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Time is of the Essence: Adaptation of Tourism Demand to Climate Change in Europe

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Time is of the essence: adaptation of tourism demand to climate change in Europe *

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Abstract

This study analyses the potential impact of climate change on EU tourism demand and provide long-term (2100) scenarios accounting for adaptation in terms of holiday duration. Our long-term projections for tourism demand are based on hedonic valuation of climatic conditions combining hotel price information and travel cost estimations. This approach allows us to analyse together the climatic aspect of recreational demand and its travel cost dimension and thus to draw alternative hypotheses regarding the time dimension of tourism demand. We derive alternative scenarios for adaptation of holiday in terms of holiday frequency and duration. We find that the climate dimension plays a significant (economically and statistically) role in explaining hedonic valuations of tourism services and, as a consequence, its variation in the long-term are likely to affect the relative attractiveness of EU regions for recreational demand. In certain cases, most notably the Southern EU Mediterranean countries climate condition in 2100 could under current economic conditions, lower tourism revenues for up to -0.45% of GDP per year. On the contrary, other areas of the EU, most notably Northern European countries would gain from altered climate conditions, although these gains would be relatively more modest, reaching up to 0.32% of GDP on an annual basis. Overall our results suggest that the change in holiday duration appears to be more beneficial than the change in the frequency of holidays in view of mitigating the cost of climate change for the tourism sector. These two time dimensions of adaptation are likely to be conditioned by broader societal and institutional factors, however.

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1. Introduction

The consequences of climate change for the tourism industry are unlikely to be uniform across European regions, see Higham and Hall (2005) and Rosselló and Santana (2005). Existing climate projections in the European case indicate that climatic conditions might become more favourable for tourism in the Northern regions and less so in the Southern regions, see Ciscar et al. (2011). The net losses or gains induced by the changes in climatic conditions will depend on the changes in tourists´ valuation of climatic-related amenities, however. For instance one would expect that inhabitants of Northern EU regions would value climatic conditions differently from people in Southern regions who have an easier access to sun tourism-related amenities which represent the most common type of tourism, see Morris and Walls (2009).[1] Likewise, the travel cost dimension of tourism demand might have a bearing on the valuation of climatic conditions and possibly on adaptation strategies to climate change.[2] Existing studies usually fail to consider issues related to the accessibility of tourism-related amenities and are thus likely to miss an important determinant of tourism destination choices. By extension, existing estimates of the potential impact of climatic change on tourism demand fail to consider the differential effects that climatic change might have depending on the region of origin of tourists.

Recent research has investigated the potential impact of long-term change in climatic conditions on tourism demand in Europe. A common feature of existing studies is that they project a significant deterioration of the suitability for tourism of EU Mediterranean regions, especially during the summer months (the traditional holiday season), and a change in some EU Northern regions' climate that would

[1] In this paper we do not consider alternative tourism activities such winter tourism although this type of activity is also very likely to be altered by climate change.

[2] Aspects of tourism adaptation 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 their holiday choices.

potentially benefit from a re-shifting of tourists flows see, for instance, Amelung and Moreno (2012) for a review. Most of these studies have been either conducted on a country-level basis (where world data is available), see, for instance, Hamilton et al. (2005), Lise and Tol (2002), Amelung et al. (2007) and Berrittella et al. (2006) or, alternatively, on a regional basis where site-specific vulnerability to climatic conditions is more easily identified, see, for instance, Maddison (2001), Maddison and Bigano (2003), Harrison et al. (1999), Perry (2000) and Amelung and Moreno (2009, 2012). Our approach relates more directly to the latter authors, who investigate the influence of climatic condition based on a Tourist Climatic Index (TCI) and include this variable as determinant of tourist flows (represented by the number of bednights) in EU NUTS2 regions.[3] We adopt a similar focus on EU NUTS2 regions and make use of the same variable to represent tourist demand (i.e. the number of bednights). Unlike the previous authors, however, we consider the influence of climatic variables separately from each other (together with their squared value in order to capture potential non-linearity), in the spirit of the literature on recreational demand and hedonic travel cost, see in particular Brown and Mendelsohn (1984), Englin and Mendelsohn (1991) and Pendleton and Mendelsohn (2000). In doing so we estimate separately the contribution of each climate variable interacted with monthly dummy variables in order to yield monthly-specific estimates of the marginal willingness to pay for specific climatic condition.

Our study brings a number of novel contributions to the existing literature. First, we derive region-specific estimates of the impact of climate change based on tourism demand in European regions taking into account regions' specific characteristics including as main explanatory variable of interest a hedonic price index reflecting tourists´ valuation of climatic conditions. Second, our hedonic price estimation combines the climatic aspect together with the transport and accommodation cost

The TCI is a weighted average of the value taken by climatic variables relevant for tourism comfort and in particular sun-tourism. Amelung and Moreno (2012) include in the TCI the maximum and mean daily temperature, the minimum daily relative humidity, mean daily relative humidity, precipitation, sunshine and wind speed.

dimension of tourism. Transport cost estimations are based on the TRANS-TOOLS model covering intermodal transports and from which bilateral tourism-specific travel cost between EU regions are obtained. The cost of accommodation is proxied using a detailed database on hotel prices at regional level. An average price of tourism services can then be derived 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). We then estimate a hedonic price equation using this price indicator as dependent variable and a set of climatic variables together with their square term (to capture non-linearity) as explanatory variables together with a number of other determinants of tourism-related regional attractiveness. By estimating such hedonic price index we can make different hypotheses regarding holiday duration simply by altering the relative weight of the transport cost in the hedonic price. This allows us to make inferences about the potential impact of climate change depending on holiday duration patterns. The duration of holidays is thus considered explicitly as a factor of adaptation together with decisions affecting the timing of holidays. The hedonic price index is then plugged into a tourism demand equation using the number of bednights per region of destination as dependent variable. The economic cost of climate change on the tourism industry is then analysed using data on tourists´ expenditure taken from the Eurostat (i.e. the EU statistical office) database.

Our main results show that the climate dimension play a significant (economically and statistically) role in explaining hedonic valuations of tourism services and, as a consequence, its variation in the long-term (2100) are likely to alter the relative attractiveness of EU regions for tourism demand. We find that in certain cases, most notably in the Southern EU Mediterranean countries, climate conditions could under current conditions, lower tourism revenues between -0.45% and -0.31% of GDP per year depending on the climatic scenario and model run considered. On the contrary in other areas of the EU, most notably in Northern European regions and the British

Isles, tourism activity could instead benefit from these long-term climatic changes. For instance the British Isles and Northern European regions could gain up to 0.32% and 0.29% of GDP per year respectively. Central European regions would be much less affected with potential losses and gains in the range of -0.16% / + 0.13% of GDP. We also show that adaptation choices in terms of holiday duration as well in the timing of holidays choices can modify change these projections. We find in particular that the cost of climate change in terms of tourism demand would fall significantly in Southern European regions to a minimum of -0.24% of GDP if tourists were assumed to adapt their holiday duration freely. In this case, the potential gains would be reduced at 0.29% and 0.22% for Northern European regions and the British Isles, respectively. We find that the changes in the timing of holiday would not result in substantial variations in Southern European regions´ losses and would reduce the potential gains of other areas. Overall our results suggest that the change in holiday duration appears to be more beneficial than the change in the frequency of holidays in view of mitigating the cost of climate change for the tourism sector. The rest of the Study is organised as follows. Section 2 outlines our research strategy while Section 3 provides the results of our hedonic price estimations. The tourism demand estimations and long-term projections are provided in Section 4. Section 5 summarizes the main results and concludes.

2. Research strategy

Our analysis is organised in three main steps. In the first step we estimate hedonic price equations to derive the hedonic price index of tourism services and associated marginal willingness to pay (MWTP) of tourists for climate amenities in EU regions. Four different climate explanatory variables are used taking monthly average of daily figures: average temperature level, average level of precipitation, average humidity and average wind speed. These variables are interacted with monthly dummy variables such that the estimated MWTP for each of these climatic characteristics is month-specific. In a first step we estimate these hedonic price equations separately for each region of origin of tourists following the literature on the recreational demand using hedonic price to value site-specific amenities, see in particular Brown and Mendelsohn (1984). The dependent variable in these equations is the sum of two components: the travel cost between each origin and destination region (estimated using the TRANS-TOOLS model, see Section 3 below) and of the average price of a standard hotel bedroom. Considering that holiday stays may vary in length, we calculate four different values of the dependent variables according to the length of holiday stays, thus considering alternatively one-night, four-night, one-week and two-week stays. The average of the estimated hedonic prices and estimated MWTP for climatic services are then calculated for each region of destination, region of origin and length of stay. In a second step these estimated MWTP are averaged across regions of destination using weighted average where the weights are given by the bilateral regional tourists flows (see Section 4 for further details on this data). In a third step the tourists demand equation are estimated for each region of destination using the total number of monthly bednights as dependent variable and the monthly hedonic price of holiday estimated previously. The average population of the origin region is added as control variable to reflect the size of the potential tourism demand (using weighted average based on bilateral tourism flows). These equations are estimated using monthly data and the estimated coefficients are used to make the long run projection according to four different climate model runs. The estimated propensity to pay for each specific climatic variable are used to extrapolate the value of the climatic variables. The latter means that the long-term projections of tourism demand are performed as if current conditions other than climate prevailed. The different steps of our research and the results obtained are presented in more details below.

