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The impact of weather variability on British outbound flows

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Abstract Climate can be understood both as a resource and a motivation for tourism. This study focuses on the second issue trying to establish the sensitivity to weather anomalies of the outbound flows from United Kingdom, the third biggest international tourist spender country. Using transfer function models it is possible to analyze the significance of the short-term weather conditions in the determination of outbound British flows and simulate the effects of different climate change scenarios. Results show how mean temperature, heat waves, air frost and sunshine days are the weather variables that can be significantly related to the dynamics of the outbound British flows time series.

1 Introduction

International tourism is considered nowadays one of the most important industries in the world, with an annual volume of 900 million arrivals (UNWTO 2008) and a projection that this number will continue growing to 1.6 billion worldwide by 2020. In terms of economic importance, the Tourism Satellite Accounts produced by the World Travel & Tourism Council estimates the contribution of travel and tourism to World Gross Domestic Product at 9.4% in 2009, a percentage that is expected to continue growing to 9.5% by 2019 (WTTC 2009).

Because of the economic magnitude of the travel and tourism industry, its social impact through the generation of jobs and, all in all, the number of people involved, the relationship between tourism and climate change is generating a growing interest.

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Both public and private sectors are driving different initiatives with the aim of widening the knowledge of the interactions between climate and tourism. Although there has been recent controversy over the weaknesses of the current models in predicting tourist flows under scenarios of climate change (Gossling and Hall 2006; Bigano et al. 2006a), academic literature has identified multiple interactions between tourism and climate, the effect of climate change on tourism flows being one of the most recurrent.

In this context, the pioneering study of Maddison (2001) investigates the impact of climate change on the chosen destinations of British tourists using classical price determinants of tourism demand and incorporating climate variables in terms of attractors. The findings could be used to predict the impact of various climate change scenarios on different tourist destinations. From a similar perspective, Lise and Tol (2002) study Dutch tourists using factor and regression analysis to find optimal temperatures at travel destinations for different tourists and different tourist activities, showing that OECD tourists prefer an average of the hottest month of the year temperature of 21°C indicating that, under a scenario of gradual warming, tourists will spend their holidays in different places than they currently do.

The redistribution of tourism flows is analyzed in Hamilton et al. (2005a, b), Bigano et al. (2006b) and Hamilton and Tol (2007) using simulation models of the flow of tourists between more than two hundred countries and generating climate change scenarios of tourist departures and arrivals. Results show how, in the medium to long term, tourism will grow in absolute terms but this increase will be smaller than population and income changes and not homogeneously distributed, being higher for colder countries and lower for warmer ones.

In the framework of time series analysis, the weather conditions as a predictor of domestic and international tourism is considered in Subak et al. (2000) and Agnew and Palutikof (2006). Subak et al. (2000) investigate three time series that relate to UK domestic tourism. Although the time series are short, all the series are found to be responsive to weather fluctuations. However, the relationship between the time series in some cases is not easy to understand, concluding that further investigations of the relationship between weather and tourism is needed.

Agnew and Palutikof (2006) investigate the sensitivity of UK tourism to weather conditions using monthly data for domestic tourism and annual data for trips abroad, showing that outbound flows of tourists are responsive to weather variability of the preceding year, whereas domestic tourism is responsive to variability within the year of travel. Using the anomalously warm year of 1995 in the UK, the potential impact of climate change is evaluated suggesting that the generally warmer and drier conditions of 1995 benefited the UK domestic tourist industry but wetter and duller-than-average conditions in the year previous to travel seem to encourage more trips abroad. However, the use of the annual scale in the analysis of tourism flows could underestimate tourism short term decisions. In this line, different studies and statistics have shown how tourist travel decisions, especially those related to summer holidays, are taken only some months before (Money and Crotts 2003; Aguiló and Juaneda 2000).

