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Impact of weather conditions on tourism demand in the peak summer season over the last 50 years

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ABSTRACT

This paper employs static and dynamic tourism-demand models to investigate the impact of weather on domestic and foreign overnight stays in Austria in the peak summer season for the period 1960–2012. The results of first-difference regression models show that average sunshine duration and temperatures in the peak summer season had a significant and positive impact on domestic overnight stays in the same season, whereas average precipitation had a significantly negative effect. For foreign overnight stays, we find that the positive impact of temperatures and sunshine duration occurs only after a 1-year lag, with larger effects for visitors from neighboring countries. In general, there is a non-linear relationship between temperatures and tourism demand in the form of an inverted u-shaped curve. Furthermore, error-correction models show a significant long-run relationship between both foreign and domestic overnight stays and sunshine duration, with an increased impact over time. While tourism demand can respond quite significantly to short-run (annual) weather variations, the long-run impact of climate change (e.g., an increase in sunshine duration) over the past 50 years has been quite modest.

1. Introduction

It is widely accepted that holiday travel is motivated by the climate and weather conditions in holiday destinations (Becken, 2013a; De Freitas, 2003; Gómez Martín, 2005; Gössling et al., 2012). Temperatures, sunshine, and rainfall have been identified as important tourism factors in the summer season. Variations in weather conditions can lead to large changes in tourism demand. Several studies find that good weather conditions in a destination in a given season lead to increases in domestic overnight stays in the same period. Furthermore, foreign (outbound) tourism demand is affected by weather conditions only after a lag of up to 1-year (Agnew and Palutikof, 2006; Giles and Perry, 1998; Smith, 1990).

The growing literature on the relationship between weather and/or climate change and tourism demand shows that extremely warm temperatures have negative impacts on tourism in Mediterranean destinations and could lead to shifts in travel from these destinations to locations in central and northern Europe (Amelung and Viner, 2006; Hamilton, Maddison, and Tol, 2005). Furthermore, climate change could lead to a shift in travel flows from lowland to highland (mountain) locations. As the United Nations Intergovernmental Panel on Climate Change (IPCC) states, “Recreational preferences are likely to change with higher temperature,” and “Outdoor activities will be stimulated in Northern Europe” (see www.ipcc.ch/ipccreports).

Therefore, one can expect the tourism industry in central European countries, such as Austria, to benefit from warmer and sunnier summer seasons, as residents are more likely to stay in their own countries during these periods. It is also possible that these countries will attract more visitors from neighboring countries. Local media and tourism representatives suggest that Austria's hot summer of 2013 increased the number of overnight stays in the country.[1] However, little is currently known about the magnitude of the relationship between weather conditions and tourism in the peak summer season and the time lag of the corresponding effects.

This paper examines the relationship between monthly weather records and the overnight stays of domestic and foreign tourists in Austria for the peak summer holiday season (i.e., July and August) for the period 1960–2012. In particular, we use historical fluctuations in temperature, sunshine duration, and precipitation based on the country's six main weather stations to identify their effects on aggregate overnight stays. In addition to domestic overnight stays, we also distinguish between 11 visitor countries.

The main contribution of this paper lies in its use of a very long time series (up to 50 years) to investigate the relationship between summer weather conditions and tourism demand. Note that a given location's climate can be regarded as the long-term average of its weather conditions. The use of a long time series makes it possible to calculate the impact of long-run changes in climate variables, such as temperature and sunshine, on tourism demand. The other contribution of the paper is that we distinguish between domestic and foreign overnight stays, as domestic tourists are more likely to be influenced by weather factors

[1] The Austrian national public-service broadcaster (ORF) stated, for instance, that the hot summer season of 2013 boosted the number of visitors to the country (“Heißer Sommer zieht Gäste an” downloaded on 5.8.2013 from http://vorarlberg.orf.at/news/stories/2596511/).

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than are their foreign counterparts. One explanation is that domestic residents are more spontaneous, whereas foreign tourists normally plan their summer activities well in advance (Taylor and Ortiz, 2009). A survey of visitors to western Austria in the summer of 2013 showed that 20% had booked a few days before traveling.[2] Furthermore, we distinguish between visitors from neighboring countries (e.g., Germany, Switzerland, and the Netherlands) and more distant countries (e.g., Denmark, Sweden, the United Kingdom and the United States) to check for possible differences in responsiveness to weather conditions. In a survey of German visitors, weather was cited most often as the reason to choose Mallorca or Turkey as a holiday destination in the summer period (Kozak, 2002). However, weather factors might be less important to visitors from Scandinavian countries (Denstadli, Jacobsen, and Lohmann, 2011). Furthermore, we investigate the impact of sunshine and rainfall rather than looking at the impact of temperatures alone. According to Gössling and Hall (2006), the effects of other weather parameters, such as rainfall and hours of sunshine, is largely unknown.