3. The Hedonic price model

3.1 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). Our aim is to analyse the correlation 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 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. However, given the potential importance of these other variables as determinant of tourism demand we consider them by means of including several control variables as described below. Following the literature on recreational demand we estimate a separate regression for each region of origin, see Brown and Mendelsohn (1983). In doing so we assume that all tourists originating from a given origin region face similar travel cost. 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. The term X 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, namely temperature, wind speed, humidity and precipitation. These coefficients can be interpreted as the *marginal willingness to pay* (MWTP) whereby β indicates the supplement a tourist from a region i is willing to pay for a given percentage change in one specific climatic variable. Since the equation (2) is estimated for each of the 303 regions of origin considered, we thus obtain a set of 4 x 12 x 303 = 14544 monthly MWTP for all the four climatic variables considered in the hedonic price equations. Before turning to the description of the variables included for the estimation of equation (2) we need to explain the way the dependent variable was constructed given that this has a direct implication for our approach of adaptation strategies to future climate change.

3.2 Hotel prices data

The hotel price data used in this paper comes from the web booking company HotelsCombined (http://www.hotelscombined.com/) and covers 53211 hotels in 233 EU NUTS2 regions (including Swiss and Croatian regions). The hotel prices are available 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 and representative of the hotel location across Europe. The original data are available on city-basis and includes geographical coordinates of the hotels which we used for the aggregation to the NUTS2 level. In addition the data includes information on the number of hotels (covered by the sample) and star-category of the hotel. Overall the coverage of the HotelsCombined database is fairly good as this data represents 26.3% of the total number of hotels in Europe (Source: Eurostat). 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 although the coverage can be considered as fairly good especially for those regions mostly concerned by sun-tourism. 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. Our (unreported) results suggest that, as expected, the star-category appears to be a significant determinant of the hotel price. 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. These results indicated that hotel prices are significantly larger during the summer month possibly reflecting the seasonal nature of hotel activity, see Barrios and Ibañez (2013) for details on these results. Finally it is important to note that these data do not include price offered in tour-operator packages which may offer further discount. The data used here is as announced in hotel websites for reservation. This could possibly result in upward biased prices.

3.3 Estimation of travel cost

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 42 European countries, covering both passenger and freight transport[4]. Two key features of TRANS-TOOLS have been adapted in order to

[4] TRANS-TOOLS (TOOLS for TRansport Forecasting ANd Scenario testing) has been developed in collaborative projects funded by the European Commission's DG MOVE and DG JRC. The model is owned by the EC and is based on IPR-free modules with an open GIS architecture. DG 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 materialised in a first fully operational tool after completion in June 2007 of the (6th FP-funded) TRANS-TOOLS project. The TENConnect studies funded by DG MOVE in 2008 and 2011 have

reflect tourists´ specific transport cost. First the survey data used to calibrate the model distinguishes tourists´ trip from other types of trip (e.g. business). Second the hotel bed capacity is used to explain potential changes in tourist´ trips between origin and destination regions. The transport cost estimated thus takes specifically into account the pull effect associated to hotel bed capacity. TRANS-TOOLS estimates the transport costs by mode associated with a given transport policy measure and simulates the impacts of such measures on the demand for transport services by mode (on network links and corridors and on origin-destination pairs). One of the unique features of TT is that it includes in the analysis networks at a European level for all transport modes. In this study the two main TT components that we have focused on refer to passenger transport and, in particular, to the total trips per mode and unitary costs per mode associated with the use of air, road and rail networks for holiday trip purposes. Holidays is one of the four trip purposes differentiated in TT, along with business, private (excluding holidays) and work (commuting). Importantly, TT includes both ticket cost and time spent during the entire trip (e.g. including queuing at the airport or train station). Within each trip purpose, TT follows a traditional 4-step modelling approach (see, for instance, Ortúzar and Willumsen, 1994). The four steps include trips generation, trips distribution, trips mode choice and trips route assignment. The trips generation evaluates the transport demand that each zone in the model (NUTS3 provinces) generates or attracts, and depends on the socio-economic characteristics of each zone, as well as on the specific economic and industrial structures characterising each zone and those connected to it. The trip distribution reflects the demand for transport between each pair of zones in the system and depends on trade and travel patterns, as well as on the availability and specific costs of transport between each pair of zones. The mode choice provides the part of the demand for each pair of zones that will use each available mode and depends on the relative costs, speed and

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improved the model further and delivered the current version of the model (TT 2.5.0), which is the one we have employed in this study. Figure 13 provides a flow-chart of the model structure.

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, within each mode, the links of the network where transport demand will be distributed and depends on costs, speed and capacities of the available route options. For this tourism trip purpose the main data element to build a passenger demand model to link observed holiday trips with level of service variables such as time or cost has been the DATELINE survey (see, for instance, Brög et al., 2003), which covers the trips carried out by respondents across Europe (a total of 85 000) regarding their holiday trip purposes in the year 2002 (the survey results are from 2003 and they also include other trip purposes). It should be noted also that TRANS-TOOLS estimates take into account the radical change in the air-transport with the entry of low-cost carriers since the early 2000s. 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) and Barrios and Ibañez (2013) for more details.

We have used the high level of detail inherent to TT (with NUTS3 to NUTS3 trip and cost matrices) to produce cost matrices at NUTS2 level including the average cost of transport between each EU NUTS2 regions. To build this NUTS2 matrix we have first analysed TT results for 2005 (the year TT is calibrated for) and compared them with data on holiday trips available from EUROSTAT at a country level. We have used this EUROSTAT country matrix to adjust TT trips in order to add up to EUROSTAT totals, in doing so we keep the fine level of detail of TT (NUTS3) while ensuring that the aggregate figures are consistent with EUROSTAT totals by 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, next 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. In the final step of our use of TT results, we use this NUTS2 trip matrix to further disaggregate the origin of the tourists leading to the total number of bednights spent in each NUTS2 region. These bednights are available for each NUTS2 region and distinguishes between country of origin of the tourists. With our NUTS2 trip matrix we disaggregate into a more detailed level and only by assuming that the relative importance of trips assigned by TT holds. Hence, we avail of a detailed indication of the bilateral transport cost specific to tourism trip for region of origin of tourists in order to estimate our hedonic price equation.

3.4 Tourism services valuation

It is important to note that the travel cost estimates are average figures for the year 2005. The potential seasonal variation is absent from this data. This means that the monthly variability of the tourism price variable Z_j^i would be entirely driven by the variability in hotel price. In order to palliate this shortcoming we introduced seasonal variation in the cost of transport indicator by using Eurostat country-level monthly price indices for transport. One must note that this change is only imperfectly reflecting the seasonal nature of tourism transport price since the country-level transport price index also includes non-tourism transport. In practice part of the transport costs for tourist are likely to be higher during the summer holiday season, especially so in the case of air and rail transport. Our tourism price variable is therefore likely to be biased downward during the holiday months and upward during the non-holiday months. In principle this issue could be controlled for (at least in part) by correcting the data used in the regressions for their seasonal component (i.e. through the inclusion of monthly dummy variables) in our regressions. These issues are discussed in more details in Section 4. In order to be able to add the hotel price to the transport cost we also deflated the monthly hotel price data in order to express them in 2005 euro values. We checked whether these transport cost and hotel price monthly variation displayed a particular seasonal pattern. In order to do so we compared the evolution of these costs for traditional regions of destinations traditionally with other less touristic regions. Figure 1 highlights a number of important features of our cost of holiday indicator for two subsets of regions depending on their sea basin. The first set of regions concerns the Mediterranean and Adriatic sea regions (48 NUTS2 regions of France, Italy, Malta, Slovenia, Greece, Italy, Cyprus, Switzerland and Bulgaria) and the second set the North and Baltic sea regions (109 regions of the UK, Sweden, Poland, the Netherlands, Latvia, Lithuania, France, Germany, Switzerland, Austria and Belgium) with the former group of regions being traditionally preferred destination for sun-tourism. Overall the difference in seasonality appears to be more pronounced when moving from short stays (which in Figure 1 corresponds to the top panels) to long stays (the bottom panels). This feature is not surprising to the extent that the accommodation share of the total holiday cost increases for long stay such that the more pronounced seasonal component of hotel price vs. transport cost is also more dominant. In addition the cost of holidays tend to be higher for holidays in traditional summer holiday regions which also can be interpreted as a higher demand. The hedonic price estimations undertaken in the sequel attempt to analyse the correlation between the cost of holiday variable depicted in Figure 1 and the climatic conditions in the EU regions. Given the highly seasonal pattern of holiday cost and the preferred choice for Southern/sunny EU regions during the summer season in particular one would expect that these cost and price variables would reflect the preferences (or marginal willingness to pay) for the climatic conditions prevailing during the holiday seasons in regions traditionally chosen as holiday destinations.