Thus, the present work focuses on the consideration of weather variability in the origin country as a key motivation factor in the tourism travel decision using a higher frequency database in order to incorporate short term travel decision motivated by weather anomalies. Monthly data for outbound tourism from the UK is used in order to develop the empirical work because of its importance as a tourist generator country and the availability of data. UK was the third biggest international tourist spender in the year 2008 with US$ 68.5 billion, just beaten by Germany and USA with 91.0 and 79.7 respectively. Its importance is also reflected in the fact that it is one the highest spenders per capita world-wide with US$ 1,121 (UNWTO 2009).

This paper is organized as follows. Section 2 briefly reviews the literature of tourism demand in the context of time series models in order to present the methodology adopted in this study. Section 3 presents data used in this study and the simulation exercise adopted in the context of temperature warming. Section 4 shows results for the case study of outbound British tourist flows showing the sensitivity of weather conditions and estimating possible responses to increases in temperature on outbound tourism flows. Section 5 concludes by highlighting the main findings from both the estimation and simulation analysis and placing these in the context of global climate change.

2 Methodology

Being one of the important areas in tourism research, tourism demand modeling has attracted much attention from both academics and practitioners. A number of review articles on tourism demand estimation have been published over the last decade and these include Crouch (1994), Li et al. (2005), Lim (1997a, b, 1999), Song and Li (2008) and Witt and Witt (1995). These reviews agreed in presenting time-series models as one of the most popular methodologies when analyzing aggregated data, as it is possible to work only with historical observations of the tourist variable (univariate models) or the use of determining variables (multivariate models). Particular attention is paid to exploring the historic trends and patterns (such as seasonality) of the time series in order to determine and/or predict the future of this series.

When high frequency data are considered, time series are often modeled on the basis of their own past values and a random disturbance term based on trends and patterns previously identified. In this field, auto regressive integrated moving averages models (known as ARIMA models) based on the Box–Jenkins methodology (Box and Jenkins 1970) are the most popular time series models used in the tourism demand field (Burger et al. 2001; Cho 2003; Coshall 2005). Through an ARIMA model, the once seasonal component is controlled and the trend-cycle component of a time series is estimated, disregarding the random component.

Transfer function models extend the analysis made by a classical ARIMA to multiple time series, combining properties of causal econometrics models and non-causal univariate ARIMA, allowing the incorporation of explanatory variables complementing, in this way, the ability of the model to estimate the trend-cycle component, thus reducing the random component. Transfer functions have been used widely in the tourism field in modeling and forecasting tourism demand (Turner et al. 1997; Chow et al. 1998; Kulendran and Witt 2003; Smeral and Wüger 2005) even in the context of climate change (Trigo and Palutikof 1999), but not specifically trying to evaluate the climate impact on tourism.

Thus, the present study intends to model the weather sensitivity of British outbound flows through a transfer function model. It is hypothesized that, once the trend-cycle component of British outbound flows is estimated through an ARIMA model, the use of the lagged weather variables at origin can improve the estimation results showing that weather conditions at the origin have an influence on tourism travel decisions. Moreover, once the model has been identified, simulation analysis can be undertaken in the context of temperature warming with the aim of evaluating its effect on tourism flows.

Analytically, the transfer function specification can be written as:

$$\phi_p(L)Y_t = \theta_q(L)a_t + \varphi_b^k(L)d_t^k \tag{1}$$

where Y_t is the number of UK residents going abroad (UK outbound flows), α_t is the innovation or moving average term, and $\phi_p(L)$ and $\theta_q(L)$ are the lag operator polynomials for both Y_t and α_t, respectively, d_t^k is a vector of the k weather variables that could influence UK outbound flows, and $\varphi_b^k(L)$ are the lag operator polynomials (or transfer function) for each one of the weather determining d_t^k variables. The within-sample predicted values, used for simulation purposes, can be calculated from the expression:

$$Y_t = \sum_{i=1}^{p} \rho_i Y_{t-i} + \sum_{i=1}^{q} \theta_q a_{t-q} + \sum_{i=1}^{b1} \varphi_{b1} d_{t-b1}^1 + \sum_{i=1}^{b2} \varphi_{b2} d_{t-b2}^2 + \ldots + \sum_{i=1}^{bk} \varphi_{bk} d_{t-bk}^k + \varepsilon_t \tag{2}$$

where ρ, θ and π are parameters to be estimated.

