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Summary

Tourism is an industry of primary importance for the world economy. For some countries, tourism is the first source of income and foreign currency, and many local economies heavily depend on tourism. Tourists are sensitive to climate and to climate change, which will affect the relative attractiveness of destinations and hence the motive for international tourists to leave their country of origin. Yet, until recently, the attention devoted by the tourism literature to climate change and by the climate change literature to tourism has been quite limited. This paper is divided in two parts. The first part reviews the literature on the relationship between climate change and tourism. We find that the existing studies have but started unveiling the complexities of this relationship, by means of very heterogeneous approaches and scarcely comparable studies. A comprehensive, coherent quantitative message cannot yet be drawn from the literature. The broad qualitative message is clear, however: climate change will affect tourism, and the consequences for the economy might be wide and pervasive. The second part analyses empirically the relationship between climate characteristics, weather extremes and domestic and international tourism demand across Europe, with a focus on Italy. This study draws on the results on the Italian tourist sector of the WISE project, a multi-sector research project that investigates the impacts of extreme weather events on the socio-economic systems of some European countries by means of both quantitative and qualitative analyses. In general, temperature is the strongest indicator of domestic tourism. The relationship between tourism and temperature is generally positive in the same-month all across Europe, except in winter sports regions. The climate impact depends as well on destination type: for example coastal resorts respond more favourably to summer temperature increases than inland resorts. Moreover, it is not just temperature that counts, but also the expectations about future temperature levels; not just the presence of weather extremes, but also the expectations about their future occurrence. Qualitative results, based on individual surveys, show that during an unusually hot summer day trips are more climate-responsive than short breaks, that short breaks are more climate-responsive than main holidays, and that most people tend not to change plans for their main vacation: those that do change either stay at home or in their own country. On the basis of our literature survey and of our empirical study's results, the paper concludes by indicating the most urgent gaps to be filled in the knowledge about the relationship between climate change and tourism and by pointing at the most promising directions for further research.

Keywords: Tourism, Climate change, Extreme weather events

JEL Classification: L83, Q25, C23, C42

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Introduction

Decisions about whether to take a holiday and where to spend that holiday are by no means secondary ones. Such decisions are relevant for our well-being, but, more importantly, are economically relevant because billions of people in the world make analogous decisions every year, many of them more than once per year[1]. This makes tourism an industry of primary importance for the world economy: it generates about 7.3% of the total worldwide exports[2]. For some countries, tourism is the first source of income and foreign currency, and many local economies heavily depend on tourism.

Among the factors taken into account by tourists when they decide upon their holidays, the destinations' climate characteristics rank very high (Hu and Ritchie, 1993; Lohmann and Kaim, 1999). Hence, tourists are sensitive to climate and to climate change (Maddison, 2001; Lise and Tol, 2002 and Hamilton, 2003). Climate change will affect the relative attractiveness of destinations and hence the motive for international tourists to leave their country of origin. Yet, until recently, the attention devoted by the tourism literature to climate change and by the climate change literature to tourism has been quite limited.

The degree of interest is now slowly increasing, and various aspects of the relationship between climate change and tourism relationship are being covered. We review this literature in Section 2. Five branches of literature have started to grow. Firstly, there are a few studies (e.g., Maddison, 2001) that build statistical models of the behaviour of certain groups of tourists as a function of weather and climate. Secondly, there are a few studies (e.g., Abegg, 1996) that relate the fates of particular tourist destinations to climate change. Thirdly, there are studies (e.g., Matzarakis, 2002) that try to define indicators of the attractiveness of certain weather conditions to tourists. Fourthly, there are a few studies (e.g., Hamilton *et al.*, 2003) that use simulation models of the tourism sector to study the impacts of climate change on tourist flows and on the tourist potential of destinations. Finally, a handful of studies (e.g., Berritella *et al.*, 2004) analyze the economic implications of tourism in the face of climate change.

Section 3 illustrates an empirical study, which represents a first attempt to cover one of the gaps in the literature, namely the relationship between tourism demand and extreme weather events. More specifically, the study looks at the relationship between climate characteristics, weather extremes and domestic and international tourism demand for Italy. This study draws on the results on the Italian tourist sector of the WISE project, a multi-sector research project that investigates the

[1] The top 10 origins for total tourist number generate almost 3 billion tourists per year. See Bigano et al. (2004b)
[2] World Tourism Organisation (http://www.world-tourism.org/facts/tmt.html).

impacts of extreme weather events (very warm summers, mild winters and storms) on the socio-economic systems of some European countries. The results considered in Section 3 cover the quantitative analysis of the impacts of climate extremes on the socio-economic system in Italy and the qualitative analysis of individuals' perception of climate extremes based on results from individuals' surveys. In order to put these results in a broader perspective, they are briefly compared with the results for other European countries. Our conclusions and a brief discussion of future research directions are in Section 4.