3.5 Hedonic price regressions

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), 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. Four such 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. 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 (2100). The KNMI-RACMO2-ECHAM5-r3 run was preferred over the alternative model/scenarios as it provides a wider set of climatic variables (see Section 6 for further details on the climatic data used for the long-term projections). The climate scenarios used in this study are the ones used in other sector-studies of PESETA II following Perch-Nielsan et al. (2010) and model-runs described in Dosio (2011). The different scenarios and model-runs are summarised in Table 2. As mentioned earlier, we focus on sun tourism as our empirical model is not designed to tackle other types of tourism activities such as, for instance, skiing. This has two important implications for the model estimated. First 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. We also need to control for the interaction between bathing facilities and local climatic conditions for bathing leisure. The set of non-climatic data used was represented by:

- the longitude and latitude of the destination region which are typically used in hedonic price regressions for recreational activities
- The share of employment in tourism-related services (in % of total employment,). 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. Whenever these data were not available we used country-wide figures instead, (Source: Labour Force Survey, Eurostat).
- the hotel density (per head of population) representing the degree of regional specialisation in tourism activities, (Source: Eurostat).
- The share of four (or more) -star hotels in the region reflecting the nature of tourism supply, (Source: Hotelscombined)
- The level of GDP per capita in the destination region to capture indirectly the cost of living in the destination region. This variable is expressed in PPS, (Source: Eurostat)
- The average distance (in km) to the nearest international airport to capture access for international tourists, (Source: TRANS-TOOLS model).
- The road density, to represent the access to transport infrastructure in the destination region measured in km of road per square km, (Source: TRANS-TOOLS model).
- A dummy variable specific to each sea basin and the dominant water type 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 estimation of Equation (2) is made following standard practice for analysing recreational demand based on the travel cost approach whereby this equation is estimated by region of origin. 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 by interacting it with a month-specific dummy variable in order to capture month-specific effect of climatic conditions. In addition 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 holiday cost. For each region the hotel price and TRANS-TOOLS based estimates of the transport cost are added and observed for each couple of origin to destination region. This yields the value of the variable Z_j^i which is used as dependent variable. We run separately the same regression for each 285 EU NUTS2 region. 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 all 285 regions of origin and for each of the four holiday durations (i.e. one-day, four-day, one-week, four-week), resulting in 1140 estimations.[5]

4. Tourism demand estimations

4.1 Data processing and descriptive analysis

The data on tourism demand comes from Eurostat and include occupancy rate, bed capacity & number of bednights per nuts2 regions, including country of origin of tourists. The main variable of interest is the number of bednights for which origin-destination data has been obtained using (i) Annual number of bed-nights by residents per nuts2 region, (ii) Annual number of bed-nights by non-residents per nuts2 region and (iii) Annual number of bed capacity per nuts2 region. The gross occupancy rate for residents and non-residents has been obtained by dividing (i) and

[5] See Barrios and Ibañez (2013) for a detailed exposition of these econometric results.

(ii) by (iii) and multiplying the resulting figure by 365 (i.e. the number of days in a year). As quality check the gross occupancy rates obtained were compared to the national figures provided by Eurostat. The resulting comparison was satisfactory as only minor discrepancies could be observed. In case of discrepancy between the national and regional figures, the latter were adjusted proportionally across countries in order to match national-figures. This data was then merged to the monthly national data on gross occupancy rate available at country level. The NUTS 2 monthly occupancy rate was subsequently derived from the country-level figures by applying the cross-monthly variation observed at the national level to the regional level. This data was then merged with the country-level data on monthly bednights at country level with information on the country of origin of tourists. The monthly gross occupancy rate per region was then decomposed in terms of country of origin of the tourists (i.e. percentage points of the occupancy rates attributable to a specific country of origin of the tourist) applying monthly national figures to regional annual figures. Figure 2 provides examples of the seasonal variation and potential trends in tourists' arrivals to Andalusia and Lombardy coming from Germany and the UK. As one can observe, German and British tourists flow to Andalusia preferably during the summer months although on a declining trend since the year 2002. Tourists flows to Lombardy seem to be less determined by summer seasonality and the declining trend can only be observed for German tourist while for British tourists outflows to Lombardy have tended to increase. More generally speaking these figures show that both seasonal and trend patterns are present in the data on tourist flows. The use of this data for regression analysis thus requires a careful treatment of the seasonality and potential trends in tourists´ arrivals.

4.2 Estimations of tourism demand equation

The data on number of bednights is used to build our dependent variable for the estimation of our demand equation. The hedonic price estimated earlier is then used as main explanatory variable of interest for the estimation of tourism demand. The long-term (2100) projections of tourism demand are based on the long-term projections of the hedonic price indicator which itself will vary according to the projected long-term changes in climatic conditions using the model-runs and scenarios described above. We proceed to estimate the tourism demand equation in three successive steps. First we take the value in 2010 of the predicted hedonic price index using our region of origin-specific estimations of equation (2). Since what we are interest in the impact of climate on the tourism flows in the *destination* regions we calculate for each climatic variable the weighted average of each MWTP estimated by region of destination taking as weight the average bilateral tourist flow observed for the period 2010-2011 (which is the period considered in the hedonic price estimations). Analytically, this amounts to calculate the following weighted average elasticities for each climatic variable as follows:

$$\lambda_j = \sum_i \left(w_{i,j} \cdot \beta_{i,j} \right) \tag{3}$$

where the elasticities (or MWTP) $\beta_{i,j}$ are obtained from the estimation of equation (2) for each climatic variable and $w_{i,j}$ are the share of the bilateral tourists flow from region i to region j in the total tourists flows to region j.[6] Each average elasticity λ can thus be used to calculate the hedonic price index as follow:

$$\hat{Z}_j = \bar{Z}_j + \sum_j \left(\lambda_j \cdot \left(C_j^n - \bar{C}_j^n \right) \right) \tag{4}$$

where all variable are expressed in log terms (whereby first differences are used to proxy percentage changes) and where $\bar{Z}_j$ stands for average value of the climatic variable (i.e. either temperature, precipitation, wind speed or humidity) considered during the period of reference (.e. 2010-2011), λ_j is the average elasticity described above, C_j^n is the actual value of the climatic variable of reference n (with n indexing the four climatic variables mentioned earlier) and $\bar{C}_j^n$ is the average value of each climatic variable n over the period of reference. Note that the set of climate variables includes their square value as well as in the hedonic price estimation in order to

[6] Note that for simplicity we omitted the differentiation by month given that each elasticity is in fact estimated on the interaction between the monthly dummies and the specific climatic variable considered.