3 Data and simulation

3.1 Data

Time series data for outbound flows from UK from 1980-January to 2009-July used for this study was taken from the International Passenger Survey that takes a random survey of residents leaving the UK to go on holiday. This data, with its methodological considerations and limitations, is freely available at the British Office for National Statistics web page[1] and has been used by other authors in studies related to climate change or tourism demand modeling (Smith 1990; Maddison 2001; Kulendran and Witt 2003; Agnew and Palutikof 2006).

With reference to the weather variables, temperature and rainfall are the most used climate variables determining tourism decisions (Hall and Higham 2005;

[1] http://www.statistics.gov.uk/statbase/tsdataset.asp?vlnk=683

Becken and Hay 2007; Giupponi and Shechter 2003). Although other climatic variables can been used[2] in determining the effect of climate and weather on tourism, temperature has been the most popular by far because of its strong correlation with other climatic variables, its availability and maybe because it is one of the continuous climatic variables that people first perceive.

Whatever the case, this study tested the influence of six weather variables on outbound tourist flows: mean maximum daily temperature, mean minimum daily temperature, days of air frost (AF), total rainfall, total sunshine duration (SD), and monthly average temperature (AT), which was calculated as the average of the aforementioned maximum and minimum daily temperatures.

Monthly climate data for the UK was taken from data provided by the British Public Weather Service for the same period as outbound flows.[3] Although from this source it is possible to find regional weather indicators from UK, data for monthly outbound tourists refers exclusively to national level, which is why data was taken at this same aggregation level. Additionally, two more variables were calculated in order to be included in the analysis because of possible weather anomalies effects. Thus, it was assumed that an optimal holidaying temperature for the British exists and, following Bigano et al. (2006c), can be estimated at 16.3°C.

Therefore, two variables are constructed in order to represent the number of degrees which deviates from that established optimum. The first one (HT) considers high temperatures computing the degrees that exceed 16.3°C and zero otherwise. The second one computes the number of degrees less than the 16.3 and zero otherwise. This non-linear response of the temperature is often applied in electricity demand estimation (Pardo et al. 2002) with the aim of measuring the intensity and duration of cold or heat in winter and summer months, respectively. In any case, different reference temperature alternatives are tested in order to ensure the suitability of the market reference.

3.2 Simulation

In order to analyze the likely effects of warmer climates in the UK on tourism flows due to global warming, a sensitivity analysis was performed using the scenarios provided in Table 1. Temperature ranges were selected according to the expectations of increase revealed in UKCIP (2002) and the expected differences between seasons. Moreover, because of the high correlation between temperature and the rest of the weather variables, simple statistical models can be estimated in order to interpolate the temperature increase on the rest of the variables.

[2]For Instance, Perry (2006) refers to sea surface temperature, Amelung and Viner (2006) and Amelung et al. (2007) used relative humidity measured in percentage and wind speed while Agnew and Palutikof (2006) included the mean hours of sunshine in their study.

[3]http://www.metoffice.gov.uk/climate/uk/datasets/index.html

Table 1 Simulated temperature scenarios

+1	Monthly mean temperatures are increased 1°C for the whole period
+3	Monthly mean temperatures are increased 3°C for the whole period
+5	Monthly mean temperatures are increased 5°C for the whole period
S1	Monthly mean temperatures for July August and September are increased 2°C. Monthly mean temperatures for December, January and February are increased 1°C. Monthly mean temperatures for the rest of the months are increased 1.5°C
S2	Monthly mean temperatures for July August and September are increased 6°C. Monthly mean temperatures for December, January and February are increased 4°C. Monthly mean temperatures for the rest of the months are increased 5°C.