More and more is being published on the relationship between weather patterns and tourism demand (see Becken, 2013a; Gössling et al., 2012; Kaján and Saarinen, 2013), (Pang, McKercher, and Prideaux, 2013 for recent surveys of the literature). A general finding of the literature is that there is a significant relationship between domestic tourism demand and weather conditions, while foreign (inbound and outbound) tourism is only affected by weather conditions with a 1-year (or -season) lag (Agnew and Palutikof, 2006). Furthermore, a striking feature of the previous literature is that there is a non-linear relationship between temperatures and visitor numbers, often in the form of an inverted u-shaped curve (Gössling and Hall, 2006; Lise and Tol, 2002; Maddison, 2001; Rossello-Nadal, Riera-Font, and Cardenas, 2011). This means that temperature has a positive effect on tourism up to a given threshold, after which there is a decline in its effect. In general, research on the impact of weather/climate on tourism demand in the winter season dominates the literature for Alpine countries. While there are plenty of studies on the relationship between tourism demand and weather patterns in coastal destinations (such as those on the Mediterranean Sea), few studies investigate the impact of summer weather on tourism demand in regions with cooler climate conditions and moderate temperatures – those in central and northern Europe, for instance, which are likely to gain from climate change (Serquet and Rebetez, 2011 is an exception).

Based on our empirical analysis, we obtain three main results. First, our estimates show that sunshine duration and temperatures have significant and positive effects on domestic overnight stays in the same summer season. Second, temperatures and sunshine duration affect foreign overnight stays only after a 1-year (read: one-season) lag. However, these effects are larger for foreign tourists from neighboring countries than for more distant countries. Third, while the effects of weather variability can be quite large, the long-term impacts of increased sunshine and temperatures on summer tourism demand are quite minor. For these domestic overnight stays, we estimate that a rise of 1 °C in mean temperatures in July and August of a given year will increase the number of domestic overnight stays in the same period by 1.1%. A one-standard-deviation increase in sunshine duration (13% over the long-term average), meanwhile, will increase the number of domestic overnight stays by 1% in the same period and those of foreign visitors by 2.1% in the following summer season. Finally, the average monthly sunshine duration for July and August rose by 35 h for each month over the period 1960–2012. This led to an average annual increase of about 45,000 in the number of domestic and foreign overnight stays, which is a relatively small effect.

The structure of this paper is as follows: Section 2 presents the theoretical background and the empirical model. In Section 3, we present various summary statistics and a description of the data before providing the empirical results in Section 4. Section 5 contains concluding remarks.

[2] Source: ORF “Heißer Sommer zieht Gäste an” downloaded on 5.8.2013 from http://vorarlberg.orf.at/news/stories/2596511/).

2. Previous literature and empirical model

According to the push-and-pull model developed by Crompton (1979), weather and climate represent both a push and a pull factor in the motivation of tourists. In particular, the desire for warm weather is a pull factor for tourists selecting a destination. Temperature and duration of sunshine are very important to those planning to sunbathe or swim in lakes or outdoor pools. Rainy summer seasons in particular hinder outdoor activities and can lead to a decrease in the number of visitor nights (De Freitas, 2003; Smith, 1993). In fact, the literature agrees that a change to warmer and drier summers in countries with moderate climate conditions would make them more attractive for outdoor/sport activities and nature-based tourism pursuits, such as hiking, hill walking, biking, camping, golfing, sunbathing, and swimming (De Freitas, 2003; Richardson and Loomis, 2005; Scott and Jones, 2006; Scott, Jones, and Konopek, 2007). According to Lohmann and Kaim (1999), German tourists rank weather as the third-most important factor in choosing destinations. Note that German overnight stays represent the greatest share of foreign tourists in Austrian destinations.