account for possible non-linearity in their impact on tourism demand. The hedonic price index calculated as in (4) yields region-of-destination specific hedonic price index by multiplying the elasticities obtained from the estimation of the hedonic price equations (as described in Section 4) by the deviation of the values taken by the different climatic variable with respect to the benchmark period which in this case is the period 2010-2011 which was used to estimate the hedonic price equation. Figures 3 to 6 plot the evolution of this hedonic price index by holiday duration over the period 2010-2099 by group of country, namely the British Isles (UK and Ireland), Southern Europe (Spain, Portugal, Italy, Bulgaria and Greece), Central Europe South (France, Austria, the Czech republic, Slovakia, Hungary, Romania, Slovenia, Croatia), Central Europe North (Belgium, the Netherlands, Germany, Poland, Luxembourg) and Northern Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Norway, Iceland and Denmark). These projected values of the hedonic prices vary as a result of the change in the temperature only, while the other variables are kept constant at their mean (monthly) value. In order to reflect the potential impact of the change in the hedonic price index the figures report the weighted average of the hedonic price index by geographical zone for each holiday duration, where the weights are given by the average (monthly) value of the total number of bednights by NUTS2 region. It is worth noting that among all the hedonic price index, the index corresponding to the one-day holiday duration is remarkably stable suggesting that climate change has a larger impact on long holidays. In fact, as commented previously, part of the explanation for this is simply because the transport cost component of the hedonic price is much higher for short rather than long-stays. Since transport costs (including all transport modes) are also less influenced by seasonal factors than hotel prices, then shorter holidays should imply a lower seasonality in the overall holiday cost. Furthermore, while in most cases the hedonic price index is relatively stable over time in most geographical zones, its variation is most pronounced for the Southern European countries where one can observe strong decline, especially from the year 2060 onward. This decline is parallel to the significant rise in temperature (as predicted by the KNMI-RACMO2-ECHAM5-r3 model) as indicated in the Table 8. During the spring months the hedonic price index experiences a pronounced fall in Southern European regions. The sharpest fall is observed during the summer month however. Considering the average of this index across the different holiday durations, the index falls from 7.09 during the period 2011-2040 to 6.55 during the period 2071-2099, i.e., corresponding to a -8% decrease in the implicit valuation of tourism services during in Southern European regions. This fall is preceded by a modest rise in the hedonic index, however, from 6.91 in 2010 to 6.94 during the period 2011-2040, (i.e. +0.4%) which illustrate the non-linearity in the effect of long-term temperature change illustrated earlier in Section 4. For the other geographical areas the hedonic price index is relatively stable through the different periods as only a modest fall can be observed for the Central Europe North and Central Europe South during the period 2011-2040, from 6.65 to 6.60, i.e. -0.7% for the former, and 6.71 to 6.69, i.e. -0.3% for the latter respectively, followed by a rise of 1.7% and 1.2% during the second period, and then followed again by a fall in the third and fourth periods of -1.8% and -0.15%, evidencing again, although to a much lower proportion the non-linear effect of temperature changes on the hedonic price of tourism services over the long-term. The fall in the index of the Central Europe North and Central Europe South during the very last years of the period also correspond to a temperature rise in 2071-2099 (from 17.5°C to 18.3°C for the former and from 18.2°C to 19.1°C for the latter).

4.3 long-term (2100) tourism demand projections

Given this descriptive evidence one would expect to observe a decline in the number of tourists heading towards Southern European regions in the long-term as a result of the rise in the temperature and the parallel decline in the hedonic price index. The estimated tourism demand equation is the following:

$$b_{j,t} = a_j \hat{Z}_j + c_j POP_{i,t} + d_j K_t + \varepsilon_{j,t} \quad (5)$$

Where $b_{j,t}$ is the log value of the total number of bednights of tourists coming to region *j*, $\hat{Z}$ is the estimated value of the hedonic price index specific to the region of destination *j* described in (4), POP_i the total population of the regions of origin *i* (using as weights the bilateral number of tourists from region *i* to region *j*) and *K* is a set of monthly dummies to account for seasonality affecting tourism demand. Equation (5) can thus be thought as a classical demand equation where the demand $b_{j,t}$ variable is regressed on a price variable $\hat{Z}$ and potential demand variable included represented by the *POP* variable. The terms *a*, *c* and *d* are the coefficients to be estimated. Note that in order to estimate (5) we consider region-of destination flows and not bilateral flows. The first obviously reason for this is that taking the total number of tourists´ arrivals greatly simplifies the calculations since instead of estimating equation (5) 285 x 285 = 81225 times, we estimate it 285 times with almost complete time series. The second and certainly the most important reason for proceeding this way however, is that the estimation of (5) is used for the long-term forecasting of tourism demand in the destination regions and such projection becomes highly uncertain when based on cross-section rather than on time series given the well-known low predictive power of cross-section/panel data. In addition, while we use a set of time dummies as control variables to control for possible seasonality in the dependent variable, the estimated hedonic price is still likely to entail a seasonal component itself. In order to remedy this we therefore filtered the time series on the estimated hedonic price index using the Hodrick-Prescott filter, see Hodrick and Prescott (1997). The results of estimating (5) are then used to predict the values of $b_{j,t..}$ In order to project the impact of tourism demand in GDP terms we used Eurostat data by country for tourists´ expenditure and number of trips by holiday duration for the base year, i.e. 2010.

The long impact of climate change on tourism demand is likely to depend on the adaptation strategies of tourism demand and supply. Here we deal only with adaptation on the demand side by considering two facets of possible behavioural and institutional changes related to adaptation. Tourists are likely to change their holiday duration and the months chosen to enjoy their holiday if climatic conditions change significantly during the traditional holiday period, i.e. the summer months. Tourists for instance prefer to distribute their holiday pattern more evenly during the year and to have shorter holidays in order to benefit for instance from more clement weather conditions during the other seasons. Of course the possibility to adapt the seasonal frequency and time length of holidays depends very much on institutional and possibly societal factors (e.g. such as ageing). It is important to note that our estimated hedonic price index $\hat{Z}$ is an average of the price indices estimated for the four alternative holiday duration options we have considered, i.e., one-day, four-day, one-week and two weeks. In order to derive an average value of $\hat{Z}$ we have used as weights the one observed at country and season levels for the year 2010 based on Eurostat data, see Eurostat (2012). The possible effect of adaptation on the holiday duration pattern should thus reflect a change in the relative weight of the different holiday duration compared to their 2010 value. We have therefore considered that the holiday duration could change endogenously instead of remaining fixed to their 2010 value by simply taking the weights given by the Eurostat data in 2010 for the period 2011-2040. We then modified the weights for the 2041-2070 and 2071-2099 periods according to the number of bednights estimated for the previous period. We therefore assume that the change in holiday duration is determined endogenously by setting it equal to the holiday duration observed in the previous period. We have thus retained two possible scenarios: one where there is full adaptation in both the duration and monthly distribution of holidays and one where there is no such adaptation, i.e., where the holiday duration and the distribution of holiday during the year are considered to be fixed. The detailed country results of these projections are reported in Table 5 considering the KNMI-RACMO2-ECHAM5-r3 climatic model run and the different adaptation scenarios. Figures 7-10 display the results by climatic zone, considering all four climatic model runs considered in the paper. Overall the impact of climate change scenarios on the tourism industry is relatively low on average for the EU since it represents between -0.15% and 0.03% of 2010 GDP depending on the adaptation scenario and, see Table 5. This impact is very unevenly distributed across EU countries, however. This is shown for instance considering the non-adaptation scenario described in Column (1) of Table 5. The potential losers are the southern European countries such as Bulgaria (-0.80%.) and Spain (-0.73%) while the winners are Estonia (0.64%), Latvia (0.63%), Slovenia (0.62%) and Slovakia (0.34%). Overall the net gain/losses nearly cancel each others since in the no-adaptation case the net gain for the EU overall would be 0.01% of GDP. Other countries affected negatively are France (-0.13%) and Portugal (-0.06%) while other winners are all located in Central or Northern Europe such as Belgium (+0.13%), Denmark (+0.21%) Lithuania (+0.16%), Luxembourg (+0.16%), Sweden (+0.24%), Finland (+0.23%) or the UK (+ 0.18%). The results are less clear-cut when adaptation is considered with a clear difference in results between adaptation in the timing and in the duration of holiday choices. The EU as a whole experiences a net loss while when the duration of holiday is allowed to change instead of the timing of holidays. In fact, the timing and duration of holiday appear to have opposite effects according to our long-term projection. The countries more negatively affected in this case are again Bulgaria (-1.03% of 2010 GDP), Spain (-0.86% 2010 GDP). On average the losses do not compensate the gains of countries such as Slovenia (+0.43%), Estonia (+0.42%) or Austria (+0.15%) such that the net effect for the EU as a whole is negative (-0.15%).

These results can be explained as follows. First, it is important to note first that we have adopted a demand-side approach without making any inference regarding the adaptation on the supply side. From an economic viewpoint this means in particular that the temperature rise will lower the hedonic value of holidays in Southern European countries without allowing for potential price adjustment in the supply side that could compensate for this effect. One could for instance consider that the tourism business sector in Southern Europe would lower its prices in order to compensate the expected reduction in tourists´ demand due to the temperature rise.