2. Review of the relevant literature

2.1 Tourism demand

Tourism demand forecasting continues to be a popular theme in the tourism literature. Reviews of this literature by Witt and Witt (1995) and Lim (1995) show that demand forecasting, in the majority of studies, is focused on economic factors. Morley (1992) criticises typical demand studies because they do not consider utility in the decision making process. Moreover, he suggests an alternative way to estimate demand based on the expected utility derived from the characteristics of the product. Lancaster (1966) originally developed the concept that the characteristics of a good are more important to the consumer than the actual good itself. How these characteristics are perceived will determine the expected utility from the consumption of the good. In the case of tourism, the product is the holiday at a certain destination and at a certain time, and this product will have certain characteristics. Most importantly, he argues that climate and landscape attributes of countries should be included in the characteristics set. Seddighi and Theocharous (2002) have applied this theory using a Logit analysis. Political stability was the focus of their study rather than environmental characteristics such as climate or landscape. Rather than just examining the demand for a single country, demand systems provide the opportunity to examine the pattern of flows of tourists to different destination countries. Recent studies, however, do not include natural resource characteristics (see Lyssiotou, 2000; Divisekera, 2003 and Lanza et al., 2003).

2.2 Tourism and Climate

There is a consensus that destination image plays an important role in destination choice, and this area has been the subject of much research. What role does climate play in destination image? Not all studies of destination image include climate as an image defining attribute, as can be seen in the extensive review of destination image studies by Gallarza et al. (2002). Of the 25 destination image studies reviewed by them, climate was included as an attribute in 12 studies. Nevertheless, from their list of 20 attributes, climate is the seventh most frequently used attribute. Studies of destination image, which include climate/weather as an attribute, find that it one of most important attributes. Measuring the importance of destination characteristics is also the focus of a study by Hu and Ritchie (1993) where they review several studies from the 1970s and find that "natural beauty and climate" were of universal importance in defining destinations attractiveness. A good climate and the possibility to sunbathe were included in Shoemaker's (1994) list of destination attributes. There are, however, differences in the preferences shown by different types of tourists and for tourists from different places (Hu and Ritchie, 1993; Shoemaker, 1994; Kozak, 2002 and Beerli and Martin, 2004).

Only one of the 142 destination image papers reviewed by Pike (2002) specifically deals with weather. This was a study by Lohmann and Kaim (1999), who assess, using a representative survey of German citizens, the importance of certain destination characteristics. Landscape was found to be the most important aspect even before price considerations. Weather and bio-climate were ranked third and eighth respectively for all destinations. Moreover, they found that although weather is an important factor, destinations are also chosen in spite of the likely bad weather. In a study by Gössling et al. (submitted) of tourists surveyed in Zanzibar, tourists were asked to rate climate's importance for their decision to travel to Zanzibar. More than half rated climate important but a small share of the respondents (17%) stated that climate was not important at all.

De Freitas (2001) classifies climate according to its aesthetic, physical and thermal aspects. The thermal aspect is assumed to be a composite of temperature, wind, humidity and radiation. There is growing evidence, however, that climate has significant neurological and psychological effects (Parker 2001), which may also have some influence on the choice of holiday destination. Many numerical indices have been developed to measure the thermal aspect of climate and to allow comparison of the suitability of different destinations for different tourism activities. De Freitas (1990) found that the relationship between HEBIDEX, a body-atmosphere energy budget index, and the subjective rating of the weather by beach users was highly correlated. Furthermore, he found that the optimal thermal conditions for beach users were not at the minimum heat stress level but at a point of mild heat stress. Matzarakis (2002) uses an index of thermal comfort to identify areas of Greece where there is high likelihood of heat stress occurring.

2.3 Tourism and Climate Change

Qualitative impact studies of climate change have been carried out for the Mediterranean (Nicholls and Hoozemans,1996 and Perry, 2000)), the Caribbean (Gable, 1997), wetland areas in Canada (Wall, 1990) and the German coast (Krupp, 1997 and Lohmann, 2001). These studies vary in their focus and techniques. The latter used surveys, scenarios and consulted both tourist and tourist industry discussion groups in their analysis. Viner and Agnew (1999) examine the current climate and market situation for the most popular tourist destinations of the British. The consequences for demand for these destinations under a changed climate are discussed.

While these studies provide information about vulnerabilities and the likely direction of change, they do not provide estimates of changes in demand. Four groups of quantitative climate change studies exist: predicting changes to the supply of tourism services, using tourism climate indices coupled with demand data, estimating the statistical relationship between demand and weather or climate and finally studies that have their foundations in economic theory. Firstly, predicting changes in the supply of tourism services has been applied to the winter sports industry. Abegg (1996) analysed the impact of changes in temperature on snow depth and coverage and the consequences of these changes on ski season length and the usability of ski facilities in the Swiss Alps. Similar studies were carried out for winter sports tourism in Scotland, Switzerland, alpine Austria and Canada. (Harrison et al, 1999; Kromp-Kolb and Formayer, 2001; Elsasser and Bürki, 2002; and Scott et al, 2001). These studies rely on the assessment of physical conditions that make tourism possible in these areas for a certain activity, that is the supply of tourism services for a specific market segment.