A simulation is considered evaluating change 12 months ahead and recovering real data for the UK tourist abroad time series. Analytically, simulated values are computed from the following expression:

$$\hat{Y}_t = \sum_{i=1}^{p} \rho_i Y_{t-i} + \sum_{i=1}^{q} \theta_q a_{t-q} + \sum_{i=1}^{b1} \varphi_{b1} \tilde{d}^1_{t-b1} + \sum_{i=1}^{b2} \varphi_{b2} \tilde{d}^2_{t-b2} + \ldots + \sum_{i=1}^{bk} \varphi_{bk} \tilde{d}^k_{t-bk} \quad (3)$$

Where, $\hat{Y}_t$ is the simulated tourist variable, and $\tilde{d}^1_{t-b1}, \tilde{d}^2_{t-b2}, \ldots, \tilde{d}^k_{t-bk}$ are the transformed weather indicators according to the increase in temperature.

4 Results

4.1 Estimation

Because of the strong seasonal component of British tourists abroad, time series HEGY test (Hylleberg et al. 1990) were used in order to analyze the presence of seasonal unit roots. Results of the HEGY test suggest the use of the 12-order differences of the original time series that were computed over the natural logarithms as has traditionally been done in tourism demand estimation literature.

Thus, for the first step, general models with the whole set of variables and the whole set of lags were estimated. However, because of the high number of no-significant variables the general-to-specific strategy (Hendry 1995) was considered in order to simplify the model. The Likelihood Ratio and the Wald Test were used as diagnostic tests for the model reduction. The Akaike Info Criterion (AIC) and the Schwarz Criterion (SC) were also calculated in order to compare different models. Finally, the Breusch–Godfrey Serial Correlation LM Test was used to check for serial correlation.

Table 1 shows the estimated equations for the dependant variable with the following lag structure: 1, 2, 3, 11, 12 and 13 of autoregressive processes and one moving average in the 12-lagged month, lag 12 for days of air frost (AF), lags 5, 8 and 12 for average temperature (AT), lag 1 for higher temperatures than 16.3°C (HT), and lag 2 for sunshine duration (SD). In the last column, the results of a simple ARIMA model are presented in order to show the superiority of the transfer function model. In this line, the likelihood ratio test (Greene 1997) that compares the performance of the unrestricted (transfer function) versus the restricted (ARIMA) model gives a value of 77.8, a value that leads to rejecting the null hypothesis and shows the superiority of the transfer function model.

According to previous literature findings, warmer temperatures can be related to a decrease in outbound British flows in the sense that the average temperature of the past 5, 8 and 12 months led to a drop in tourist flows. In this way, the last month's temperature exceeding 16.3°C reduced international tourist affluence, a variable that can be related to heat waves. At this point it should be mentioned how sensitivity analysis of the temperature threshold of 16.3 did not reveal significant differences in the model adjustment. Meanwhile, more hours of sunshine duration in the last 2 months discouraged the British to travel abroad. Moreover, the days of air frost provoked an increased number of British passengers going abroad. Thus, mean maximum daily temperature, mean minimum daily temperature, total rainfall and the constructed variable for month temperature below 16.3°C were not significant at 10% in any zero or lagged month.

With reference to the lag structure and the timing of travel decisions it seems that average temperature is related to outbound flows between 5 and 12 months in advance showing how the relationship between temperature and travel decisions takes place at the same time or in advance. However, it should be pointed out that sunshine duration and heat waves are related to outbound flows only 1 and 2 months in advance, an issue that could be related to the phenomenon of last minute trips.

4.2 Discussion

Because simulation has been considered in the context of average temperature warming, but other climatic variables have been found to be significant in explaining outbound British tourism flows, the repercussion of a temperature increase over the rest of the variables has been extrapolated. Thus, according to Fig. 1, the effect of temperature increases of 1°C, 2°C and 3°C on tourism flows can be both direct, through the recalculation of the AT variable, or indirect through the estimation of the HT, SD and AF variables. In the case of AT and HT variables, the consideration of the temperature increase is direct. However, in order to evaluate the effect of a temperature increase on SD and AF, statistical models, shown in Appendix, were estimated.