No such supply-side adaptation is contemplated here, however.[7] A deterioration of the climatic conditions for tourism activity will necessarily lead to lower demand in those regions most affected and tourism demand will decrease more if tourists´ adjust their holiday pattern. Since tourism demand in Southern Europe is predominant during the summer months, then it is not surprising to observe a fall in the tourism demand if adaptation in the timing of holiday is accounted for. The results are more nuanced when adaption in the duration of holidays is considered instead. In this case the losses are more mitigated and closer to the no-adaptation case. For instance the losses of Bulgaria (-0.85%) and Spain (-0.67%) are now closer than in the case without adaptation. The same applies for the countries that would experience economic gain from climate changes such as Estonia (+0.67%), Latvia (+0.66%) or Austria (+0.38%). Other countries also experience lower losses when holiday duration is allowed to change. For instance France would lose -0.20% of GDP against -0.35% under the timing adaption hypothesis, Greece would now experience a small gain of +0.01% against a loss of -0.10% and Hungary would also gain +0.16% while it would loose -0.01% of GDP in the previous case. A possible explanation for these results could come from the fact that the institutional constraint with regarding to the change in the timing of holiday choices is more binding than possible change in the duration of holidays. The adaptation in the duration of holidays may be easier than the adjustment in the timing of holiday and allow for an adjustment in tourist demand which is less costly for the regions most negatively impacted. In fact, one could consider that the timing and the duration of holidays could vary simultaneously as a result of institutional changes and change in tourists´ habits. In the fourth column of Table 9 we consider this possibility by assuming that tourists are completely free to choose the month and duration of their holidays. It is

[7] A possibility to consider this type of supply-side adaption could be to impose a lower limit to the value of $\hat{Z}$ in the estimation of the demand equation or alternatively a factor of adjustment in the change in $\hat{Z}$ which could possibly be linked to the GDP per capita of the region concerned if one assumes that supply-side adaptation strategies are easier to implement with a higher level of economic development. These questions are not considered here, however and left for future research.

interesting to note that in some cases, the resulting change in tourism demand is even worse than when the two alternative hypotheses regarding adaptation are considered separately. This is the case for instance of Bulgaria which would loose -1.10% of GDP, France would also loose -0.44% of GDP. Spain on the contrary would loose less than in the case of timing adaption (-0.81%).

Figures 7-10 compare the results obtained by broad geographical areas and considering the laternative adaptation scenarios and model runs.[8] As can be seen, the three alternative climatic projections provide results very similar to the ones obtained with the KNMI-RACMO2-ECHAM5-r3 climate projections. In all cases Southern European countries are the most negatively impacted by changes in the climatic conditions. The results are also rather homogenous for Northern European countries but display some differences for the Central Europe South, Central Europe North and British Isles depending on the climatic model projection used. These differences are not sizeable, however. For instance, in the case of the British Isles the projected gain with No adaption turn into a small net loss once the DMI model is considered instead. For Central Europe North and Central Europe South, the projections show a small net gain or loss depending on the climate scenario considered. Overall the results reported appear to be rather robust to the alternative climatic scenario used for the projections.

5. **Summary and conclusion**

In this paper we investigate the impact of climatic change on tourism demand. The analysis is based on a bottom-up approach to derive country-wide figures making use of detailed regional data. 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

[8] Barrios and Ibañez (2013) provide country-level results for all scenarios.

specialisation in) tourism activities and related vulnerability to potential climate change scenarios. We base our long-term projections for tourism demand on hedonic valuation of climatic conditions combining hotel price information and travel cost estimations. Such an approach allows us to estimate different valuations of climate amenities depending on the distance travelled by tourists. We are therefore able to estimate the valuation of climatic conditions depending on the time duration of holidays. Based on this approach we can derive alternative scenarios for adaptation of holiday demand to potential climate change scenarios assuming alternative adaptation strategies of tourism demand. We consider alternatively a no adaptation scenario, a partial adaptation scenario based on perfect flexibility in the timing of holiday demand (i.e. the month chosen for the holiday), a partial adaptation scenario based on a perfect flexibility in terms of duration of holidays and a full adaptation scenario where both the timing and the duration of holidays are considered together. Our main results show that the climate dimension play a significant (economically and statistically) role in explaining hedonic valuations of tourism services and, as a consequences, its variation in the long-term are likely to affect the relative attractiveness of EU regions for tourism demand. In certain cases, most notably the Southern EU Mediterranean countries climate condition in 2100 could under current economic conditions, lower tourism revenues for up to -0.45% of GDP per year. On the contrary, other areas of the EU, most notably Northern European countries would gain from altered climate conditions, although these gains would be relatively more modest, reaching up to 0.32% of GDP per year. We also find that the demand adaptation in terms of timing of holidays is more costly for Southern European regions and more beneficial for Northern and Central European countries and the British Isles. The adaptation in the duration of holiday appears to limit both the losses of Southern European regions and the gains of the potential winners from climatic change. When considering both duration and timing adaption together, the projected falls and gains in tourism demand appear to be much more contained, suggesting that the effect of potential changes in the timing tend to be compensated by the effects of changes in the duration of holidays. It is important to note that these estimates only reflect the tourism related to hotel occupation only without accounting for other possible accommodation modes. Moreover, non-EU regions are not considered in the analysis. Including other accommodation modes and broadening the geographical coverage of the study could be the scope of future research.

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7. Tables

Table 1: Model-runs and Scenarios for the long-run climate projections

Institute	Downscaling RCM	Driving GCM
	A1B climate change scenario	
METO-HC	HadRM3Q0	HadCM3Q0
KNMI	RACMO2	ECHAM5-r3
DMI	HIRHAM5	ECHAM5
	E1 climate change scenario	
MPI	REMO	E4

Table 2. 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 3: 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 4: Average temperature by season and geographical zone

	Winter			
	2010	*2011-2040*	*2041-2070*	*2071-2099*
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*	*2071-2099*
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*	*2071-2099*
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*	*2071-2099*
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	6.16	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 5: Impact of climate change in the tourism industry revenue in the destination region in 2100 (in percent of 2010 GDP): country-results

Results using the KNMI-RACMO2-ECHAM5-r3 climatic model run

	No adaptation	***Holiday timing adaptation***	***Holiday duration adaptation***	***Full adaptation*** *Holiday timing + duration adaptation*
		Country-results		
Austria	0.39%	0.15%	0.38%	0.12%
Belgium	0.13%	0.02%	0.13%	0.01%
Bulgaria	-0.80%	-1.03%	-0.85%	-1.10%
Czech republic	0.07%	-0.09%	0.04%	-0.13%
Germany	0.13%	-0.09%	0.14%	-0.09%
Denmark	0.21%	-0.01%	0.22%	-0.02%
Estonia	0.64%	0.42%	0.67%	0.43%
Spain	-0.73%	-0.86%	-0.67%	-0.81%
Finland	0.23%	-0.07%	0.25%	-0.07%
France	-0.13%	-0.35%	-0.20%	-0.44%
Greece	0.00%	-0.10%	0.01%	-0.09%
Hungary	0.11%	-0.03%	0.16%	0.01%
Italy	-0.03%	-0.14%	0.00%	-0.12%
Lithuania	0.16%	0.01%	0.18%	0.01%
Luxembourg	0.16%	-0.23%	0.23%	-0.19%
Latvia	0.63%	0.39%	0.66%	0.40%
Netherlands	0.13%	-0.01%	0.04%	-0.11%
Poland	-0.02%	-0.12%	-0.01%	-0.11%
Portugal	-0.06%	-0.13%	-0.05%	-0.12%
Romania	0.02%	-0.07%	0.02%	-0.07%
Sweden	0.24%	0.00%	0.27%	0.00%
Slovenia	0.62%	0.43%	0.05%	-0.13%
Slovakia	0.34%	0.15%	0.35%	0.15%
United Kingdom	0.18%	0.00%	0.18%	-0.02%
		Geographical zones		
Southern Europe	-0.33%	-0.45%	-0.31%	-0.45%
Central Europe South	0.12%	-0.05%	0.13%	-0.07%
Central Europe North	0.07%	-0.16%	0.09%	-0.08%
British Isles	0.32%	0.15%	0.22%	-0.02%
Northern Europe	0.28%	0.06%	0.29%	0.15%
EU average	0.01%	-0.15%	0.03%	-0.10%

Note:
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 the UK*

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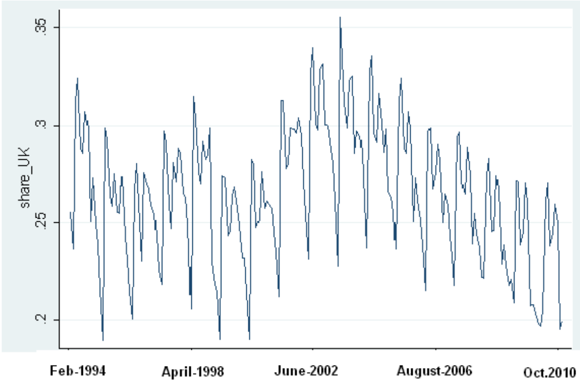
Northern Europe*: Sweden, Finland, Estonia, Latvia and Lithuania*