Many studies investigate the relationship between tourism demand and weather and climate conditions based on historical data. There are three strands of the literature, one of which uses visitor surveys to study the impact of warmer holiday seasons on tourist behavior. For instance, based on a visitor survey taken at East Anglia beaches in the UK, Coombes and Jones (2010) find that increases in temperature and less rainfall will lead to an increase in the number of visitors as well as greater participation in sunbathing and paddling. Another strand of the literature uses a regression analysis to estimate the impact of historical weather data on past tourism. For instance, Scott et al. (2007) investigate the impact of monthly temperature and precipitation on visits to Waterton Lakes National Park (Alberta, Canada) using monthly data from 1996 to 2003. The authors find no relationship between visitation in the summer peak season (July and August) and weather. A growing share of the related literature also incorporates weather and climate variables into tourism demand models (Agnew and Palutikof, 2006; Álvarez-Díaz and Rosselló-Nadal, 2010; Goh, 2012; Kulendran and Dwyer, 2012; Rossello-Nadal et al., 2011; Taylor and Ortiz, 2009). For example, Goh (2012) finds that weather conditions in Hong Kong have a significant and positive impact on foreign tourism demand in the region when controlling for real income and relative prices. In particular, the author calculates the tourism climatic index (TCI) – a composite indicator that represents a function of temperature, relative humidity, level of precipitation, duration of sunshine, and wind speed. Using time series data for the UK, Agnew and Palutikof (2006) find that outward tourism is significantly influenced by rainfall and sunshine in the previous year. Domestic tourism, meanwhile, is positively affected by good weather conditions (measured as temperatures and rainfall in the same month in central England) in the same month, with larger effects in March and April than in the peak summer season. With regard to the relationship between outbound tourism and weather in countries of origin, Rossello-Nadal et al. (2011) find that the impact of weather conditions on British outbound tourism flows is greater during the summer months than in spring. Similarly, Álvarez-Díaz and Rosselló-Nadal (2010) find that meteorological variables (days of sunshine, mean temperatures, days of rain) in origin countries have a significant impact on British tourism demand on Spain's Balearic Islands. For New Zealand, Becken (2013b) finds that weather indicators (sunshine, rain, and temperature) do not have a significant impact on the year-on-year variation in visitor nights. Temperatures are, however, the key driver of seasonality in visitor nights within a given year. Day, Chin, Sydnor, and Cherkauer (2013) use a different approach to investigate the impact of weather on tourism, examining information on the performance of the tourism industry rather than data on arrivals or visitor nights. They find that weather has no impact on the performance of the tourism sector in the short term (measured on a weekly basis), but does have significant long-run effects.

A common finding in the literature is that weather conditions in origin countries affect outbound tourism only after a lag. For instance, Jørgensen and Solvoll (1996) find that poor summer weather in Norway leads to an increase in outbound tourism in the summer period of the following year. For England, Smith (1990) finds that wet and cold summer seasons lead to an increase in travel to Portugal in the subsequent winter. Rossello-Nadal et al. (2011) find that higher temperatures have a negative impact on British outbound tourism demand in the subsequent year.

The impact of weather on summer tourism demand is likely to be different for domestic and foreign residents. In particular, it is often suggested that domestic tourism is more likely to be affected by weather conditions than is foreign tourism. The reason is that domestic holidays do not need to be planned too far in advance (Taylor and Ortiz, 2009). For the UK, Taylor and Ortiz (2009) find that temperature and hours of sunshine increase the numbers of both domestic arrivals and domestic overnight stays. Using monthly data on Galicia (northwestern Spain), however, Otero-Giráldez, Álvarez-Díaz, and González-Gómez (2012) find that the number of domestic overnight stays in the region increases when the weather is drier and colder.

For countries with moderate summer temperatures, few studies focus explicitly on the relationship between weather factors and summer tourism and/or outdoor activities in the summer period. Using data on temperatures and domestic overnights stays for 40 Swiss Alpine resorts, Serquet and Rebetez (2011) find that hotter temperatures in the lowlands lead to an increase in overnight stays in mountain destinations. In particular, the authors find that the correlations are stronger for June and August than for July, and for temperature rather than sunshine duration. For the summer holiday season in New Zealand, Becken and Wilson (in press) find that half of their respondents reduced their participation in outdoor activities because of unfavorable weather conditions. These activities included walking/tramping, beach visits, and swimming. In addition, the authors find that 40% of the respondents reduced their length of stay during their current trip due to bad weather. Giles and Perry (1998), meanwhile, find that the exceptional summer of 1995 in the UK reduced the number of holiday bookings to Mediterranean destinations and increased demand for domestic destinations during the same season. Finger and Lehmann (2012) find that rainfall and temperature have a strong impact on the number of visitors to two lidos on Lake Zurich. In particular, a 1% increase in temperature will cause the number of visitors to rise by 40%.