Secondly, the index approach has been used. Scott and McBoyle (2001) apply the tourism index approach to assess the impact of climate change on city tourism in several North American cities. Cities are ranked according to their climatic appropriateness for tourism and the relationship between tourist accommodation expenditures is examined. Then this ranking is recalculated using data from a scenario of climate change. The authors predict an increase in revenue from tourist accommodation for Canadian cities. In the above studies, changes in the relative market position of the destinations or the sites examined are neglected, as well as the change in climate relative to the origin climate of tourists. Amelung and Viner (2004) have produced detailed data on the climatic attractiveness of Europe. Using monthly climate data, they calculate the tourism climate index for Europe with a spatial resolution of 0.5˚x0.5˚. They then recalculate the indices using climate data for a scenario of climate change. Their detailed maps show that higher latitudes will become more attractive for tourists.

Thirdly, some studies use the statistical relationship between demand and weather. For example, Agnew and Palutikof (2001), within the same research framework of Section 3[3], model domestic tourism and international inbound and outbound tourism using a time series of tourism and weather

[3] The analysis presented in Section 3 differs from the one in Agnew and Palutikof (2001) in that it restricts its geographical focus to Italy and pays more attention to extreme weather events.

data. In a similar study for the Netherlands, Tol (2000) finds that Dutch tourists show no significant response to the weather, but that more foreigners visit the country during hot summers.

Fourthly, we have the studies that are grounded in economic theory, the impact of climate change in the US on eight recreation activities are examined by Loomis and Crespi (1999). They estimate demand equations relating the number of activity days to temperature and precipitation. Under a scenario of a +2.5°C change in temperature and a 7% reduction in precipitation, they predict sharp reductions in the number of skiing days (-52%) and increases in the number of days spent playing golf (14%), at the beach (14%) and at reservoirs (9%). Mendelsohn and Markowski also estimate the impact of climate change on a range of recreation activities. The aggregate impact is estimated in terms of welfare and ranges from a reduction of 0.8 billion 1991$ to an increase of 26.5 billion 1991$. Using the contingent visitation approach, Richardson and Loomis (2004) find that temperature is a positive determinant of demand for visits. Moreover, depending on the climate change scenario, they estimate an increase in recreational visits from 9.9% to 13.6% in 2020. Snow dependent activities are the focus of a study by Englin and Moeltner (2004). Using data on price, weekly conditions at ski resorts and the participant's income they find that although demand increases as snow amount increases, trip demand is more responsive to changes in price.

A development of the travel cost model, the "Pooled Travel Cost Model" (PTCM) has been applied for tourists from the UK, the Netherlands and Germany (Maddison, 2001; Lise and Tol, 2002; Hamilton, 2003). Nevertheless, they have estimated the relationship between demand and certain climate variables. The possibility of taking a vacation in the origin country was included in the study by Hamilton. In addition to the travel cost approach, Lise and Tol (2002) study the holiday travel patterns of tourists from a range of OECD countries. They find that that people from different climates have the same climate preferences for their holidays. Similar results were found by Bigano et al. (2004a), who find that people from countries with a warmer climate are more particular about their destination climate. This is can be seen by a peaked temperature-demand relationship.

2.4 Global models on climate change and tourism

Hamilton et al. (2003) present a simulation model (Hamburg Tourism Model) that traces the flows of international tourists from and to 207 countries. The model is calibrated for 1995, using data for total international departures and arrivals. Bilateral tourism flows are generated by the model. The simulations are driven by four variables: distance, population, income, and temperature. Population growth leads to more tourists. Income growth causes changes in trip frequency, and since tourists avoid poor countries developing countries become more attractive as tourist destinations.

Climate change has two effects. Firstly, cool destinations become more attractive as they get warmer, and warm destinations become less attractive. Secondly, cool countries generate less international tourists as they get warmer, and warm countries generate more. Put together, these two effects generate an interesting pattern. Climate change leads tourists to seek out cooler regions in higher latitudes and at higher altitudes. However, climate change also reduces the total number of tourists, because international tourism is dominated by the Germans and the British, who would prefer to take their holidays in their home countries. The reduction in international tourism because of climate change is, however, dwarfed by the growth due to population and economic growth. A modification of the model, presented in Hamilton et al. (2004), examines the effect of demand saturation i.e. a limit on the number of tourists who can be accommodated in a given location. This does not drastically change the results. In addition, the Hamburg Tourism Model is used as an input to a computable general equilibrium model, which is used to examine the economy-wide implications of climate change. The results show that the global impact of climate change on tourism is negligible (Berritella et al., 2004). There is substantial redistribution, however. Countries in Western Europe, the subtropics and the tropics are negatively affected. North America, Eastern Europe and the former Soviet Union, and Australasia are positively affected. The negative impacts may amount to –0.3% of GDP by 2050, the positive impacts of 0.5% of GDP. These numbers are large compared to other monetized impacts of climate change (e.g., Smith et al., 2001).