Figure 1: The cost of holiday in selected regions groups and by holiday duration

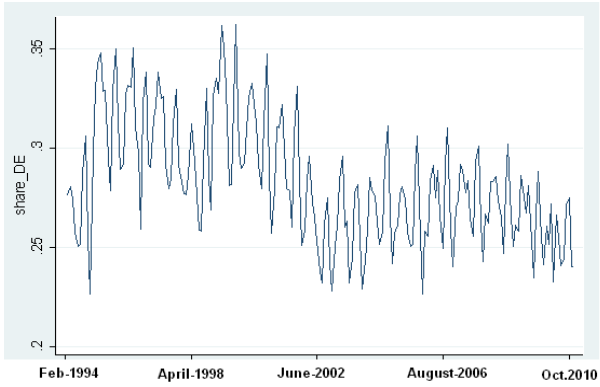
Sources: HotelsCombined and JRC, European Commission

Figure 2: Share of bed night stays country of origin and region of destination

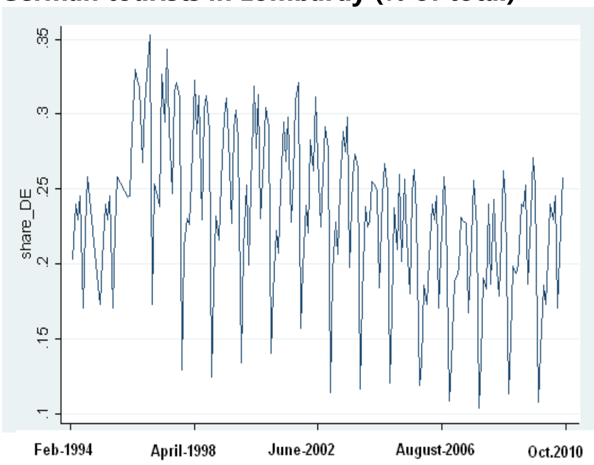
German tourists in Andalusia (% of total)



British tourists in Andalusia (% of total)



German tourists in Lombardy (% of total)



British tourists in Lombardy (% of total)

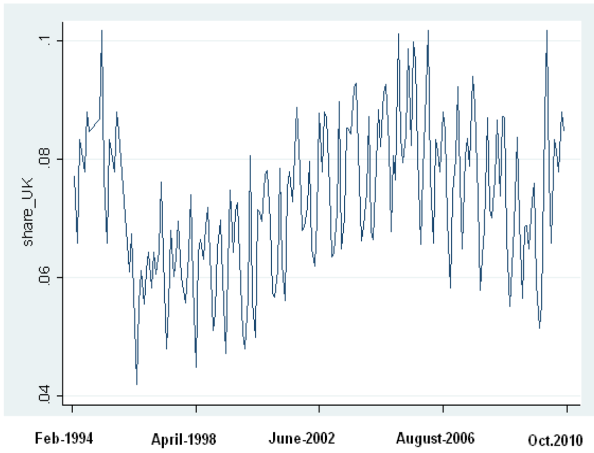


Figure 3: Evolution of the predicted hedonic price index during the spring months: 2010-2099 (average by country and months)

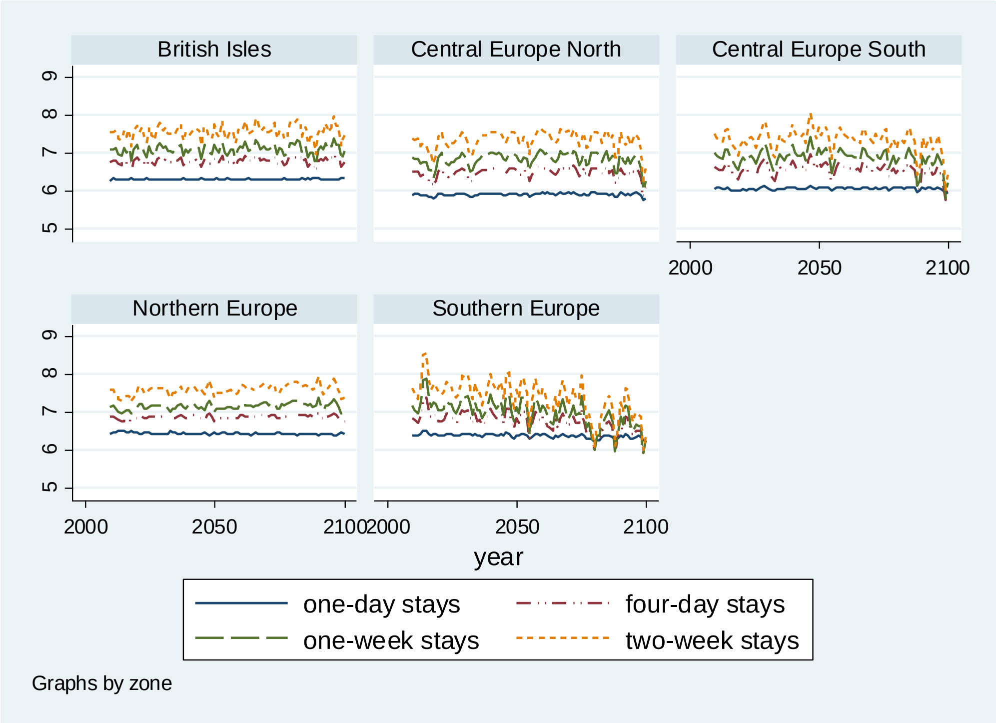


Figure 4: Evolution of the predicted hedonic price index during the summer months: 2010-2099 (average by country and months)

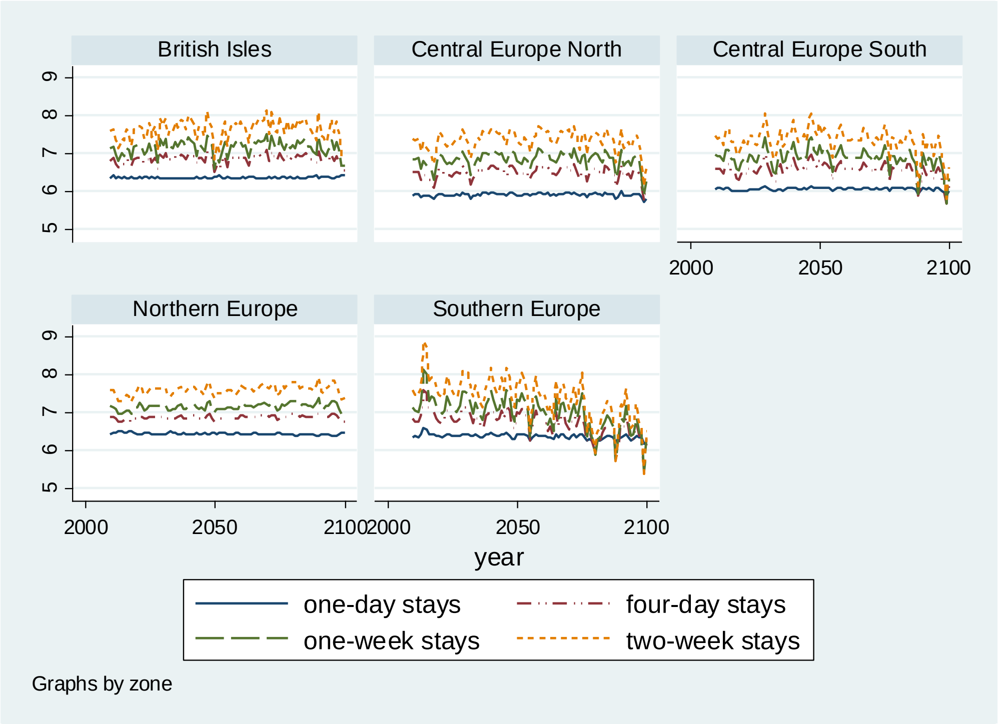


Figure 5: Evolution of the predicted hedonic price index during the autumn months: 2010-2099 (average by country and months)