A third strand of the literature uses simulation methods to estimate the impact of global warming on future visitation patterns. For instance, Bigano, Hamilton, and Tol (2006) suggest that mountain destinations will benefit from climate change. Amelung, Nicholls, and Viner (2007) predict that Mediterranean destinations will experience a decline in visitors during the peak summer period, with regions in central and northern Europe likely to experience lengthier summer seasons.

In order to investigate the impact of weather factors on tourism demand, we use a standard tourism model in which visitor nights are a function of relative prices and real income (Song and Witt, 2000; Song, Witt, and Li, 2009). Since the determinants of tourism demand are likely to differ across visitor countries (Cortés-Jiménez and Blake, 2011), we use a panel data model in which overnight stays from visitor country i at time t is the dependent variable. The tourism demand model for different visitor countries is augmented by weather factors. The static panel model can be expressed as follows:

$$\ln X_{it} = \beta_1 \ln Y_{it} + \beta_2 \ln RP_{it} + \ln W_{it} C + \alpha_t + \alpha_i + \varepsilon_{it}$$

Here, $i = 1,..,12$ denotes the visitor country and t is time. X_{it} denotes overnight stays from visitor country i, and Y is the real GDP of visitor country i. RP is the bilateral real exchange rate (foreign currency per EURO/ECU), measured as the consumer price index of the destination country and converted into the respective foreign currency relative to that of the origin country. W_{it} is a vector of variables that captures weather phenomena, such as precipitation, sunshine, and average temperature. In order to allow for a non-linear relationship, we include both temperature and its squared term as explanatory variables. α_i and α_t are fixed and time effects for visitor countries, with the latter meant to capture changes in overnight stays over time that are not accounted for by income, prices, or weather factors. ε_{it} is the error term, which is assumed to be iid. The coefficients of the weather indicators can be interpreted as elasticities of tourism demand with respect to weather factors.

In order to make the data stationary and remove visitor–country effects, we use the first-difference model. Since changes in weather factors may affect inbound or outbound overnight tourism demand only after a 1-year (summer-season) lag, we include weather indicators from the previous summer season. The first-differences specification of the tourism demand model for domestic and foreign overnight stays can thus be expressed as follows:

$$\Delta \ln XD_t = \widetilde{\beta}_{1D} \Delta \ln YD_t + \widetilde{\beta}_{2D} \Delta \ln RP_t + \Delta \ln W_t \widetilde{C}_{1D} + \Delta \ln W_{t-1} \widetilde{C}_{2D} + \widetilde{\varepsilon}_i$$

$$\Delta \ln XF_{it} = \widetilde{\beta}_{1F} \Delta \ln YF_{it} + \widetilde{\beta}_{2F} \Delta \ln RP_{it} + \Delta \ln W_{it} \widetilde{C}_{1F} + \Delta \ln W_{t-1} \widetilde{C}_{2F} + \widetilde{\varepsilon}_{it}$$

Here, Δ is the first difference operator. XF and XD are the number of overnight stays of foreign and domestic visitors, respectively. YF represents the GDP of the visitor countries in constant local prices, whereas YD denotes domestic GDP in constant prices. Note that the first difference of the variable in logarithm is a measure of annual growth rate. This regression equation can be estimated by OLS, where t-values are based on standard errors robust to heteroscedasticity. $\widetilde{C}_{1D}$, $\widetilde{C}_{2D}$, $\widetilde{C}_{1F}$, and $\widetilde{C}_{2F}$ measure short-run weather elasticities. Since variations in weather can be regarded as exogenous and random, the regression relationship can be seen as a natural experiment and is therefore clearly identified (Schlenker and Roberts, 2008).

