zivinm J. and M. J. Neidell, (2010), "Temperature and the allocation of time: implications for climate change", NBER Working Paper 15717, National bureau of Economic Research , Cambridge. *Forthcoming in Journal of Labour Economics*.

Harrison, S.J. , S.J. Winterbottom and C. Sheppard (1999), The potential effects of climate change on the Scottish tourist industry, *Tourism Management* 20 (2): 203–211.

Higham J, Hall CM (2005), Making tourism sustainable: the real challenge of climate change? In: Hall M, Higham J (eds) Tourism, Recreation and Climate Change. Channel View Publications, London, UK: 301–307.

Hellerstein, D., (1993), "Intertemporal data and travel cost analysis", *Environmental and Resource Economics* 3(2): 193-207.

Hamilton JM, Maddison D, Tol RSJ (2005), Climate change and international tourism: A simulation study, *Global Environmental Change* 15(3):253–266.

Hodrick, R.J. and E.C. Prescott (1997), "Postwar U.S. Business Cycles: An Empirical Investigation", *Journal of Money, Credit and Banking* 29(1): 1-16.

Kim, Ch. W., T.T. Phipps and L. Anselin, (2003), "Measuring the benefits of air quality improvement: A spatial hedonic approach", *Journal of Environmental Economics and Management* 45: 24-39.

van der Linden P. and Mitchell, J.F.B. (2009), ENSEMBLES: climate change and its impacts. Summary of research and results from the ENSEMBLES project. Met Office Hadley Centre, Exeter, 2009.

Lancaster, K.J.A, (1966), "A New Approach to Consumer Theory", *Journal of Political Economy* 74(2):132-157.

Lise, W., Tol RSJ (2002), Impact of climate on tourist demand. *Climatic Change* 55(4):429–449.

Maddison D (2001), In search of warmer climates? The impact of climate change on flows of British tourists. *Climatic Change* 49(1/2):193–208.

Maddison, D. and A. Bigano, (2003), "The Amenity value of the Italian Climate", *Journal of Environmental Economic and Management* 45: 319-332.

Mendelsohn, R. (1981), "The Choice of Discount Rates for Public Projects", *American Economic Review* 71: 239-241.

Mendelsohn, R. (1987), "A Review of Identification of Hedonic Supply and Demand Functions", *Growth and Change* 18: 82-92.

Mendelsohn, R. W. D. Nordhaus and D. Shaw, (1994),"The Impact of Global Warming on Agriculture: A Ricardian Analysis", *American Economic Review* 84(4): 753-771.

Mendelsohn, R. and M. Schlesinger, (1999), "Climate Response Functions", *Ambio* 28: 362-366.

Mendelsohn, R. (2007), "Measuring Climate Impacts With Cross-Sectional Analysis: An Introduction" Climatic Change 81: 1-7.

Mendelsohn, R. and S. Olmstead, (2009), The Economic Valuation of Environmental Amenities and Disamenities: Methods and Applications. *Annual Review of Environment and Resources* 34: 325-347.

Morris, D. and M. Walls, (2009), "Climate Change and Outdoor Recreation Resources", *Resources for the Future*, Backgrounder, April, Washington D.C.

Nakicenovic, N. and R. Swart. (2000). Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K.

Nielsen, O. A. and A. Burgess, (2008), The European TRANSTOOLS Transport Model. Transportation, 2008.

Pendleton, L. and R. Mendelsohn, (2000),"Estimating Recreation Preferences Using Hedonic Travel Cost and Random Utility Models", *Environmental and Resources Economics* 17: 89-108.

Perry, A., (2000), "Impacts of Climate Change on Tourism in the Mediterranean: Adaptive Responses", *FEEM Working Paper* 35.

Rich, J., and S.M. Lindhard (2011), A long-distance travel demand model for Europe. In: *European Journal of Transport and Infrastructure Research*, Vol. 12, No. 1, 2012, p. 1-20.

Rich J., Bröcker J., Hansen C.O., Korchenewych A., Nielsen O.A., Vuk G. (2009), Report on Scenario, Traffic Forecast and Analysis of Traffic on the TEN-T, taking into Consideration the External

Dimension of the Union – TRANS-TOOLS version 2; Model and Data Improvements, Funded by DG TREN, Copenhagen, Denmark.

Rosen, S., (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition" Journal of Political Economy 82(1): 34-55

Riera Font, A. (2000), "Mass Tourism and the Demand for Protected Natural Areas: A Travel Cost Approach", *Journal of Environmental Economics and Management* 39(1): 97–116.

Stern, N. (2008), "The Economics of Climate Change", *American Economic Review: Papers & Proceedings* 98:2, 1-37.

7. Tables

Table 1: Hotel prices vs star-category.

VARIABLES	Hotel prices vs. star category
2-star	0.324***
	(0.0823)
3-star	0.457***
	(0.0782)
4-star	0.663***
	(0.0787)
5-star or more	1.085***
	(0.0931)
Constant	3.835***
	(0.0775)
Observations	10,786
R-squared	0.052

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2: Hotel prices and seasonality

VARIABLES	Hotel prices vs. month
January	-0.0467***
	(0.0176)
February	-0.0374**
	(0.0173)
March	-0.0251
	(0.0173)
April	0.0218
	(0.0171)
May	0.0487***
	(0.0170)
June	0.0725***
	(0.0170)
July	0.114***
	(0.0170)
August	0.115***
	(0.0170)
September	0.0596***
	(0.0198)
October	0.0139
	(0.0196)
November	-0.0239
	(0.0198)
Constant	4.311***

	(0.0140)
Observations	10,786
R-squared	0.029

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3: Average temperature by season and geographical zone

	Winter			
	2010	*2011-2040*	*2041-2070*	*2071-2100*
British Isles	3.4	2.4	4.0	4.8
Central Europe North	-0.2	-0.7	1.3	2.6
Central Europe South	-0.2	-0.2	1.1	2.4
Northern Europe	-4.5	-5.8	-4.0	-2.5
Southern Europe	5.5	5.6	5.9	7.0
	Spring			
	2010	*2011-2040*	*2041-2070*	*2071-2100*
British Isles	9.5	8.7	8.5	8.9
Central Europe North	10.0	8.8	9.0	9.3
Central Europe South	10.1	8.7	9.3	10.0
Northern Europe	5.4	2.7	4.5	5.1
Southern Europe	12.4	10.7	11.8	12.9
	Summer			
	2010	*2011-2040*	*2041-2070*	*2071-2100*
British Isles	14.5	16.2	15.5	16.5
Central Europe North	16.4	18.4	17.5	18.3
Central Europe South	16.9	18.8	18.2	19.1
Northern Europe	14.0	14.1	14.4	15.6
Southern Europe	20.8	21.6	21.6	22.8
	Autumn			
	2010	*2011-2040*	*2041-2070*	*2071-2100*
British Isles	9.5	10.3	10.3	11.6
Central Europe North	8.5	10.5	10.1	11.1
Central Europe South	9.2	10.3	10.5	11.3
Northern Europe	3.8	6.1	6.1	7.5
Southern Europe	13.9	14.0	14.7	15.7

Notes: Southern Europe: Portugal, Spain, Italy, Greece and Bulgaria. **Central Europe South**: France, Austria, Czech Republic, Slovakia, Hungary, Romania and Slovenia. **Central Europe North**: Belgium, the Netherlands, Germany and Poland. **British Isles:** Ireland and the UK **Northern Europe**: Sweden, Finland, Estonia, Latvia and Lithuania

Table 4. Holiday trips made by EU residents by length of stay and destination in 2010

	Domestic tourism	Outbound tourism	Total
Average length of stay *(number of days)*	4.3	9.1	5.5
Percentage in total tourist trips	60.8%	39.2%	100%