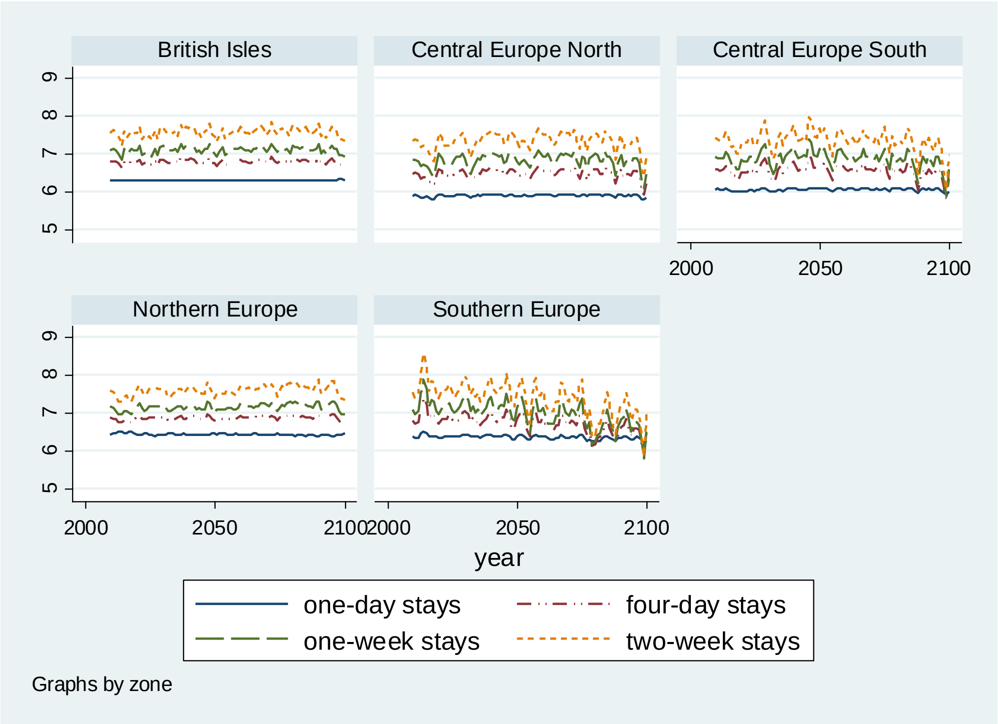


Figure 6: Evolution of the predicted hedonic price index during the winter months: 2010-2099 (average by country and months)

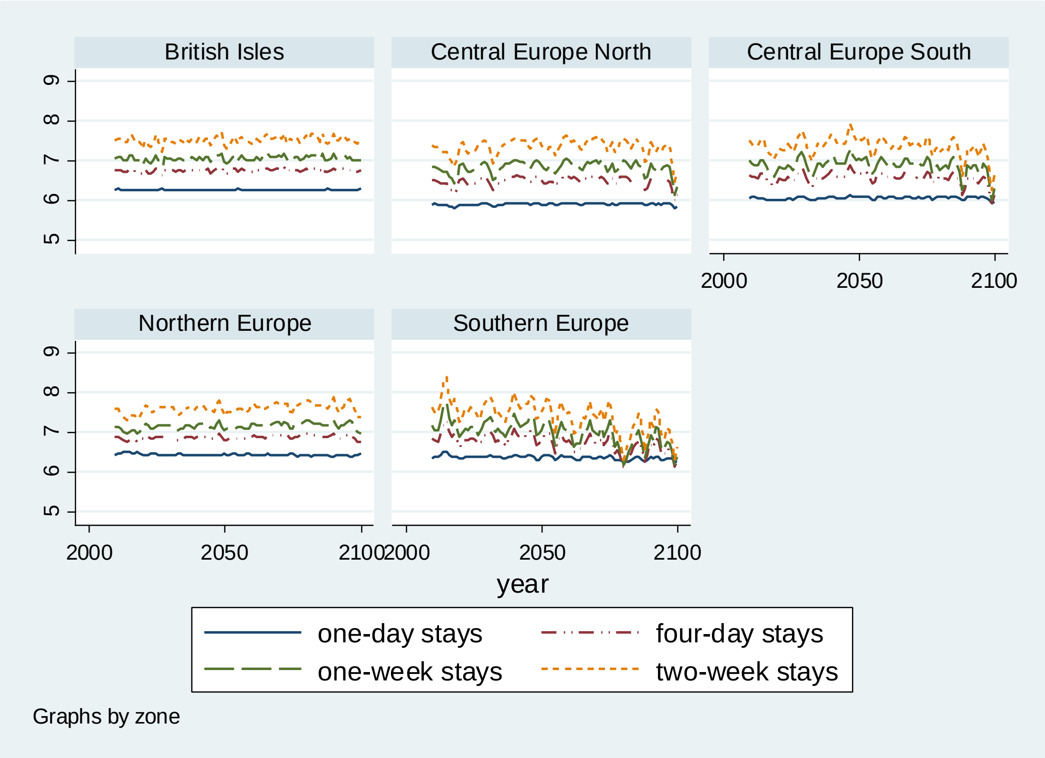


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Figure 7: Long-term (2100) economic impact of climatic change on Tourism in the EU
Results by geographical zone, No adaptation scenario

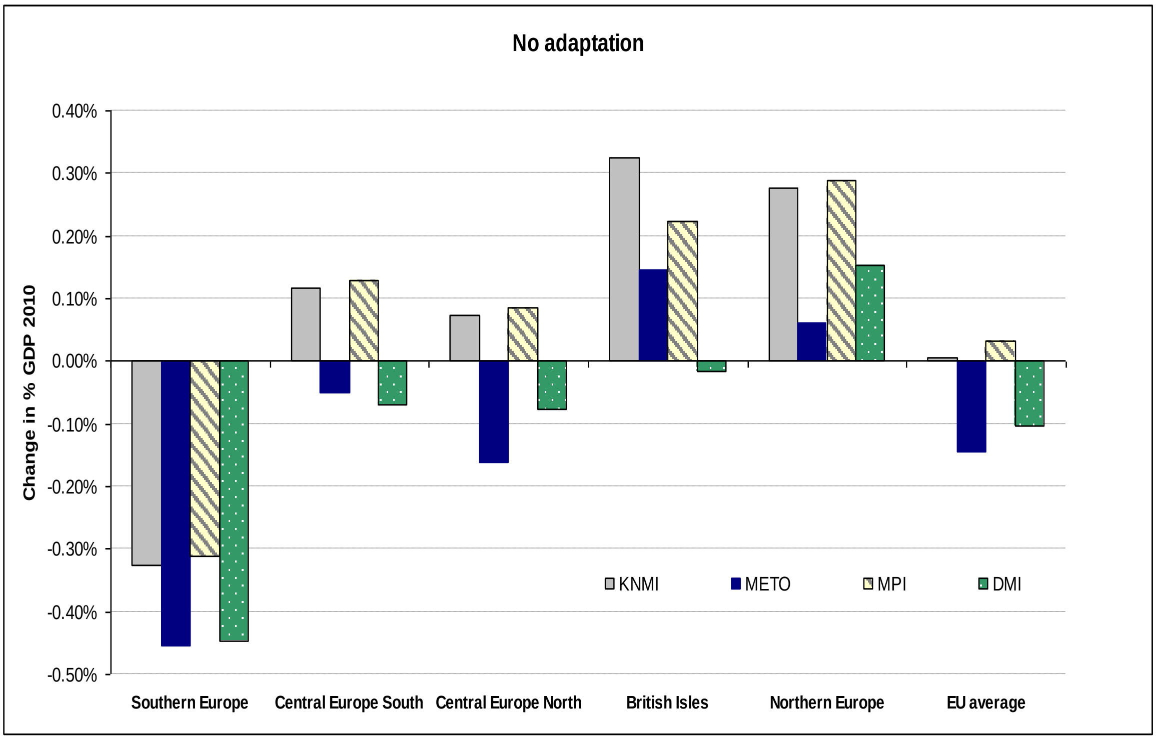


Figure 8: Long-term (2100) economic impact of climatic change on Tourism in the EU
Results by geographical zone, Full adaptation scenario