As can be seen from this review there has been an extensive variety of research carried out on tourism and climate and on tourism and climate change. The majority of these studies look at the role that climate plays in destination choice or in determining demand. Climate data, however, is based on thirty-year averages, and so does not account for extreme conditions, which may affect short-term decision-making. Hence, these studies neglect the role that such extreme weather conditions have on demand, whether this is through the choice of destination, change to the length of the trip, or changing the departure time of the holiday. The following sections of this chapter describe one first attempt to investigate the effects of weather extremes on tourism demand.

3. A study on the impacts of climate extremes on the tourism sector across Europe: the WISE project

A recent, European Commission sponsored study, addresses the impacts of extreme weather events on tourism across Europe, using time series of tourism and weather data in selected European countries. The tourism impact study is part of a wider project (WISE project: *Weather Impacts on Natural, Social and Economic Systems*), conducted in 1997-1999 in four European countries, namely Italy, U.K., Germany and the Netherlands. The project addresses the evaluation of the

overall impact of extreme weather events on the natural, social and economic systems in Europe, and provides, where possible, a monetary evaluation of these impacts. Beside tourism, the other key sectors studied in the project include agriculture, energy consumption, forest fires and health.
The project was carried out in Italy by Fondazione Eni Enrico Mattei[4], following a methodology jointly agreed upon by all partners.

3.1 The WISE Methodology

All country studies consist of a qualitative analysis and a quantitative analysis. The qualitative analysis investigates, by means of mail and telephone surveys, the individuals' perception of climate change impacts on their daily life, including tourism behaviour. The quantitative analysis estimates weather extremes' impacts on tourism and other key economic sectors, through econometric models and national statistics data which cover all regions for the last three decades. In the first part of this section, the methodology and the main results of the quantitative analysis will be presented in depth. The second part illustrates the results of the quantitative analysis carried out in Italy. Finally, we present a brief comparison of qualitative and quantitative results across partner countries.
More specifically, indicators of productivity and key variables in the social and economic sectors of interest are expressed as a linear function of weather parameters, and a linear estimation procedure is applied to estimate the weather impacts on the socio-economic system over the years and across regions.
Therefore the methodology used is not 'sector-specific', and the analysis of the impacts of climate change and extreme weather events on tourism is based on the general modelling framework applied to the various sectors of interest.
The general model used for annual and national observations is:

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 T + \alpha_3 W_t + \alpha_4 W_{t-1} + u_t$$

where *t* expresses the time-series dimension of the model, *X* denotes the index of interest (i.e. number of bed-nights/ tourist arrivals in the tourism impact Italian study). *X* depends on its lagged value to indicate that most influences other than weather (income, technology, institutions) are much the same now and in the past.
T denotes time: for annual observations T indicates the year of observation[5]. Time is taken up as an explanatory variable to capture all unexplained trends.

[4] See Galeotti et al. (2004a).
[5] T is the time trend variable, while *t* is the time index of each observation.

W denotes the weather variable that it is assumed to influence *X*. *W* is a vector including only those climate variables which are supposed to have an influence on *X*: the climate variables selected vary depending on the core sector under analysis.

The weather variable consists of the average value over the time dimension *t* of the climate variable under consideration; when yearly observations on *X* are available, the weather variable *W* generally consists of the yearly average of the climate variable. However, when specific seasons during the year are thought of having a stronger influence on the dependent variable, the average value of the climate variable over that season in each year is used in the regressions.

The lagged value of *W* is taken up to address a dynamic dimension in the model, and because past weather may influence current behaviour, particularly in the tourism sector. *u* denotes the error term. The intercept is included assuming that at least one of the variables is not expressed in deviations from its mean. Under the assumption that *u* is i.i.d.[6] and has normal distribution, the model is estimated by Ordinary Least Squares (OLS) estimators, based on the following procedure: after a first estimation insignificant explanatory variables are removed and the model is re-estimated, checking whether the residuals are stationary.

When monthly observations on X are available, lagged values of *X* and *W* for both the month before and the corresponding month in the year before are used. If in addition regional observations are available, the general model is applied to a panel data structure, covering the time series and cross-section regional data.

The availability of regional and monthly data on tourism demand makes it possible to carry out a panel estimation of the effects of climate change and extreme weather events in Italy.

The panel model estimated across regions (indexed by *i*) and over a monthly time series (indexed by *t*) is:

$$X_{it} = \alpha_0 + \alpha_1 X_{i\,t-1} + \alpha_2 X_{i\,t-12} + \alpha_3 T + \alpha_4 W_{it} + \alpha_5 W_{i\,t-1} + \alpha_6 W_{i\,t-12} + u_{it}$$

In the panel estimation of the general model, dummy variables are used for the years showing patterns of extreme weather to capture the effect of extreme seasons on the dependent variable, as well as for regions or macro-regions in order to identify specific regional effects on the dependent variables.