Source: Eurostat

Table 5: Estimations of the hedonic price model: pooled regressions results

	(1)	(2)	(3)	(4)
Dependent variable: holiday cost (travel + accommodation in hotel)	**one-day stay**	**four-day stay**	**one-week stay**	**two-week stay**
Temperature_jan	0.00283*	-0.0139***	-0.0225***	-0.0328***
	(0.00160)	(0.00117)	(0.000966)	(0.000746)
Temperature_feb	-0.0194***	-0.0295***	-0.0344***	-0.0404***
	(0.00182)	(0.00133)	(0.00110)	(0.000850)
Temperature_mar	-0.0846***	-0.0752***	-0.0687***	-0.0597***
	(0.00385)	(0.00281)	(0.00233)	(0.00180)
Temperature_apr	-0.141***	-0.0984***	-0.0734***	-0.0408***
	(0.00734)	(0.00537)	(0.00444)	(0.00343)
Temperature_may	-0.131***	-0.0372*	0.0146	0.0791***
	(0.0286)	(0.0209)	(0.0173)	(0.0134)
Temperature_jun	0.0370	0.111***	0.154***	0.211***
	(0.0235)	(0.0172)	(0.0142)	(0.0110)
Temperature_jul	0.103***	0.211***	0.273***	0.354***
	(0.0233)	(0.0171)	(0.0141)	(0.0109)
Temperature_aug	-0.0732***	0.00907	0.0579***	0.123***
	(0.0222)	(0.0162)	(0.0134)	(0.0104)
Temperature_sep	-0.115***	-0.0700***	-0.0469**	-0.0203
	(0.0325)	(0.0238)	(0.0197)	(0.0152)
Temperature_oct	-0.277***	-0.198***	-0.157***	-0.108***
	(0.0201)	(0.0147)	(0.0122)	(0.00939)
Temperature_nov	-0.0764***	-0.0677***	-0.0626***	-0.0559***
	(0.00406)	(0.00297)	(0.00246)	(0.00190)
Temperature_dec	0.00634**	0.000823	-0.00202	-0.00533***
	(0.00289)	(0.00212)	(0.00175)	(0.00135)
Humidity_jan	-1.691***	-1.615***	-1.560***	-1.487***
	(0.131)	(0.0958)	(0.0793)	(0.0613)
Humidity_feb	0.626***	0.0505	-0.236***	-0.589***
	(0.132)	(0.0968)	(0.0801)	(0.0619)
Humidity_mar	0.218*	-0.0691	-0.198***	-0.342***
	(0.118)	(0.0860)	(0.0712)	(0.0550)
Humidity_apr	0.336***	-0.110	-0.334***	-0.594***
	(0.106)	(0.0778)	(0.0644)	(0.0497)
Humidity_may	-0.718***	-0.884***	-0.948***	-1.006***
	(0.113)	(0.0828)	(0.0685)	(0.0529)
Humidity_jun	0.823***	0.810***	0.815***	0.834***
	(0.0541)	(0.0395)	(0.0327)	(0.0253)
Humidity_jul	0.239***	0.0545	-0.0463	-0.170***
	(0.0603)	(0.0441)	(0.0365)	(0.0282)
Humidity_aug	0.222***	0.172***	0.180***	0.223***
	(0.0635)	(0.0464)	(0.0384)	(0.0297)

Humidity_sep	-0.321**	-0.299***	-0.300***	-0.306***
	(0.142)	(0.104)	(0.0862)	(0.0666)
Humidity_oct	0.540***	0.391***	0.337***	0.306***
	(0.166)	(0.122)	(0.101)	(0.0778)
Humidity_nov	-2.370***	-2.162***	-2.014***	-1.779***
	(0.325)	(0.238)	(0.197)	(0.152)
Humidity_dec	1.036***	1.722***	2.068***	2.471***
	(0.234)	(0.171)	(0.142)	(0.109)

Table 5 (continued): Estimations of the hedonic price model: pooled regressions results

Precipitations_jan	-0.266***	-0.220***	-0.190***	-0.147***
	(0.00468)	(0.00342)	(0.00283)	(0.00219)
Precipitations_mar	-0.00260**	0.00289***	0.00582***	0.00953***
	(0.00127)	(0.000930)	(0.000770)	(0.000595)
Precipitations_apr	-0.0571***	-0.0416***	-0.0333***	-0.0229***
	(0.00644)	(0.00471)	(0.00390)	(0.00301)
Precipitations_may	-0.0504***	-0.0561***	-0.0575***	-0.0574***
	(0.0112)	(0.00817)	(0.00676)	(0.00523)
Precipitations_jun	-0.0385***	-0.0299***	-0.0246***	-0.0176***
	(0.00212)	(0.00155)	(0.00128)	(0.000991)
Precipitations_jul	-0.0171***	-0.0213***	-0.0239***	-0.0275***
	(0.00147)	(0.00107)	(0.000888)	(0.000686)
Precipitations_aug	-0.0438***	-0.0360***	-0.0325***	-0.0291***
	(0.00286)	(0.00209)	(0.00173)	(0.00134)
Precipitations_sep	-0.0265***	-0.0252***	-0.0244***	-0.0233***
	(0.00389)	(0.00284)	(0.00235)	(0.00182)
Precipitations_oct	-0.0348**	-0.00770	0.0122	0.0433***
	(0.0177)	(0.0129)	(0.0107)	(0.00827)
Precipitations_nov	-0.193***	-0.136***	-0.0982***	-0.0433***
	(0.0208)	(0.0152)	(0.0126)	(0.00973)
Precipitations_dec	0.0466***	0.0834***	0.102***	0.124***
	(0.0147)	(0.0107)	(0.00889)	(0.00687)
Windspeed_jan	0.325***	0.159***	0.0590***	-0.0768***
	(0.0368)	(0.0269)	(0.0223)	(0.0172)
Windspeed_feb	0.0271	-0.0477***	-0.0899***	-0.146***
	(0.0207)	(0.0151)	(0.0125)	(0.00967)
Windspeed_mar	0.0270	-0.0110	-0.0299**	-0.0528***
	(0.0226)	(0.0165)	(0.0137)	(0.0106)
Windspeed_apr	0.216***	0.0982***	0.0346**	-0.0429***
	(0.0290)	(0.0212)	(0.0175)	(0.0135)
Windspeed_may	0.379***	0.233***	0.147***	0.0337*
	(0.0391)	(0.0286)	(0.0237)	(0.0183)
Windspeed_jun	0.0782**	-0.0676**	-0.151***	-0.257***

	(0.0395)	(0.0289)	(0.0239)	(0.0185)
Windspeed_jul	-0.244***	-0.296***	-0.332***	-0.384***
	(0.0311)	(0.0228)	(0.0188)	(0.0146)
Windspeed_aug	-0.0164	-0.256***	-0.393***	-0.568***
	(0.0349)	(0.0255)	(0.0211)	(0.0163)
Windspeed_sep	-0.0290	-0.0660*	-0.0948***	-0.136***
	(0.0461)	(0.0337)	(0.0279)	(0.0216)
Windspeed_oct	0.379***	0.155***	0.0214	-0.159***
	(0.0391)	(0.0286)	(0.0236)	(0.0183)
Windspeed_nov	0.127***	-0.00245	-0.0846***	-0.199***
	(0.0484)	(0.0354)	(0.0293)	(0.0226)
Windspeed_dec	-0.137***	-0.0776***	-0.0463**	-0.00724
	(0.0355)	(0.0260)	(0.0215)	(0.0166)

Table 5 (continued): Estimations of the hedonic price model: pooled regressions results

sq_Temperature_jan	0.0135***	0.0125***	0.0117***	0.0106***
	(0.000850)	(0.000622)	(0.000515)	(0.000398)
sq_Temperature_feb	0.0322***	0.0227***	0.0174***	0.0107***
	(0.00127)	(0.000927)	(0.000767)	(0.000593)
sq_Temperature_mar	0.0450***	0.0305***	0.0221***	0.0111***
	(0.00330)	(0.00241)	(0.00199)	(0.00154)
sq_Temperature_jun	0.0308***	0.00897*	-0.00357	-0.0196***
	(0.00687)	(0.00502)	(0.00416)	(0.00321)
sq_Temperature_jul	-0.0150**	-0.0540***	-0.0763***	-0.105***
	(0.00741)	(0.00542)	(0.00448)	(0.00347)
sq_Temperature_aug	0.0463***	0.0338***	0.0276***	0.0206***
	(0.00703)	(0.00514)	(0.00426)	(0.00329)
sq_Temperature_sep	0.0345***	0.0202***	0.0131**	0.00533
	(0.00872)	(0.00638)	(0.00528)	(0.00408)
sq_Temperature_oct	0.102***	0.0759***	0.0626***	0.0471***
	(0.00689)	(0.00503)	(0.00417)	(0.00322)
sq_Temperature_nov	0.0519***	0.0406***	0.0341***	0.0259***
	(0.00225)	(0.00164)	(0.00136)	(0.00105)
sq_Temperature_dec	0.0269***	0.0205***	0.0162***	0.0101***
	(0.00170)	(0.00125)	(0.00103)	(0.000797)
sq_Precipitations_jan	0.0387***	0.0350***	0.0319***	0.0271***
	(0.00238)	(0.00174)	(0.00144)	(0.00111)
sq_Precipitations_feb	0.00716***	0.00890***	0.00938***	0.00961***
	(0.000823)	(0.000602)	(0.000498)	(0.000385)
sq_Precipitations_mar	0.000973***	0.000626***	0.000413**	0.000117
	(0.000266)	(0.000195)	(0.000161)	(0.000125)
sq_Precipitations_apr	0.0145***	0.0110***	0.00911***	0.00660***
	(0.00126)	(0.000924)	(0.000765)	(0.000591)
sq_Precipitations_may	0.00114	0.00288**	0.00358***	0.00421***
	(0.00195)	(0.00143)	(0.00118)	(0.000911)
sq_Precipitations_jun	0.00198***	0.00138***	0.000838**	-7.98e-05
	(0.000641)	(0.000469)	(0.000388)	(0.000300)
sq_Precipitations_j	-	-0.00278***	-	-0.00256***

ul	0.00298***		0.00267***	
	(0.000376)	(0.000275)	(0.000228)	(0.000176)
sq_Precipitations_aug	0.00802***	0.00615***	0.00510***	0.00377***
	(0.000719)	(0.000526)	(0.000435)	(0.000336)
sq_Precipitations_sep	-0.000774	0.000139	0.000589	0.00112***
	(0.000918)	(0.000671)	(0.000555)	(0.000429)
sq_Precipitations_oct	0.00247	0.000101	-0.00178	-0.00486***
	(0.00277)	(0.00203)	(0.00168)	(0.00130)
sq_Precipitations_nov	0.0249***	0.0170***	0.0116***	0.00363**
	(0.00317)	(0.00232)	(0.00192)	(0.00148)
sq_Precipitations_dec	-0.00612***	-0.0121***	-0.0152***	-0.0190***
	(0.00227)	(0.00166)	(0.00137)	(0.00106)
sq_Humidity_jan	-4.569***	-4.098***	-3.839***	-3.529***
	(0.378)	(0.277)	(0.229)	(0.177)
sq_Humidity_feb	0.647	-0.450	-0.996***	-1.672***
	(0.399)	(0.292)	(0.242)	(0.187)
sq_Humidity_mar	-0.187	-0.717***	-0.958***	-1.226***
	(0.293)	(0.214)	(0.177)	(0.137)
sq_Humidity_apr	0.895***	0.162	-0.213*	-0.655***
	(0.191)	(0.140)	(0.116)	(0.0895)