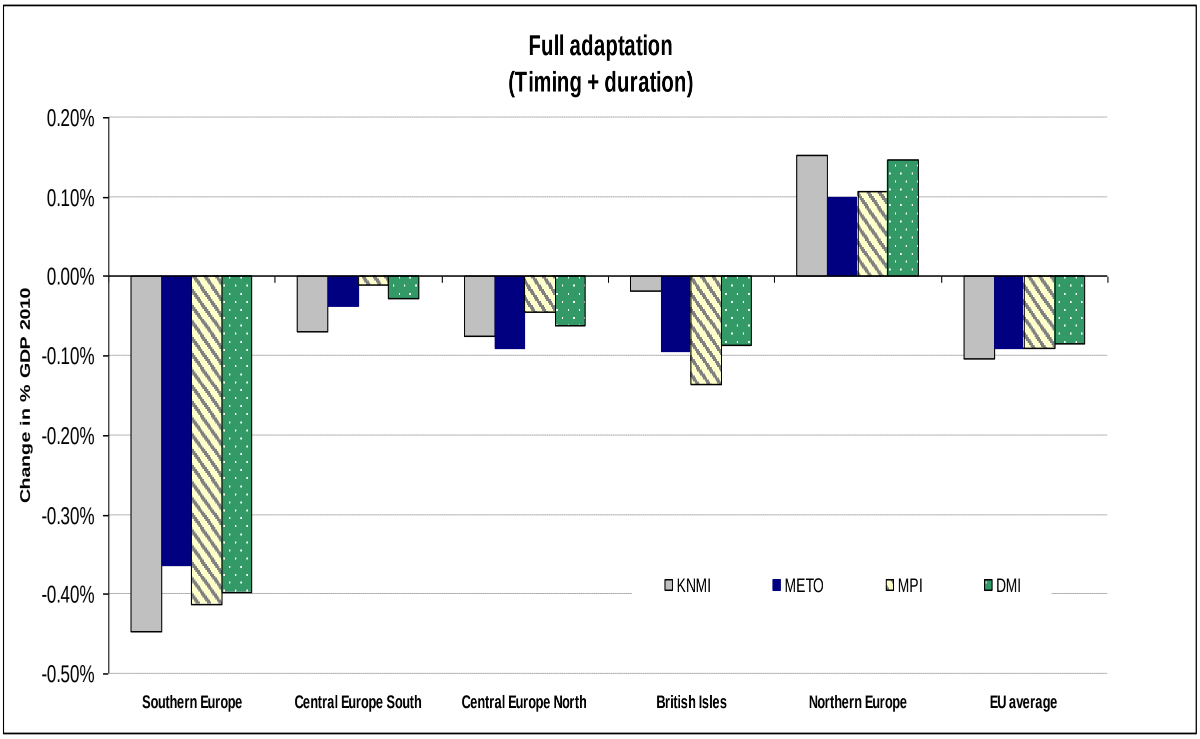

Full adaptation
(Timing + duration)
Change in % GDP 2010
0.20%
0.10%
0.00%
-0.10%
-0.20%
-0.30%
-0.40%
-0.50%
KNMI
METO
MPI
DMI
Southern Europe
Central Europe South
Central Europe North
British Isles
Northern Europe
EU average

Figure 9: Long-term (2100) economic impact of climatic change on Tourism in the EU
Results by geographical zone, Duration adaptation scenario

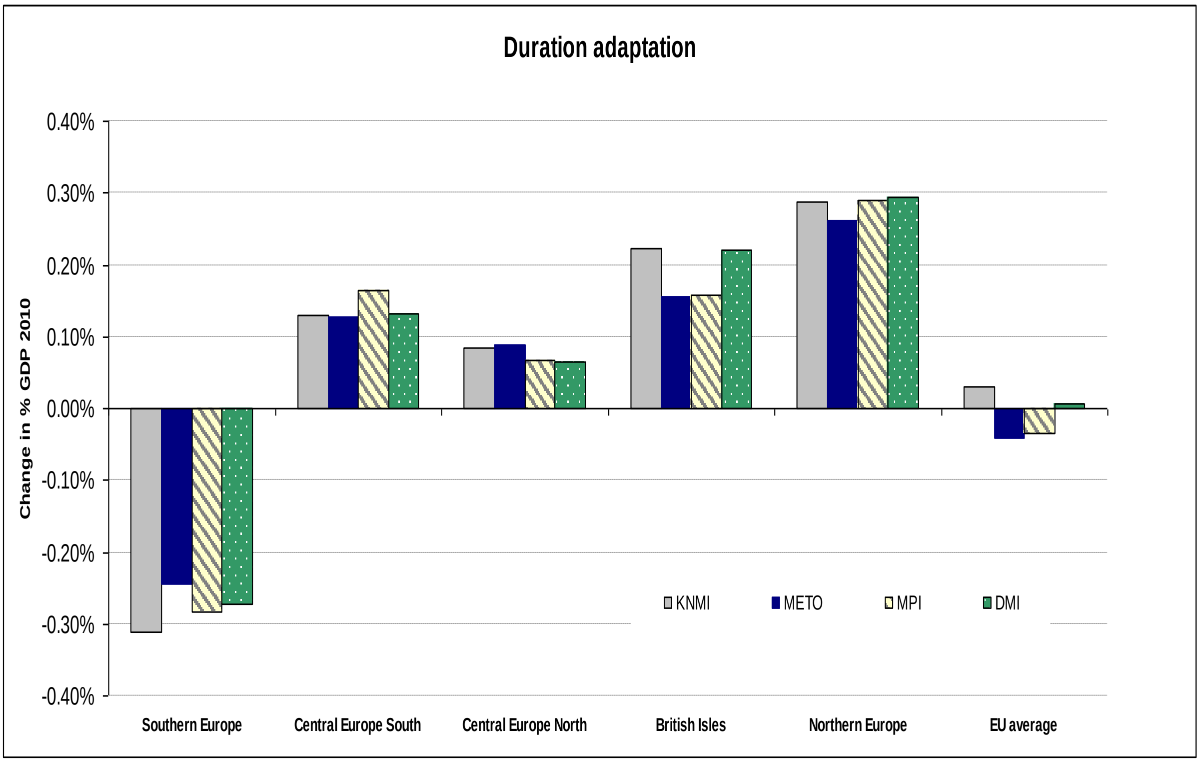
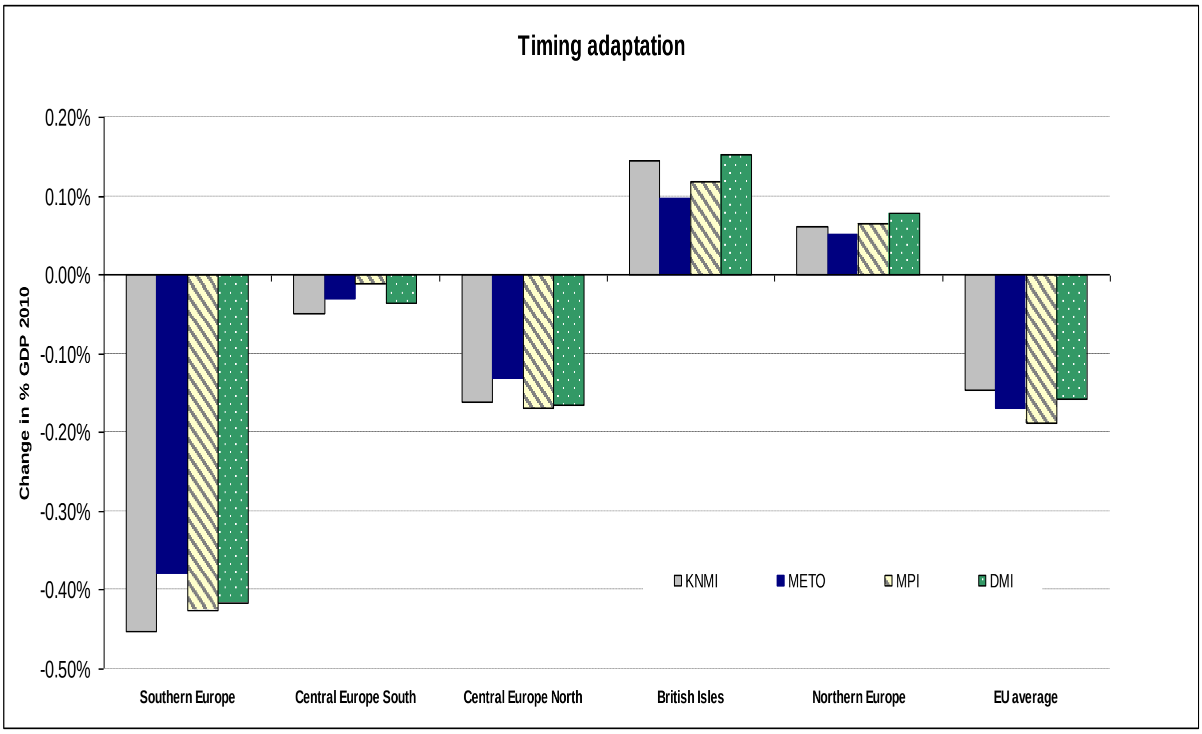


Figure 10: Long-term (2100) economic impact of climatic change on Tourism in the EU
Results by geographical zone, Timing adaptation scenario


Timing adaptation
0.20%
0.10%
0.00%
-0.10%
-0.20%
-0.30%
-0.40%
-0.50%
Change in % GDP 2010
KNMI
METO
MPI
DMI
Southern Europe
Central Europe South
Central Europe North
British Isles
Northern Europe
EU average