Therefore, higher temperatures, a higher number of heat waves and sunshine hours and fewer days of air frost, imply, overall, an increased number of observations

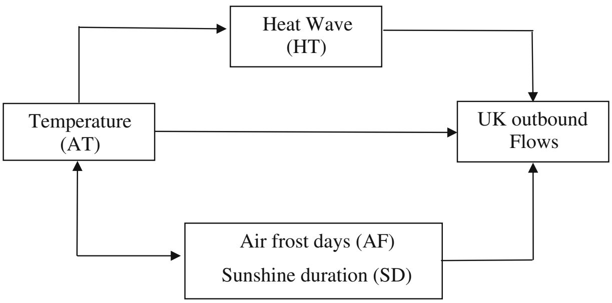

Fig. 1 Structure of influence of changes in temperature on UK outbound flows

Table 2 Estimated LS coefficients

Variable	Transfer function coefficients	ARIMA coefficients
Constant	0.1493*	−36.469
AR(1)	0.2796**	0.2408**
AR(2)	0.2834**	0.2259**
AR(3)	0.1045**	0.1201*
AR(11)	0.1613**	0.2427**
AR(12)	0.2857**	0.2440**
AR(13)	−0.2421**	−0.1736**
MA(12)	−0.9282**	−0.7484**
AF_{-12}	0.0027**	–
AT_{-5}	−0.0045**	–
AT_{-8}	−0.0044**	–
AT_{-12}	−0.0023**	–
HT_{-1}	−0.0036**	–
SD_{-2}	−0.0002**	–
Equation statistics		
R^2	0.5210	0.4186
Adjusted R^2	0.5013	0.4060
DW statistic	2.0507	2.0261
Log likelihood	492.5764	460.6051
Akaike info criterion	−2.9004	−2.7430
Schwarz criterion	−2.7393	−2.6510
F-statistic	26.4432	33.1238
Observations	330	330

Note: **Significant at 1%, *Significant at 5%

exceeding the optimal holidaying weather conditions and consequently, negatively affecting British outbound flows. Table 2 shows the estimated results according to the simulation exercise and methodological considerations mentioned above.

Thus, it is estimated than an additional 1°C to the UK average temperature will provoke an annual decrease of a 1.73% of British outbound flows, a percentage

Table 3 Effects on UK outbound flows due to increased temperature

	+1	+2	+3	S1	S2
Yearly	−726.72	−2,143.13	−3,503.86	−1,096.93	−3,552.44
Yearly (%)	−1.73%	−5.10%	−8.34%	−2.61%	−8.46%
January	−1.85%	−5.42%	−8.57%	−2.56%	−8.51%
February	−1.82%	−5.24%	−8.22%	−2.48%	−8.06%
March	−1.76%	−4.94%	−7.63%	−2.78%	−7.91%
April	−1.46%	−4.30%	−6.77%	−2.40%	−7.05%
May	−1.33%	−3.87%	−6.52%	−1.97%	−6.51%
June	−1.34%	−4.35%	−7.58%	−1.81%	−7.16%
July	−1.69%	−5.09%	−8.49%	−2.43%	−8.29%
August	−1.81%	−5.36%	−8.91%	−2.77%	−9.04%
September	−1.89%	−5.58%	−9.24%	−3.09%	−9.86%
October	−2.01%	−5.84%	−9.50%	−3.16%	−9.92%
November	−1.96%	−5.61%	−9.09%	−3.07%	−9.51%
December	−2.01%	−5.74%	−9.08%	−2.78%	−9.02%

Note: Absolute values in thousands

that will reach 5.10% and 8.34% in the case of increases in temperatures of 2°C and 3°C, respectively (Table 3). Additionally, it is important to note how this fall will not be homogeneous throughout the year. Due to increased temperatures, more months will experience more than 16.3°C, augmenting the probability of heat waves during summer time and, consequently, affecting summer outbound flows with more emphasis. In a similar way, the number of air frost days will especially affect winter months and, consequently, it can also be observed how winter months are more sensitive to temperature warming than spring months. This result suggests the presence of non-linear relationships between temperatures and tourist flows.