Following the estimation, a direct cost evaluation method is used to assess the impact of climate change on some of the core sectors identified. The direct cost method assumes that the welfare change induced by the weather extremes can be approximated by the quantity change in the relevant

[6] Random variables are independent and identically distributed (i.i.d.) if their probability distributions are all mutually independent and if each variable has the same probability distribution as any of the others.

variable times its price. The direct cost thus imputed would be a fair approximation of the change in consumer surplus if the price does not change much. The use of dummy variables for extreme seasons in the time-series and panel estimations allows an evaluation in monetary terms of the relative impacts of those extreme seasons on the various sectors, exploiting estimates of quantity changes in those seasons and the corresponding seasonal prices, if available.

3.2 The Italian WISE case study on tourism

3.2.1 Data on Climate

Climate data in Italy are available[7] for most variables on a monthly basis, at the regional level, from 1966 until 1995. Italy seems to show weather patterns, which differ from those identified by northern and central European countries. The UK, the Netherlands and Germany identify the summers of 1995 and 1992 as the most extreme. In the ’90s Italy indeed experienced extremely high summer temperatures and anomalies in 1994. During the ’80s, a strong temperature anomaly was recorded in the summer of 1982. 1994 was recorded as one of the driest summers, together with the summer of 1985. In addition, the summer of 1985 had a very high sunshine rate, comparable only to the late ’60s (in particular 1967).

With regard to extreme winter seasons, the 1989 winter is definitely the mildest winter recorded, showing strong anomalies in temperature, in exposure to sunshine and lack of precipitation. The winter of 1989 was followed by relatively mild winters, reaching very high peaks in temperature again in the year 1994.

In contrast with the evidence collected by the other European partner countries, where the 1990 winter was recorded as mild and wet, the 1990 winter season in Italy was mild and extremely dry all over the country. Anomalies in yearly precipitation versus yearly temperature, as well as anomalies of winter precipitation versus winter sunshine rates show the highest negative correlation. Overall, the summers of 1994 and 1985, and the 1989 winter can be identified as the most extreme seasons in Italy. With regard to the regional variability of weather data, it can be generally observed that there is a low variance of weather variables across regions in the extreme seasons with respect to the other seasons: this shows a relative homogeneity of weather extremes within the country.

3.2.2 Data on Tourism

The data on tourism demand includes data on the number bed-nights and on the number of arrivals for both domestic and foreign tourism. Monthly data are available at the national level for a period

[7] The WISE project was carried out in 1997-1999. The time series for the relevant variables cover at the latest half decade in the ‘90s.

of two decades, starting from 1976 for domestic tourism and from 1967 for foreign tourism, and at the regional level starting from 1983.

Since 1990, due to a new legislation, the data refer only to accommodation provided by registered firms (thus excluding accommodations provided by private individuals) and consequently both series show a structural break. Separate analyses are carried out for the two time periods. *Both variables generally show an increasing trend over the three decades, and a seasonal peak during the summer season for both domestic and foreign tourism.*

Focusing on the second period under analysis, a high positive correlation exists between the monthly number of bed-nights and the monthly temperature (0.7072), as well as the monthly temperature in the year before (0.6310), all measured at the national level. The national number of bed-nights during the summer is highly correlated with the summer national temperature (0.6838) and even more correlated with the summer national temperature in the year before (0.9486). The regional number of bed-nights over winter is highly and negatively correlated with the monthly regional temperature in the previous year.

Looking at the correlation coefficients between bed-nights and temperatures, in 1986-1995, temperature is positively correlated with tourism during the month of May, and the summer months of June, July and August. A very high positive correlation exists between temperature and tourism in March: this evidence suggests a very sensitive demand for tourism in the spring intermediate season. A relatively strong negative correlation indeed exists between temperatures and monthly tourism in December, perhaps due the negative effect of high temperatures on the skiing season in the Alps and in the Apennines. Data for the first period under analysis, between 1976-1989, generally shows much higher correlation coefficients, certainly due to the fact that the data includes accommodation provided by private individuals, which meet a high share of tourism demand.

3.2. 3 Main results

The national monthly data on bed-nights of domestic tourism is non-stationary. The analysis is based on the regional data on domestic tourism, which is available on a monthly basis starting from 1983; due to a structural break in the data, separate analyses are carried out for the period 1983-1989 and for the period 1990-1995.

During mild winters we may expect a decrease in domestic tourism to mountain regions due to the shortening of the skiing seasons and a general increase of domestic tourism across the country due to warmer weather. The expected sign of the net outcome across the whole country could be slightly positive or uncertain. During extremely hot summer months we would expect a decrease in domestic tourism since domestic tourists may prefer to take their summer holidays abroad, particularly in Northern countries, where it is cooler than in Italy. We may also expect an increase in domestic tourism during summer months due to more weekend trips because of hotter weather. The relative strength of the latter effect is tested.

In both periods, following the methodology previously described OLS fixed effects panel estimation regressions are performed, first over all months in the year and then over selected summer and winter months. Dummy variables are included for the years that show extreme weather patterns and for each region.

The final results of the OLS fixed effects panel estimation for all the months of the year for both periods are presented in Table 1. The most interesting results can be summarised as follows. In both periods higher monthly regional temperature is estimated to have a positive effect on domestic tourism flows. In the first period under analysis, even last year's temperature in the corresponding month appears to trigger monthly domestic tourism. In the second period under analysis, last year's rainfall in the corresponding month appears to work as a deterrent for monthly domestic tourism flows, as expected. However, in the same period, monthly precipitation *unexpectedly* has a positive influence on domestic tourism. In both periods model estimates are robust.