Table 5 (continued): Estimations of the hedonic price model: pooled regressions results

sq_Humidity_jun	0.561***	0.584***	0.613***	0.666***
	(0.0584)	(0.0427)	(0.0354)	(0.0273)
sq_Humidity_jul	0.352***	0.128**	0.0127	-0.123***
	(0.0680)	(0.0497)	(0.0412)	(0.0318)
sq_Humidity_aug	0.229***	0.172***	0.175***	0.211***
	(0.0712)	(0.0520)	(0.0431)	(0.0333)
sq_Humidity_sep	-0.390*	-0.355**	-0.348***	-0.343***
	(0.212)	(0.155)	(0.128)	(0.0992)
sq_Humidity_oct	0.686**	0.274	0.0840	-0.0982
	(0.321)	(0.235)	(0.194)	(0.150)
sq_Humidity_nov	-8.407***	-8.391***	-8.307***	-8.087***
	(1.195)	(0.874)	(0.723)	(0.559)
sq_Humidity_dec	1.364**	3.942***	5.242***	6.768***
	(0.638)	(0.467)	(0.386)	(0.299)
sq_Windspeed_jan	-0.124***	-0.0739***	-0.0421***	0.00221
	(0.0160)	(0.0117)	(0.00970)	(0.00750)
sq_Windspeed_feb	-0.0357***	-0.00847	0.00737	0.0287***
	(0.00913)	(0.00668)	(0.00553)	(0.00427)
sq_Windspeed_mar	-0.0342***	-0.0324***	-0.0318***	-0.0310***
	(0.0110)	(0.00805)	(0.00666)	(0.00515)
sq_Windspeed_apr	-0.0668***	-0.0314***	-0.0129	0.00894
	(0.0153)	(0.0112)	(0.00926)	(0.00716)
sq_Windspeed_may	-0.184***	-0.113***	-0.0714***	-0.0169*
	(0.0203)	(0.0148)	(0.0123)	(0.00949)
sq_Windspeed_jun	-0.0732***	-0.00639	0.0317***	0.0794***
	(0.0199)	(0.0146)	(0.0121)	(0.00933)
sq_Windspeed_jul	0.161***	0.162***	0.167***	0.179***
	(0.0168)	(0.0123)	(0.0102)	(0.00787)
sq_Windspeed_aug	0.0161	0.124***	0.185***	0.262***
	(0.0187)	(0.0136)	(0.0113)	(0.00872)
sq_Windspeed_sep	0.0621***	0.0669***	0.0744***	0.0866***
	(0.0223)	(0.0163)	(0.0135)	(0.0104)
sq_Windspeed_oct	-0.151***	-0.0629***	-0.0114	0.0574***
	(0.0171)	(0.0125)	(0.0103)	(0.00799)
sq_Windspeed_nov	-0.0426*	0.0146	0.0500***	0.0985***
	(0.0218)	(0.0160)	(0.0132)	(0.0102)
sq_Windspeed_dec	0.0687***	0.0125	-0.0169	-0.0535***
	(0.0174)	(0.0127)	(0.0105)	(0.00814)
Share of employment in services	0.466***	0.131***	-0.0667***	-0.329***
	(0.0219)	(0.0160)	(0.0133)	(0.0103)
longitude	-0.00572***	-0.00468***	-0.00405***	-0.00325***
	(0.000142)	(0.000103)	(8.56e-05)	(6.62e-05)
latitude	0.0136***	0.0131***	0.0131***	0.0135***
	(0.000243)	(0.000178)	(0.000147)	(0.000114)
Share of four (or more)-star hotels	0.104***	0.147***	0.169***	0.195***
	(0.00315)	(0.00230)	(0.00191)	(0.00147)
GDP per capita	0.0194***	0.0740***	0.104***	0.143***

	(0.00208)	(0.00152)	(0.00126)	(0.000974)

Table 5 (continued): Estimations of the hedonic price model: pooled regressions results

Hotel density (# hotels/sq. km)	-0.00829***	0.000321	0.00444***	0.00917***
	(1.54e-05)	(1.13e-05)	(9.34e-06)	(7.22e-06)
Road density (per sq. km)	-0.505***	-0.354***	-0.277***	-0.185***
	(0.00614)	(0.00449)	(0.00371)	(0.00287)
Adriatic sea	-0.0503***	0.0214***	0.0620***	0.114***
	(0.00404)	(0.00295)	(0.00245)	(0.00189)
Aegean-Levantine sea	0.357***	0.329***	0.315***	0.300***
	(0.00508)	(0.00372)	(0.00308)	(0.00238)
Atlantic Ocean	-0.0148***	0.00255	0.0123***	0.0249***
	(0.00392)	(0.00287)	(0.00237)	(0.00183)
Black Sea	-0.109***	-0.0404***	-0.00340*	0.0435***
	(0.00303)	(0.00222)	(0.00183)	(0.00142)
Ionian sea and Central Med. sea	0.338***	0.344***	0.349***	0.357***
	(0.00552)	(0.00403)	(0.00334)	(0.00258)
North sea	-0.247***	-0.159***	-0.114***	-0.0577***
	(0.00264)	(0.00193)	(0.00160)	(0.00123)
Eastern Mediterranean sea	0.0306***	0.0721***	0.0983***	0.135***
	(0.00405)	(0.00296)	(0.00245)	(0.00189)
Coastal	0.122***	0.0938***	0.0776***	0.0562***
	(0.00441)	(0.00323)	(0.00267)	(0.00206)
Lake	-0.0287***	-0.0434***	-0.0553***	-0.0735***
	(0.00452)	(0.00330)	(0.00273)	(0.00211)
River	0.0607***	0.0226***	0.00130	-0.0257***
	(0.00545)	(0.00398)	(0.00330)	(0.00255)
Observations	1,176,202	1,176,202	1,176,202	1,176,202
R-squared	0.135	0.151	0.173	0.232

Table 6: Estimated percentage change of hedonic values of holidays in January and July for Tourists from Brussels to Andalusia*

Tourists from Brussels (BE10) to Andalusia (ES61) in January				
	Holidays duration			
	One-day	Four-day	One-week	Two-week
Temperature	0.70%	0.39%	0.26%	0.11%
Precipitation	-0.08%	0.24%	0.33%	0.39%
Wind speed	-1.89%	-1.19%	-0.98%	-0.83%
Humidity	3.66%	2.04%	1.45%	0.88%
Tourists from Brussels (BE10) to Andalusia (ES61) in July				
	Holidays duration			
	One-day	Four-day	One-week	Two-week
Temperature	2.48%	0.51%	-0.33%	-1.24%
Precipitation	-0.01%	-0.06%	-0.08%	-0.11%
Wind speed	0.03%	-0.12%	-0.25%	-0.42%
Humidity	-2.25%	-0.99%	-0.56%	-0.15%

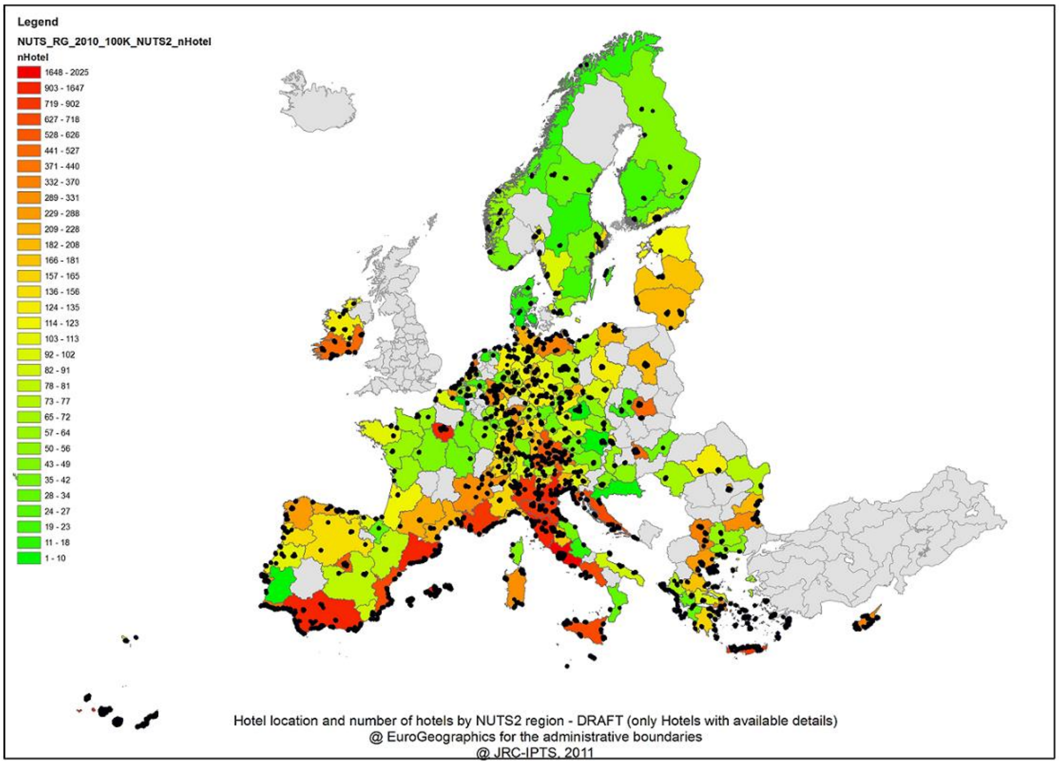
* Estimated change of the cost of holiday trip including travel cost and hotel stay. The net effect of the temperature variable is calculated for a 5% increase which corresponds to 1 degree increase for an average temperature of 20 degrees. Identical percentage changes are considered for the other climatic variables.