First-difference estimation is inefficient, however, because it ignores the information on the levels of the time series. This may hold particularly true for the relationship between real GDP and overnight stays, which are likely to be non-stationary. Therefore, we also employ error-correction models. This makes it possible to estimate both the short- and long-term impacts of real income, prices, and weather on tourism demand (see Song and Li, 2008), (Song et al., 2009 for an overview). It also avoids the problem of spurious relationships caused by the non-stationarity of the variables. The error-correction model can be derived from an autoregressive distributed-lag model. For overnight stays from different visitor countries, we employ the pooled mean group (PMG) estimator introduced by Pesaran, Shin, and Smith (1999). The estimation equation takes the following form:

$$\Delta \ln XF_{it} = -\phi\left(\ln XF_{it-1} - \widetilde{\widetilde{\beta}}_1 \ln YF_{it} - \widetilde{\widetilde{\beta}}_2 \ln RP_{it} - \ln W_{it} \widetilde{\widetilde{C}}_{1F} - \beta_3 t - \alpha_{it} \right) + b_{1i} \Delta \ln YF_{it} + b_{2i} \Delta \ln RP_{it} + \Delta \ln W_{it} D_{it} + \widetilde{\widetilde{\varepsilon}}_{it}$$

Here, XF is the number of overnight stays of foreign visitors, YF is the GDP of the visitor countries in constant local prices, W is a vector of weather indicators, t is the time trend, and $\widetilde{\widetilde{\varepsilon}}_{it}$ is the error term. The error-correction model assumes that long-run parameters are likely to be similar across visitor countries, while short-run parameters – namely b_{1i}, b_{2i}, and D_{it} – are allowed to vary across visitor countries. The pooled mean group estimator employs the maximum likelihood technique to estimate the parameters.

Previous research finds that the relationship between weather conditions and tourism demand is likely to be different across visitor countries (Kulendran and Dwyer, 2012). In addition, price elasticities of tourism demand are likely to differ between short- and long-haul tourists (Crouch, 1994). We therefore provide estimates for two visitor groups: those from neighboring or proximate countries (i.e., BE + LU, DE, IT, CH, HU, and NL) and from more distant and overseas countries (DK, FR, SE, US, and UK). In addition, neighboring countries are likely to be more sensitive to weather factors than are long-haul destinations. For domestic overnight stays, we estimate a standard error-correction model in which the results are obtained from the mean group estimator (Pesaran and Smith, 1995).

3. Data and descriptive statistics

The weather data is drawn from the HISTALP dataset (Auer et al., 2007). The dataset contains information on monthly temperatures, precipitation, and sunshine from up to 59 weather stations until 2008. The longest time series for weather goes back to the 18th century (e.g., Innsbruck). We select six weather stations – Bregenz, Graz (university), Innsbruck (airport), Klagenfurt (airport), Salzburg (airport), and Wien-Hohe Warte – and use the average of each weather indicator from July and August. For the time period 2008–2012, we draw data from the ZAMG Yearbook. All of the weather data is freely available, and all of the weather variables are continuous.

Monthly data is available from 1960 onwards for domestic overnight stays, from 1967 onwards for foreign overnight stays, and from 1951 onwards for the summer half-year (May to October). Data for a 6-month period may, however, conceal substantial variations in weather. Therefore, we employ visitor nights for the peak holiday season (read: July and August). Our sample includes 12 visitor countries: Austria, Belgium (combined with Luxembourg), Denmark, France, Germany, Italy, Hungary, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States. The sample periods are 1960–2012 for domestic overnight stays and 1967–2012 for foreign overnight stays.

Consumer price indices, exchange rates, and GDP in constant prices are taken from World Bank development indicators. We combine overnight stays for 12 different visitor countries (including domestic overnight stays) with weather data from six weather stations for the period 1967–2012. One should note that the selection of visitor countries is constrained by the availability of a sufficient time span. For visitors from Eastern European countries, only a short time period is available. Tourism in the peak holiday season is dominated by German tourists, who account for about 50% of all overnight stays. That said, the German share has declined by 20 percentage points over the last 45 years.

Table 1 in the appendix shows the evolution of domestic and foreign overnight stays as well as of the three weather indicators. From the early 1970s to 2000, a long-term decline was witnessed in the number of foreign overnight stays in July and August. Since the 2000s, the number of foreign overnight stays has remained stable, with domestic overnight stays seemingly stagnating around 9 million bed nights.

4. Empirical results

We start by reporting the results of the static regression models. Table 1 shows the results of the tourism demand model estimated in first differences by OLS with heteroscedasticity-consistent standard errors, where the dependent variable is the change in log domestic overnight stays in July and August compared to the same months in the previous year. Table 2 reports the corresponding results for the log change in foreign overnight stays. Here, we also provide the effects of lagged weather conditions (middle panel) and the results for the subsample of visitors from neighboring countries (lower panel). The coefficients can be interpreted as short-run elasticities. The number of time periods is 52 for domestic and 47 for foreign overnight stays.