The OLS panel estimation including the dummy variables for each region shows that in the period 1983-1989 the regions where Italian tourists spend the highest number of bed-nights are Emilia-Romagna, Trentino, Liguria and Lazio.

The same procedure is applied to the estimation of climate predictors of domestic tourism during the summer months over the two periods under analysis (Table 2).

In both periods the summer regional temperature has a high positive effect on the number of bed-nights, and the twelve-month lagged value of temperature has an even stronger positive effect. In line with the hypotheses initially formulated, these results suggest the important role that temperatures and expectations play on tourism demand: not only do the number of bed-nights tends to increase during hot summers, but also a hot summer in the year before influences the number of bed-nights that domestic tourists decide to take.

When we re-estimate the panel model including extreme season dummies[8], the dummy for the 1994 extreme season has a significant and negative effect on the number of bed-nights of domestic tourists during the summer months.

Tables 3-7 report results from the estimation of the climate predictors of domestic tourism bed-nights across Italy in selected months, representative of the main seasons.

It is interesting to note that tourism in February is strongly and negatively influenced by high temperatures in January: as it was initially formulated, this may be due to the *negative influence of high temperatures on the skiing season*, at least in the Alps and Apennines, or to anticipated winter trips or vacations due to good weather in the month of January.

[8] Theis results has not been reported in Table 2.

Higher temperatures in the intermediate seasons of spring and fall turn out to trigger domestic tourism flows; the results suggest *a relatively higher elasticity of domestic tourism to climate factors in the intermediate seasons.*

However, precipitation in July works as a deterrent for domestic tourism flows in that month, and higher temperatures in July reduce domestic tourism considerably in the month of August. Following our initial considerations, this result may be partly due to a '*substitution effect' between domestic and foreign destinations in tourism demand due to climate variability*.

Overall, domestic tourism demand seems to be quite sensitive to climate factors, and extreme seasons seriously affect tourism demand.

To summarise some of the most interesting results, based on estimates over the last ten years*, a 1° C temperature increase in July in the coastal regions is estimated to increase the number of bed-nights by 24,783 in those regions. In the month of August a 1° C temperature increase would imply an increase of 62,294 bed-nights. These effects are likely to increase welfare in those regions.*

Focusing on winter temperatures and Alpine regions, over the same period the model instead estimates that *a 1° C increase in winter temperature would result in a decrease in local domestic tourism equal to 30,368 bed-nights, with a reduction in welfare*.

On average across all regions the model estimates that anomalous hot weather in July would diminish domestic tourists' flows in the following month by 39,494 bed-nights. However in the intermediate seasons an increase in temperature is estimated to have a positive effect on domestic tourism: a 1° C increase in temperature in May and October may explain an increase in domestic tourism, for every region, by 6,135 and 11,540 bed-nights respectively. Therefore *the net welfare effect of climate extremes on tourism across regions and during the year is unclear*.

The computed elasticity of domestic tourism bed-nights to climate, including accommodation provided by private individuals, suggests a 0.071 percentage increase in tourism per marginal percentage increase in monthly temperature, and a 0.49 percentage increase per marginal percentage increase in summer monthly temperature, which reaches a 0.79 per marginal percentage increase in summer monthly temperature when private accommodation is not included.

3.3 Comparison of WISE results across Europe

The quantitative results from the Italian study correspond to the results from the other European partner countries[9].

In general, temperature is the strongest indicator of domestic tourism. The relationship is generally positive in the same-month all across Europe, except in a winter sports region. A summer warming of 1°C is estimated to increase domestic holidays by 0.8-4.7% with respect to the period's average.

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[9] See Agnew and. Palutikof (2001) for a more detailed comparison of international results.

The climate impact depends as well on destination type: for example coastal resorts respond more favourably to summer temperature increases than inland resorts.

In the U.K., where data on international tourism is available, the evidence suggests that outbound tourism is more sensitive to climate than inbound tourism. Temperature is generally regarded as having the greatest influence on international tourism. For example, a 1°C increase in temperature in the Netherlands increases outbound tourism in the following year by 3.1%. Globally the optimal summer temperature at the destination country is estimated to be 21°C[10]. There is little deviation from country-to-country. Moreover, there is little evidence that in extremely hot seasons Dutch tourists prefer domestic to foreign beach holidays.

As to the qualitative results, a very brief overview of the surveys of individuals' perception across the European partner countries shows that, during an unusually hot summer, day trips are more climate-responsive than short breaks and short breaks are more climate-responsive than main holidays. In an unusually hot summer, most people tend not to change plans for their main vacation: those that do change either stay at home or in their own country. However several regional differences in the adaptive response to climate extremes can be noted.