Table 7. Distribution of tourists visiting the EU by country of origin, destination and length of stay, 2011

	Holidays abroad		Holidays in country of residence		
Country of origin	Long-stay	Short-stay	Long-stay	Short-stay	Share in total EU Tourists´ bednights
Austria	35.1%	18.9%	14.7%	31.3%	2.4%
Belgium	52.6%	9.3%	21.7%	16.4%	1.9%
Bulgaria	9.3%	34.8%	3.4%	52.5%	0.4%
Cyprus	43.2%	10.8%	5.1%	40.9%	0.2%
Czech republic	12.5%	21.3%	3.3%	62.9%	1.1%
Denmark	15.9%	10.6%	5.9%	67.7%	1.1%
Estonia	22.2%	8.6%	14.5%	54.7%	0.1%
Finland	7.2%	15.3%	8.5%	69.0%	1.2%
France	8.7%	39.5%	2.6%	49.2%	10.8%
Germany	27.9%	21.9%	5.5%	44.7%	21.3%
Greece	18.4%	26.4%	5.3%	49.9%	1.4%
Hungary	11.7%	18.2%	7.7%	62.4%	0.8%
Ireland	18.4%	26.4%	5.3%	49.9%	0.6%
Italy	14.8%	38.0%	4.7%	42.5%	11.1%
Latvia	14.3%	7.4%	7.8%	70.4%	0.1%
Lithuania	24.1%	11.3%	12.3%	52.3%	0.2%
Luxembourg	59.9%	0.6%	39.1%	0.4%	0.1%
Malta	37.3%	5.1%	10.9%	46.6%	0.1%
Netherlands	41.4%	21.3%	10.8%	26.5%	3.3%
Poland	11.2%	35.4%	2.7%	50.7%	2.0%
Portugal	6.4%	25.6%	2.7%	65.3%	1.3%
Romania	6.2%	35.2%	0.6%	58.1%	1.2%
Slovakia	29.8%	26.4%	9.6%	34.1%	0.4%
Slovenia	32.0%	10.1%	23.7%	34.2%	0.2%
Spain	5.7%	28.0%	2.7%	63.7%	8.9%
Sweden	15.9%	19.5%	8.4%	56.2%	2.3%
United Kingdom	32.6%	19.1%	5.8%	42.5%	13.6%
Rest of the World		-	-	-	*11.7%*

Source: Eurostat and authors´calculations. Note: Greece and Ireland values are EU-average given that the data were missing for these two countries.

Map 1: Hotel location across NUTS2 regions



Sources: HotelsCombined and JRC, European Commission

Map 2: Road Network and Airports considered in TRANS-TOOLS

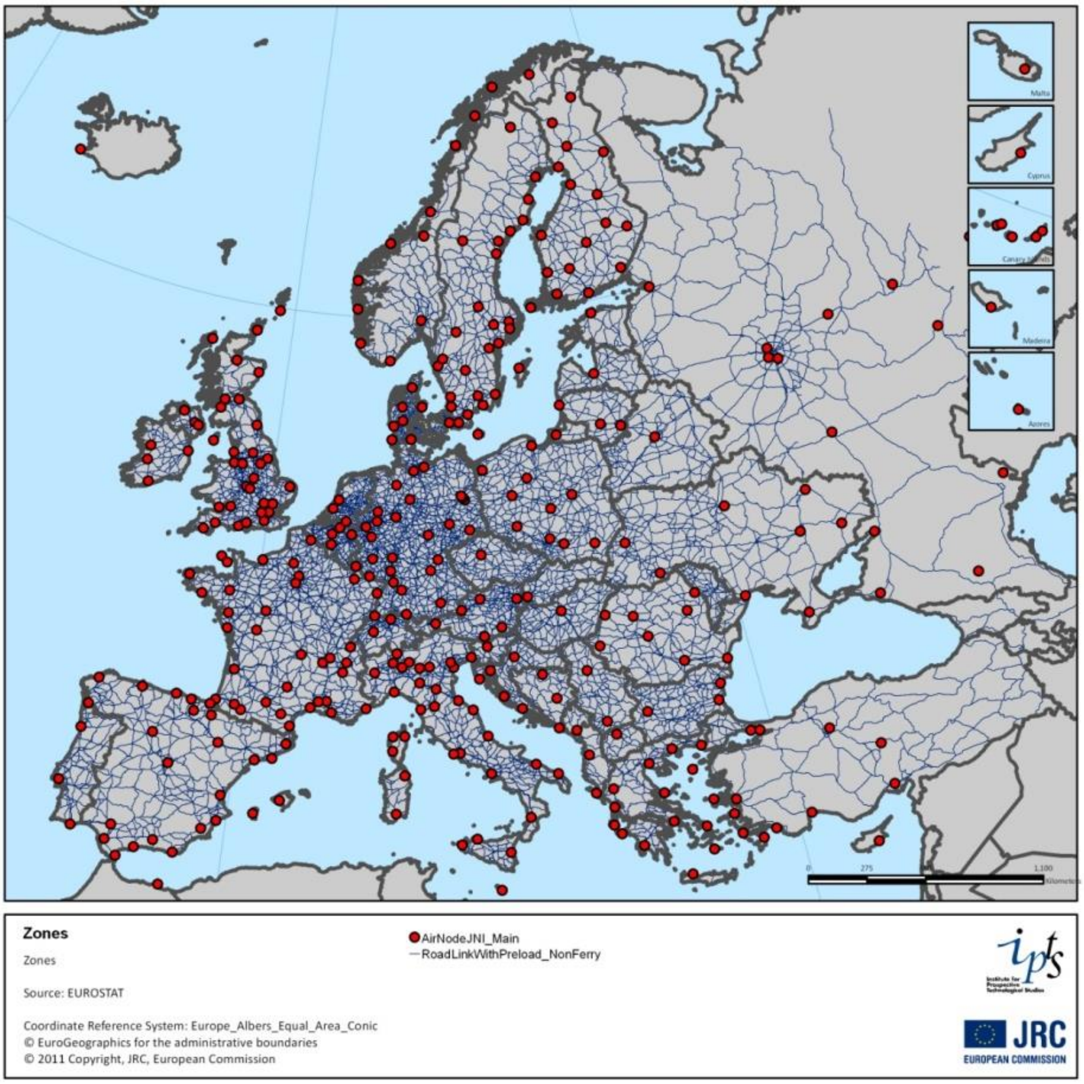
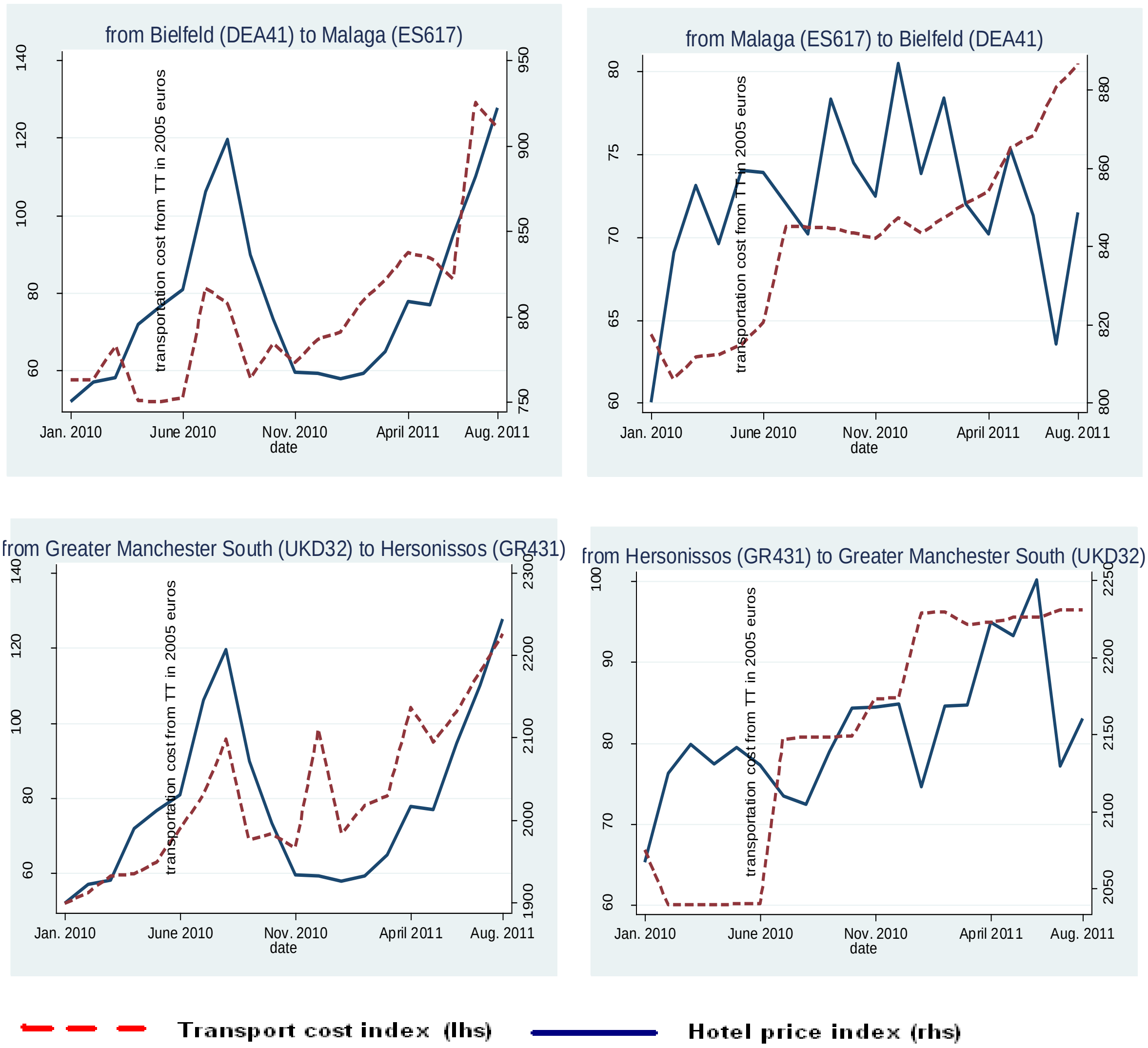