5 Conclusion

Climate change will lead to warmer climates in the principal tourist-generator countries. Therefore, testing the weather sensitivity of outbound flows is relevant for destination countries which sometimes strongly depend on tourism as the main economic sector. Previous studies have considered the influence of climate in the destination, neglecting the influence of the weather conditions in the origin country on outbound tourism flows. The reason for this framework has been the consideration of climate as a factor of attraction rather than motivation. However, weather experiences can motivate travel decisions, often taken in the short run, as shown in this work by the case study of British outbound flows.

Thus, using transfer function models, monthly time series of weather and outbound tourist flows have been investigated showing how the inclusion of average temperatures, sunshine hours, heat waves and air frost days significantly increased the performance of a specified ARIMA model for British outbound flows. Afterwards, a simulation study using the framework of global warming was undertaken through the hypothesized increase of average temperatures of 1°C, 2°C and 3°C and their influence on the rest of the significant weather variables included in the model.

The main results of the simulation show how higher temperatures will imply a change in the optimal holidaying weather conditions and, consequently, negatively affect British outbound flows. Meanwhile, because of the non linear relationship introduced in the model by the heat wave variable, it was shown that the effect of temperature warming on tourist flows will not be homogeneous throughout the year, showing the highest impact during summer months and the lowest one during springtime. This result will be of special interest for those tourist destinations located in the Mediterranean as a high percentage of summer British tourist flows chose this destination for their summer holidays.

Limitations of this study arise from the fact that it tries to simulate a social phenomenon that future drivers of demand are uncertain of. The scenario used to estimate the results do not include changes in population size and other determining tourist demand variables. It has only taken the patterns of tourist flows and projected, ceteris paribus, these patterns under a scenario of temperature warming. Unfortunately, the impact of random events, such as terrorism or natural disasters, cannot, of course, be modeled.

Models incorporating meteorological information such as those developed in this paper could be essential for national and regional tourism organizations to assess the effect of new weather conditions on tourism in a context of global warming. This knowledge is needed for public and private tourism organizations in order to allow them to provide better strategic information to their clients on how to manage the impact of the weather more effectively. As global warming progresses we can expect an increase in the demand for such models. So, further research will have to focus on the desegregation of the data analyzing how warmer and colder regions will be differently affected by climate change scenarios and also on the quantification of the effects of climate change on tourism demand using non-parametric techniques in order to capture non-linear relationships between climate conditions and human behaviour.

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Appendix

In order to estimate the effect of temperature warming on sunshine hours and air frost days, two statistical models were estimated. For the sunshine hours variable (Table 4) OLS estimation was undertaken because of the normal distribution of the dependent variable. Results show a correlation between the observed and the estimated variable of 0.939.

Table 4 Estimated LS coefficients for SUN variable

Variable	Coefficients
Constant	51.91**
AT	−6.418**
AT^2	0.752
January	5.948**
February	28.92**
March	60.74**
April	100.66**
May	119.57**
June	71.04**
July	45.22**
August	37.51**
September	31.58**
October	32.66**
November	14.07*
Estimation method: least squares	
Equation statistics	
R^2	0.882
Adjusted R^2	0.877
DW statistic	1.814
Log likelihood	−1,554.266
Akaike info criterion	8.810
Schwarz criterion	8.963
F-statistic	196.802
Observations	356

Note: **significant at 1%, *significant at 5%

However, for the case of air frost days (Table 5) a Tobit estimation was required because of the censored nature of the variable that often takes 0-values for the hottest months. Results show a correlation between the observed and the estimated variable of 0.979.

Table 5 Estimated Tobit coefficients for AF variable

Variable	Coefficient
Constant	23.5294**
AT	−3.7977**
AT^2	0.1370**
AT^3	−0.4271**
January	−0.5445
February	0.4000
March	1.3093
April	2.1392**
May	2.3978**
June	2.4365**
July	1.5783**
August	0.1373**
September	23.5294**
October	−3.7977**
November	0.1370
Estimation method: censored normal (Tobit)	
Equation statistics	
Log likelihood	−463.1418
Akaike info criterion	2.6749
Schwarz criterion	2.8164
Observations	356

Note: **significant at 1%, *significant at 5%

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