Results of the management perception surveys, conducted among operators in the tourist supply system, indeed show the relevance of weather/climate for short holiday trips, domestic trips and spontaneous trips. Weather conditions (actual and anticipated) are found to be very important for determining the attractiveness of a holiday destination: tourists have great freedom of destination choice, and climate is a significant consideration in tourist destination choice decision-making. Nevertheless, it is not always easy to tease out the impact of climate from the many other factors influencing holiday choice. There are extremely complex processes at work. Global models pick out the broad relationships with temperature. But the results suggest that the intricacies of the climate relationships differ even within countries. Micro-analyses using individual tourist behaviour provide the most detail, but lack the temporal perspective. Ideally, to understand the influence of climate more clearly we would have data differentiating between pre-booked and spontaneous trips, between destination type (coastal, urban, winter sport regions), information on the difference between the climate at the target destination and the climate of the source region, and knowledge of when trips were planned or booked[11].

4. Conclusions

[10] Both the study on the UK and the study on the Netherlands include quadratic temperature terms. The global optimal temperature has been derived within the study on the Netherlands. See Agnew and Palutikof (2001).

[11] See Agnew and Palutikof (1999, 2001).

The relationship between climate change and tourism is multi-faceted and complex. The existing studies have but started unveiling these complexities, by means of often very heterogeneous approaches and scarcely comparable studies. A comprehensive, coherent quantitative message cannot yet be drawn from the existing studies.

The broad qualitative message emerging from the literature is clear, however: climate change will affect tourism, and the consequences for the economy might be wide and pervasive, given the importance of the industry.

The empirical example we have presented illustrates how complex the relationship between climate and tourism demand can be even in a simple framework where weather and its extremes are the only explanatory factors taken into account: it is not just temperature that counts, but also the expectations about future temperature levels, (with different impacts according to the month and the region under scrutiny): not just the presence of weather extremes, but also the expectations about their future occurrence.

There is much more that needs to be explored. As far as extreme weather events are concerned, the range of events to be taken into consideration should be expanded to include the impacts of increased occurrence of storms, heat waves, and drought, with particular attention to the likely increase in their geographical and temporal variability.

Other gaps in the literature can be pinpointed by looking at our survey of the main strands of the literature on tourism and climate change. Our survey has disregarded the issue of adaptive behaviour. In a sense, all destination choice studies are about adaptation: changing holiday destination is a form of adaptation on the part of the tourist. However, there is shortage of detailed information on adaptive behaviour, which could be obtained for instance, by means of survey analysis. We need better knowledge about which aspects of climate tourists are sensitive to: pleasant weather is attractive, but what about its predictability? Can lack of weather predictability be compensated by the availability of alternative activities? The relative importance of spatial and temporal substitution is unknown. Tourists in fact may react to adverse weather conditions not only by changing their planned destination, but also by revising their planning, by means of last minute changes, or by changing their booking patterns, taking shorter holidays more frequently or at different times of the year. They might try to reduce the risk associated with the reduced predictability of climate by relying more on travel insurance that can make cancellation cheaper.

On the supply side, firms in the tourism sector can be very adaptive too. They may limit the damages to their business for instance by installing air conditioning appliances, by building swimming pools or other architectural improvements, by building artificial snow plants in case of mountain resorts, and, to a certain extent, by insuring themselves against the occurrence of extreme events. Gradual climate change does not pose a particular threat to such a versatile sector. The limits of adaptability of course may be reached if climate change threatens the very existence of the only reason that may attract tourists in a given area: if an atoll becomes submerged, there is no more scope for adaptation there.

We also have disregarded studies about the role of mitigation policies (e.g., Piga, 2003). There is a growing interest about the impact of carbon reduction policies, which can have a direct impact on tourism (e.g. an aviation carbon tax) and in general about the impact of carbon taxes on the operation of the tourism industry. Mitigation measures may have interactions with the adaptive behaviour of firms in the tourist sector: air conditioning runs on electricity, which may be targeted by a carbon tax.

Also, the interactions among various climate impacts on tourist areas need to be assessed. Tourists might be deterred not only by unbearable weather conditions, but also because the nice sandy beaches that used to be the pride of a resort are not there any more due to sea-level rise and coastal erosion, or because the unique ecosystem of a destination has been compromised, or because, by travelling in that area, catching some tropical disease has become more likely. On the other hand, the position of some resorts will be strengthened as their competitors disappear (e.g., atoll islands, and skiing on natural snow).

The research on climate change and tourism is still far from having covered all the angles of the relationship between climate change and tourism. Results to date indicate that further research would be fruitful and worthwhile.