Figure 1: The cost of tourism services by region of origin and destinations -Examples of estimates for selected regions



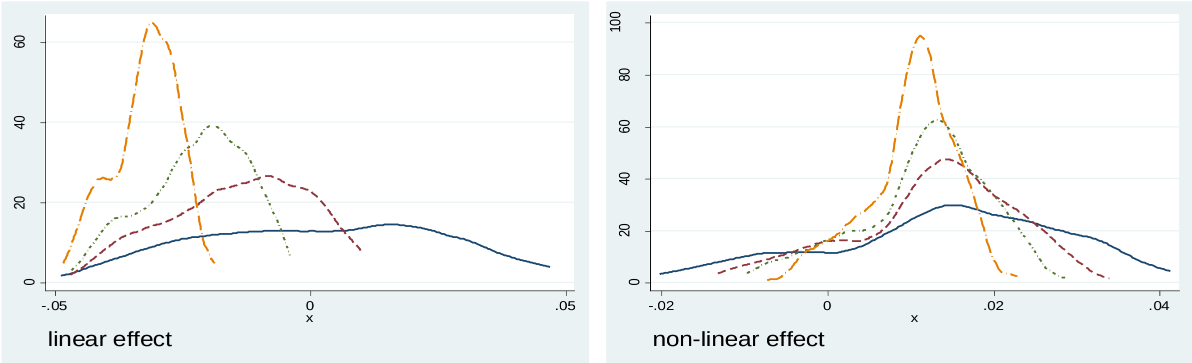
Sources: HotelsCombined and TRANS-TOOLS estimates, JRC, European Commission

Figure 2: The cost of holiday in selected regions groups and by holiday duration

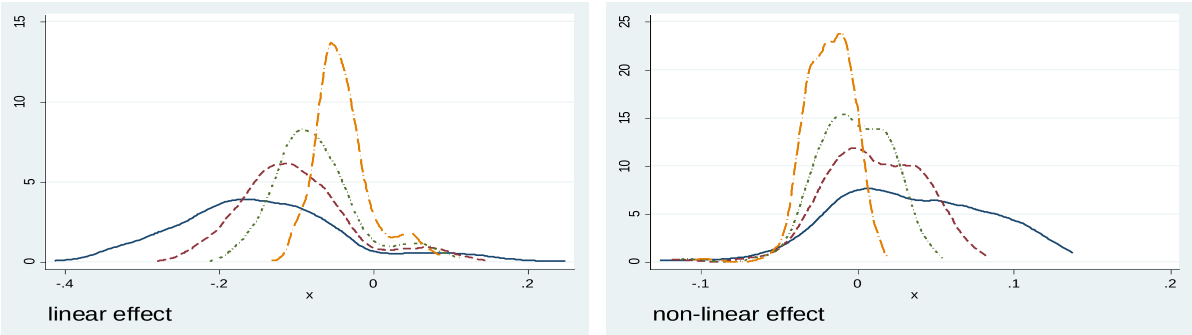
Sources: HotelsCombined and JRC, European Commission

Figure 3: Kernel distribution of estimated marginal willingness to pay for the temperature variable in January and April: linear effect (lhs) and non-linear effect (rhs).