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Annex

Table 1. OLS fixed effects panel estimation of the monthly regional number of bed-nights of domestic tourism across Italy all over the year

Independent variables	**Coefficient Estimates for the period 1983-1989**	*t-statistics*	**Coefficient Estimates For the period 1990-1995**	*t-statistics*
Constant	-203610.7***	-2.803	-118313**	-1.999
One-month lagged # of regional bed-nights	0.2545983***	12.248	0.3748518***	15.590
Twelve-months lagged # of regional bed-nights	0.5831289***	27.063	0.4085923***	16.741
Time trend				
Monthly regional temperature	84619.3***	4.454	44203.16***	8.207
One-month lagged regional temperature	-25735.59***	-3.285	-23126.96***	-4.224
Twelve-months lagged regional temperature	-32630.28*	-1.736		
Monthly regional precipitation			1150.442**	2.174
One-month lagged regional precipitation			1086.217***	2.662
Twelve-months lagged regional precipitation			-2865.918***	-5.541
# of observations	1364		1131	
F test	402.06		223.68	
R-squared				
Within	0.6002		0.5860	
Between	0.4652		0.6085	
Overall	0.5866		0.5922	

* significant at 95% **significant at 97.5% *** significant at 99%

Table 2. OLS fixed effects panel estimation of the monthly regional number of bed-nights of domestic tourism across Italy during the summer months June, July and August

Independent variables	**Coefficient Estimates for the period 1983-1989**	*t-statistics*	**Coefficient Estimates For the period 1990-1995**	*t-statistics*
Constant	-2853644***	-6.511	-1638962***	-6.746
One-month lagged # of regional bed-nights	1.011495***	27.607	1.123286***	39.348
Twelve-months lagged # of regional bed-nights	0.0881233***	2.791		
Time trend				
Monthly regional temperature	80178.66***	3.506	41022.48***	2.864
One-month lagged regional temperature				
Twelve-months lagged regional temperature	93467.5***	4.091	49305.5***	3.665
Monthly regional precipitation			1595.653**	2.269
One-month lagged regional precipitation			1698.946***	2.953
Twelve-months lagged regional precipitation				
# of observations	342			240
F test	507.90			510.92
R-squared				
Within	0.8647			0.9210
Between	0.9234			0.9663
Overall	0.8408			0.9201

* significant at 95% **significant at 97.5% *** significant at 99%

Table 3. OLS fixed-effects panel estimation of number of bed-nights of domestic tourism across Italy in February, 1983-1989

Independent Variables	**Coefficient Estimates**	*t-statistics*
Constant	390832.9 ***	6.978
Regional bed-nights in January	.9285 ***	7.810
Regional bed-nights in February of the year before	-.6450 ***	-6.556
Regional temperature in January	-12887.39 ***	-2.959
Dummy for the winter 1988	57988.49 ***	2.989
# of observations	108	
F test (4, 86)	20.79	
R-squared		
Within	0.4916	
Between	0.9126	
Overall	0.8722	

* significant at 95% **significant at 97.5% *** significant at 99%

Table 4. OLS fixed-effects panel estimation of number of bed-nights of domestic tourism across Italy in May, 1986-1995

Independent Variables	**Coefficient Estimates**	*t-statistics*
Constant	372574.3 ***	4.299
Regional bed-nights in April	.3264 ***	2.672
Regional temperature in May	6135.286 **	2.246
Regional temperature in May of the year before	-9748.003 ***	-3.526
# of observations	98	
F test (3, 78)	8.85	
R-squared		
Within	0.2539	
Between	0.9454	
Overall	0.9224	

* significant at 95% **significant at 97.5% *** significant at 99%

Table 5. OLS fixed-effects panel estimation of number of bed-nights of domestic tourism across Italy in July, 1983-1989

Independent Variables	**Coefficient Estimates**	*t-statistics*
Constant	7.34e+07 ***	2.680
Regional bed-nights in June	2.1685 ***	9.205
Regional bed-nights in July of the year before	.5816 ***	7.429
Time trend	-37375.1 ***	-2.705
Regional precipitation in July	-2014.282 ***	-3.029
# of observations	120	
F test (4, 96)	45.44	
R-squared *Within* *Between* Overall	 0.6544 0.8876 0.8805	

* significant at 95% **significant at 97.5% *** significant at 99%

Table 6. OLS fixed-effects panel estimation of number of bed-nights of domestic tourism across Italy in August, 1983-1989

Independent Variables	**Coefficient Estimates for the period 1983-1989**	*t-statistics*
Constant	1044081 **	2.074
Regional bed-nights in July	1.1424 ***	3.477
Regional bed-nights in August of the year before	.2119 **	-2.037
Regional temperature in July	-39493.91 **	-2.037
# of observations	107	
F test (3, 86)	148.18	
R-squared *Within* *Between* Overall	 0.8379 0.9919 0.9885	

* significant at 95% **significant at 97.5% *** significant at 99%

Table 7. OLS fixed-effects panel estimation of number of bed-nights of domestic tourism across Italy in October, 1986-1995

Independent Variables	**Coefficient estimates**	*t-statistics*
Constant	-271016.3 **	-2.150
Regional bed-nights in September	.1731 ***	2.468
Regional bed-nights in October of the year before	.2787 ***	2.741
Regional temperature in October	11540.6 ***	2.787
Regional temperature in October of the year before	14488.39 ***	4.108
# of observations	78	
F test (3, 78)	10.13	
R-squared		
Within	0.4112	
Between	0.7562	
Overall	0.7496	

* significant at 95% **significant at 97.5% *** significant at 99%

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