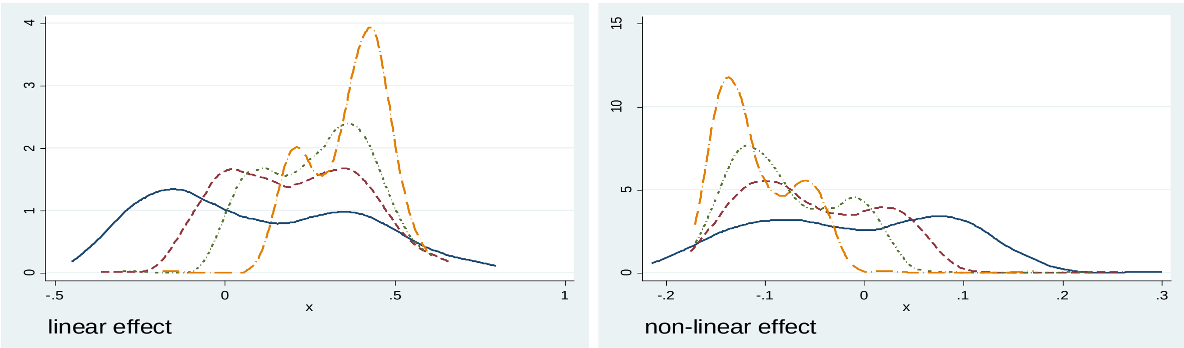
January



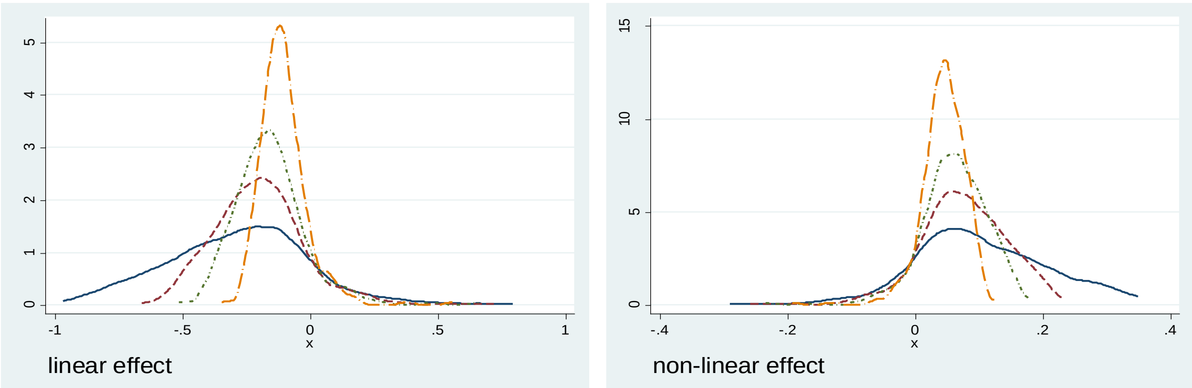
April



July

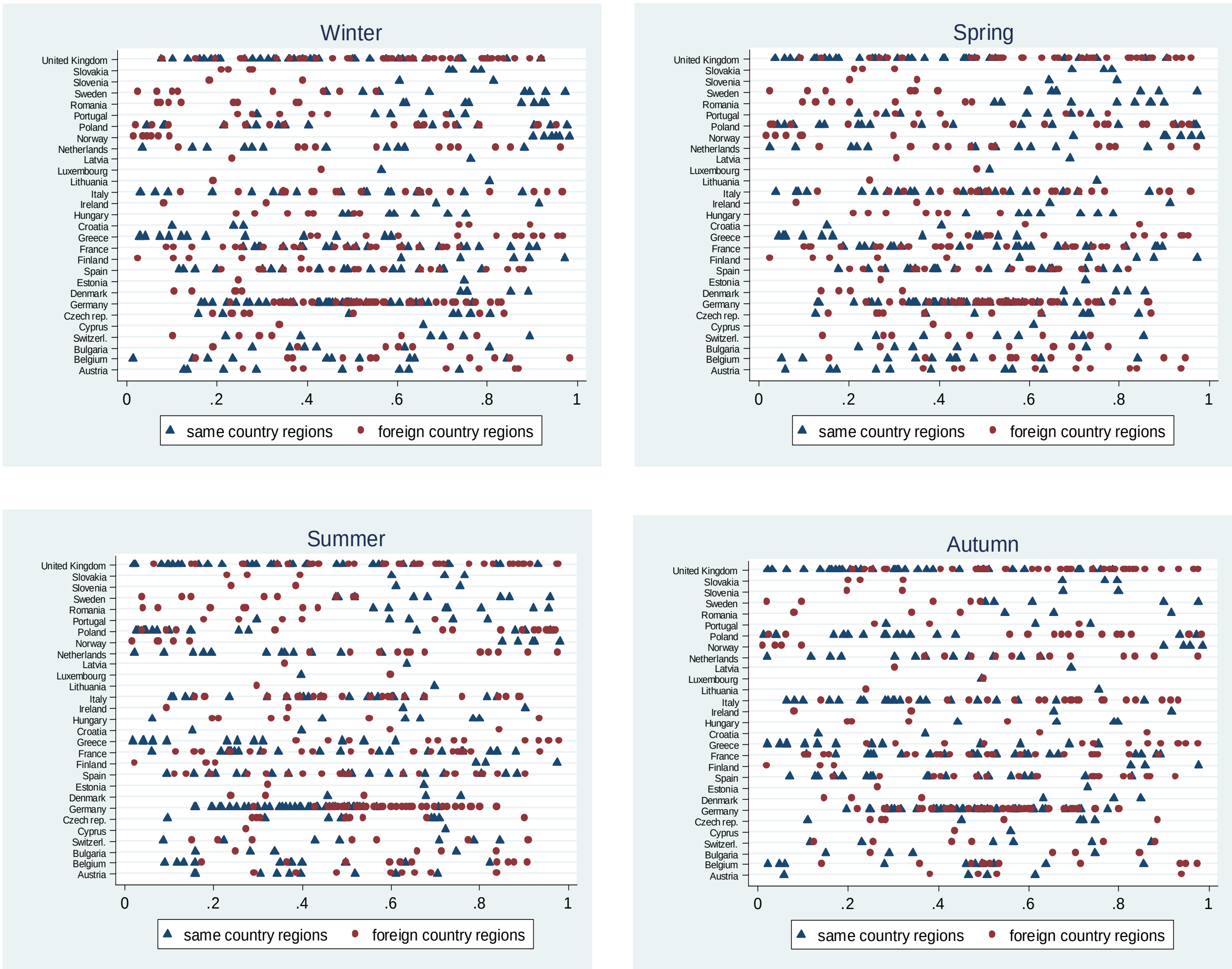


October




temperature, one day
temperature, four day
temperature, one week
temperature, two week

Figure 4: Distribution of bednight by region of origin and destination of tourists (foreign vs. domestic)



Note: Each do represents a NUTS2 region of origin tourists. A triangle represents the share (in %) of tourists outside the country of residence. A circle represents the share (in %) of tourists within the same country of residence. Sources: EUROSTAT, TRANSTOOLS and authors´ calculations

Figure 5: Marginal Willingness to pay for temperature in a selected sample of origin regions: long-run projections

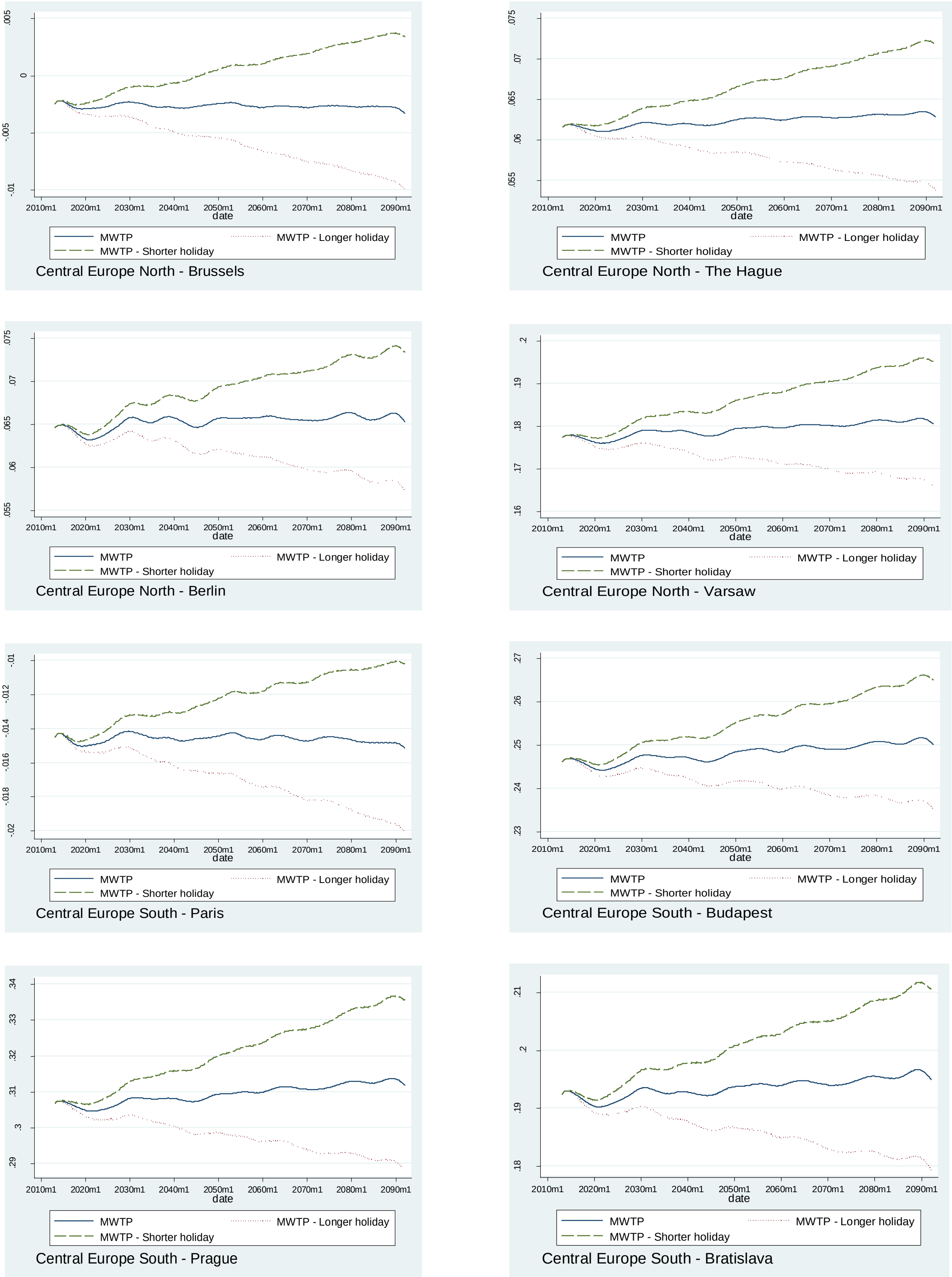
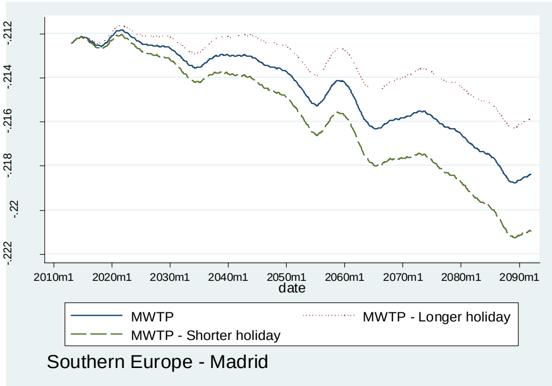
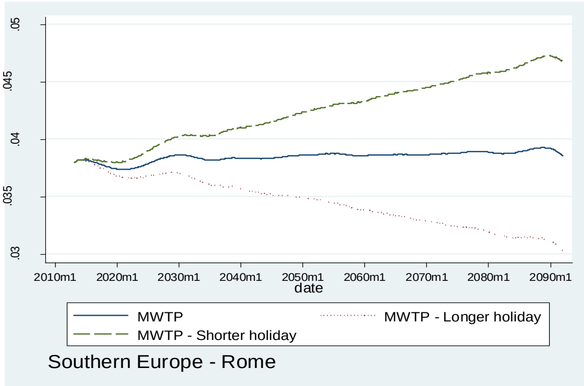
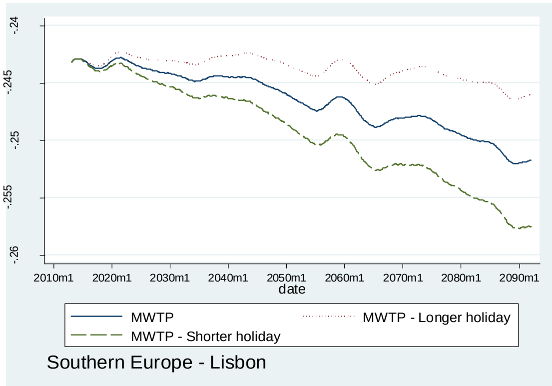
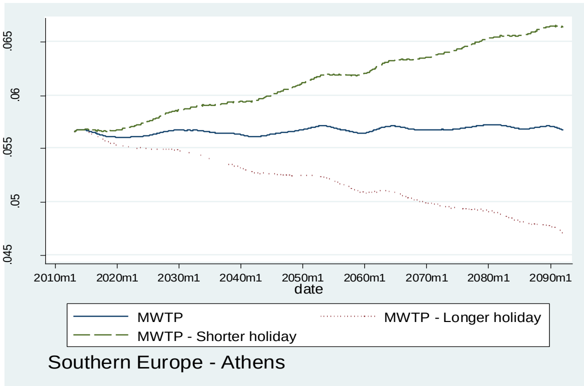


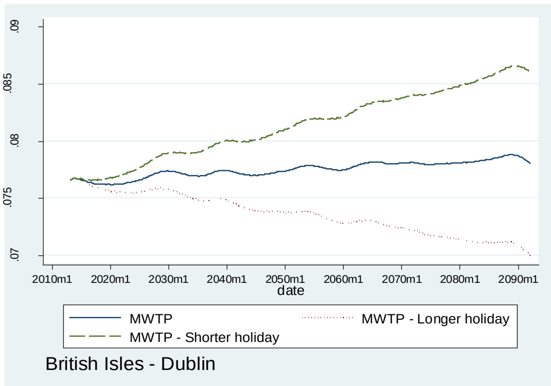
Figure 5 (*continued*): Marginal Willingness to pay for temperature in a selected sample of European regions: long-run projections.

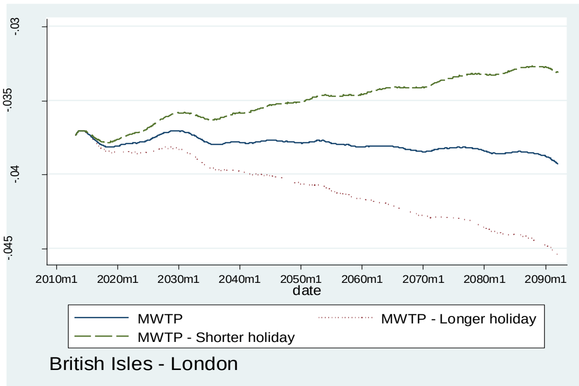


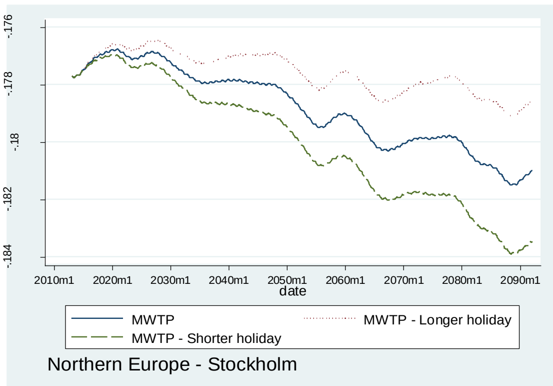












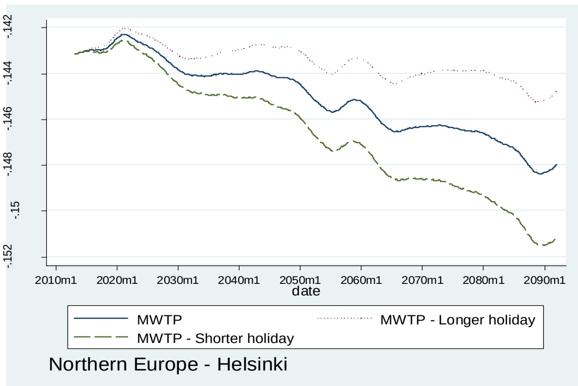
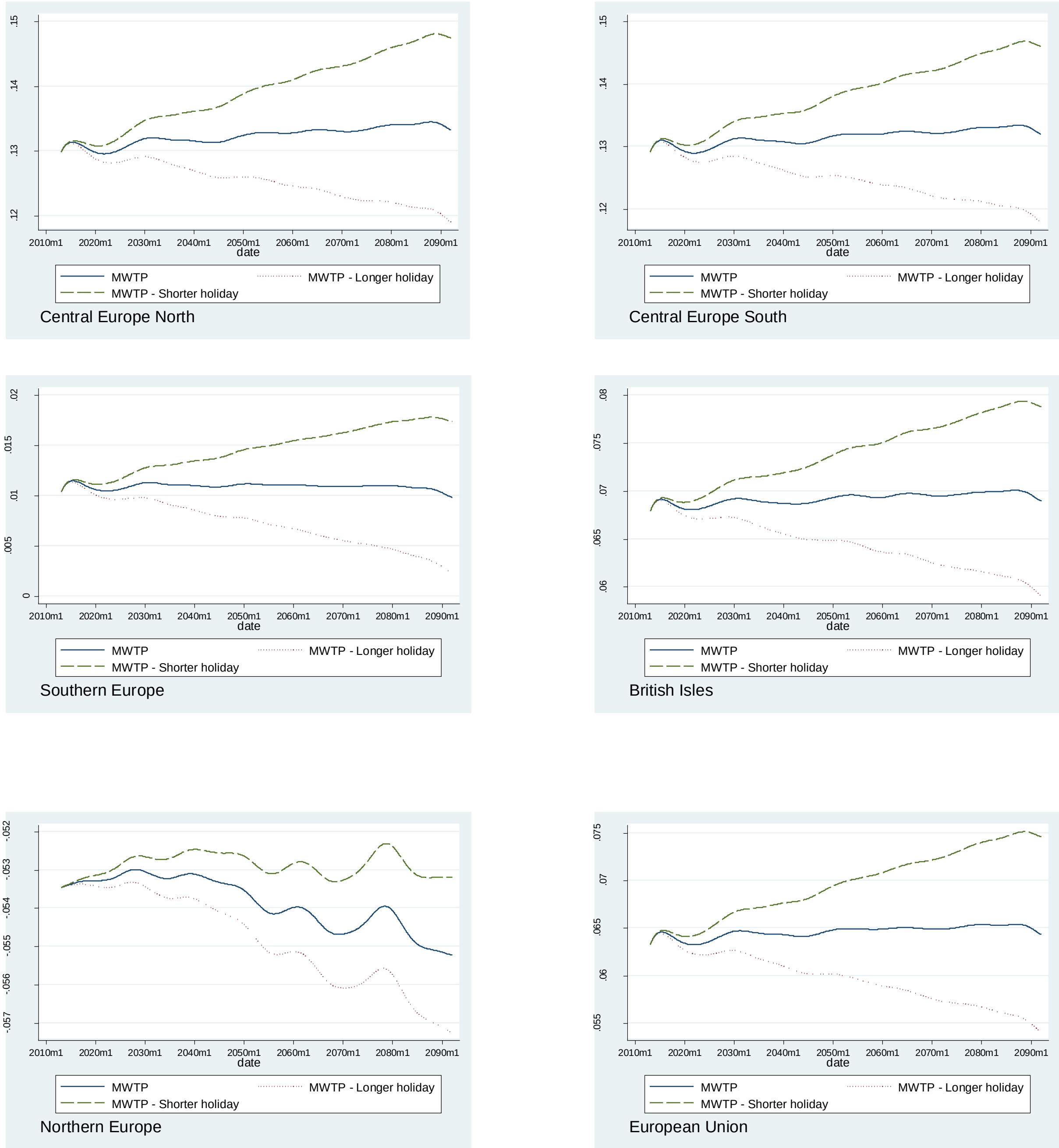
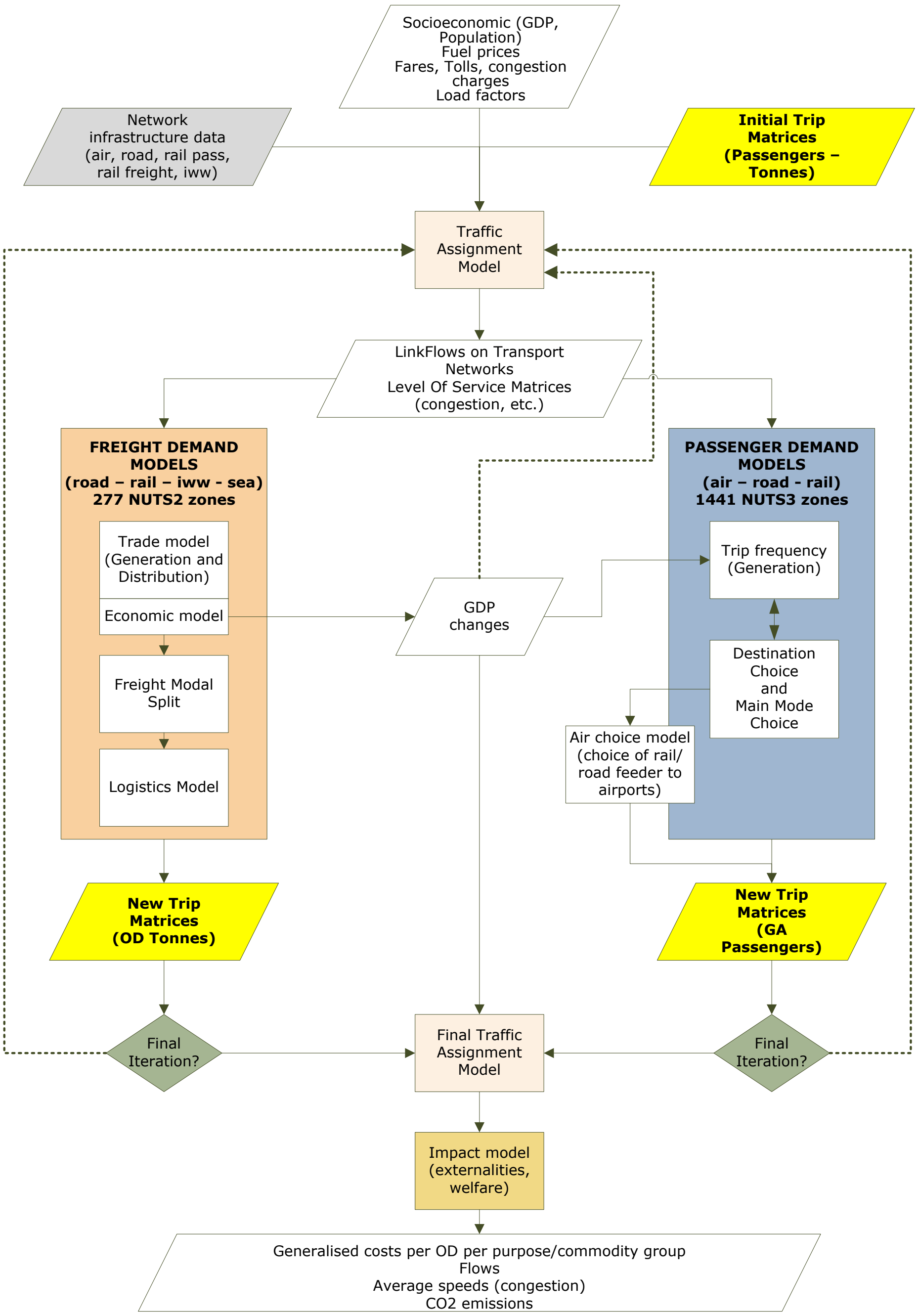


Figure 6: Marginal Willingness to pay for temperature by broad geographical areas and the EU: long-run projections



Appendix 1: TRANS-TOOLS flowchart



Appendix 2: Trans-Tools model estimation procedure

This appendix describes the different stages of the Trans-Tool model simulations and the structure of the nested-logit model that represents the backbone of the model. A first regression is run that determines the attraction variable *Size* for each region *d* according to the following expression:

$$Size_d = \theta_1 \ln\left(POP_d + \theta_2 JOB_d\right) + \theta_3 \ln CAP_d + \theta_4 \ln GDP_d \quad \text{(A1)}$$

where POP_d is the population of zone *d* , JOB_d is the number of jobs, CAP_d represents the bedplace capacity for visitors, and GDP_d is the gross domestic product. The probability that the transport mode *m* is chosen to complete a tour of type *n* is modeled as a 2-level nested logit model as indicated below where *m* refers to the mode of transport chosen to complete the tour (air, rail, car, bus) and *d* refers to any of the potential destination zones reachable in tour *n*. Destination and origin zones define a specific tour. We identify them at the sub-division of the NUTS2, i.e. the NUTS3 level.

$$P_n(m,d) = P_n(d) \cdot P_n(m|d) = \frac{e^{V_n(d)}}{\sum_{d'} e^{V_n(d')}} \cdot \frac{e^{V_n(m|d)}}{\sum_{m'} e^{V_n(m'|d)}} \quad \text{(A2)}$$

The utilities participating in both levels of the nested logit are defined as:

$$\begin{aligned} V_n(d) &= Size_d + Adj_n + \mu_d \ln \sum\nolimits_{m'} e^{V_n(m'|d)} \\ V_n(m|d) &= \varphi_m \\ &+ \sum\nolimits_q \varphi_{q,GTC} f\left(GTC_{m|d,q}\right) \\ &+ \varphi_{q,AE} AccEg_{m|d,q} \\ &+ \varphi_{q,F} Freq_{m|d,q} \\ &+ \varphi_{q,FT} FerryTime_{m|d,q} \\ &+ \varphi_{q,HW} HeadwayTime_{m|d,q} \\ &+ \varphi_{q,TT} TransferTime_{m|d,q} \\ &+ \varphi_{q,m=car} CarAv_n \end{aligned} \quad \text{(A3)}$$

Where $Size_d$ is the attraction variable that varies over destinations, $Adj_{d,q}$ is a sampling correction factor, $f(GTC_{m|d,q})$ is the generalised travel cost on the basis of in-vehicle time and out-of-pocket costs as follows:

$$GTC_{m|d,q} = Cost_{m|d,q} + \gamma_{nm}\left(OnboardTime_{m|d,q} + \kappa_n CongestionTime_{m|d,q}\right) \quad \text{(A4)}$$

$AccEgg_{m|d,q}$ is access and return time (only valid for the rail and air mode), $Freq_{m|d,q}$ is rail frequencies, $FerryTime_{m|d,q}$ is gross ferry time including on-board ferry time and waiting time, $HeadWayTime_{m|d,q}$ is the headway time for the air transport mode, $TransferTime_{m|d,q}$ is transfer time for the air transport mode and $CarAv_n$ is car availability based on the number of private cars in the households in destination zone n (recorded from the DATELINE survey).

The estimation of the coefficients for the nested logit model is carried out after the calculation of the coefficients of the *Size* equation. Different cost functions (*f* above) are used for short and long distance travel (100 km being the threshold) and also, within the long-distance category, a 600km threshold is considered to define different cost function below and beyond such threshold. The final result of the cost specification is the outcome of an exploration of linear and non-linear forms of the transport costs reflecting the different characteristics of short and long-distance travel. In particular, the functional form issue has been considered along two dimensions, through a distance dependent parameter split (under and over 600 km) and linear versus logarithmic specification of the generalised travel cost variable (f). In the passenger model the mode and destination choice model presented above is linked to a frequency model by a logsum measure to account for accessibility effects in the trip generation of induced traffic. The frequency, destination and mode models therefore cover the three first steps of the modelling. The fourth step of the modelling is related to the assignment of the trips between zones into actual routes in the network, with routes being compared in terms of their time and cost components and the total trips per mode and origin and destination being assigned according to them. In this fourth stage TT calculates the generalised cost applicable for a return trip by each of the three modes of transport considered for holiday trips. These costs are consistent with the nested logit passenger demand and take the following form for the different transport modes considered:

(i) Air - Holiday:

$$\begin{aligned} GenCost = {} & LinkCostVacation + TotalConCost \\ & + 0.230 \cdot VoTFactor \cdot ConTime \\ & + 0.230 \cdot VoTFactor \cdot LinkTime \\ & + 0.345 \cdot VoTFactor \cdot TransferTime \\ & + 0.345 \cdot VoTFactor \cdot HeadwayTime \end{aligned} \tag{A5}$$

Where *LinkCostVacation* is the total cost for a return air fare, *TotalConCost* is the total cost involved in accessing and returning from the airport, *VoTFactor* is the value of time accruing to travelers from a given zone and *ConTime*, *LinkTime*, *TransferTime* and *HeadwayTime* are the four types of times characteristics of an air trip (the former refers to the time spent in accessing/returning from the airport).

(ii) Road - Holiday:

$$\begin{aligned} GenCost = {} & LinkCostPC + FuelCostPC \\ & + 0.0928 \cdot VoTFactor \cdot FreeFlowTime \\ & + 0.1448 \cdot VoTFactor \cdot CongestedTime \\ & + 0.0096 \cdot VoTFactor \cdot FerrySailingTime \\ & + 0.1448 \cdot VoTFactor \cdot FerryWaitingTime \end{aligned} \tag{A6}$$

$$LinkCostPC = Length(km) * TollCostPC + GenericCostPC$$

Where *LinkCostPC* is basically toll fares and specific vignettes applying in part of the network, *FuelCostPC* is fuel costs, *VoTFactor* is equivalent to the one for air (although TT controls for changes in values of time by mode) and *FreeFlowTime, CongestedTime, FerrySailingTime* and *FerryWaiting* time are the types of time a typical road trip is divided into (obviously the ferry times only apply to certain trips.)

(iii) Rail - Holiday:

$$\begin{aligned} GenCost = {} & 0.1500 \cdot LinkLength \\ & +0.1090 \cdot VoTFactor \cdot FreeFlowTime \\ & +0.1090 \cdot VoTFactor \cdot ConTime \end{aligned} \tag{A7}$$

The main out-of-pocket costs for air and rail are the ticket costs (15 Euro cents per km in rail and specific collected data for each air route) and for road these are the fuel costs (according to unitary costs of each of the countries covered in the route). The use of values of time per from zone (*VoTFactor*) takes into account the fact that holiday trips are return trips.

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