We find that average temperatures in July and August (based on the unweighted average from the six weather stations) have a significantly positive impact on domestic overnight stays in the same period ($p < 0.01$). The temperature coefficient of 0.2 means that an increase in temperature by 10% (equal to an increase of 2 °C) over the previous summer season will lead to a 2% increase in the number of domestic overnight stays. Furthermore, the squared term of average temperatures is negative and significant, indicating a non-linear relationship between average temperatures and domestic visitor nights. In particular, there is an inverted u-curve relationship between the change in average temperatures in the peak summer season and the change in domestic overnight stays. The R^2 indicates that temperature and its squared

Table 1
OLS estimates of the change in domestic overnight stays.

	Dependent variable: nights spent of domestic visitors for July and August									
	(i)		(ii)		(iii)		(iv)		(v)	
	coef	t	coef	t	coef	t	coef	t	coef	t
ΔlnYD	0.43 **	2.05	0.31	1.54	0.46 **	2.09	0.39 *	1.80	0.39 *	1.85
ΔlnRP	−0.07	−0.85	−0.01	−0.15	−0.10	−1.07	−0.11	−1.07	−0.08	−0.71
Δlntempm7-8	0.20 ***	2.92	0.19 ***	3.45						
Δlntempm7-8sq			−1.87 ***	−3.25						
Δlnsunm7-8					0.05	1.53				
Δlnprecipm7-8							−0.03 ***	−2.44	−0.03 ***	−2.71
Δlnprecipm7-8sq									−0.05 *	−1.78
constant	−0.01	−1.52	0.00	0.36	−0.01	−1.33	−0.01	−1.04	−0.00	−0.22
R2	0.23		0.33		0.13		0.17		0.21	
DW statistics	1.61		1.87		1.69		1.68		1.86	
# of obs	52		52		52		52		52	
	Dependent variable nights spent of domestic visitors for August									
ΔlnY	0.19	0.71	0.25	0.58	0.23	0.81	0.25	0.85	0.25	0.84
ΔlnRP	0.01	0.06	0.14	0.54	−0.05	−0.44	−0.08	−0.59	−0.08	−0.57
Δlntempm8	0.23 ***	4.53	0.05	4.60						
Δlntempm8sq			0.56	−1.46						
Δlnsunm8					0.07 ***	2.95				
Δlnprecipm8							−0.02*	−1.76	−0.02 *	−1.70
Δlnprecipm8 sq									0.00	0.05
constant	0.00	−0.23	0.01	0.53	0.00	−0.25	0.00	−0.25	0.00	−0.23
R^2	0.24		0.26		0.15		0.07		0.07	
# of obs	481		481		481		481		481	

Notes: ***, ** and * denote significance at the 1, 5 and 10% significance levels. temp7-8 are the average temperatures for July and August, sun7-8 is the average sunshine duration for the months July and August, precip7-8 denotes the average monthly level of precipitation of six weather stations in Austria. Regressions report t ratios based on Huber/White heteroscedasticity-consistent standard errors standard errors. The time period is 1961–2012.

Table 2
OLS estimates of the change in foreign overnight stays.

	(i)		(ii)		(iii)		(iv)		(v)	
	coef	t	coef	t	coef	t	coef	t	coef	t
Specification with same month weather indicators										
ΔlnY (t)	0.78 ***	3.01	0.77 ***	2.99	0.77 ***	3.00	0.78 ***	3.01	0.77 ***	3.01
ΔlnRP (t)	−0.79 ***	−3.97	−0.78 ***	−3.85	−0.79 ***	−3.96	−0.79 ***	−3.96	−0.79 ***	−3.96
Δlntempm7 + 8 (t)	0.01	0.15	−0.02	−0.27						
Δlntempm7 + 8sq (t)			−1.53 *	−1.75						
Δlnsunm7 + 8 (t)					−0.01	−0.11				
Δlnprecipm7 + 8 (t)							0.00	0.10	0.00	0.06
Δlnprecip m7 + 8sq (t)									0.02	0.45
constant	−0.00	−0.43	0.00	0.27	−0.00	−0.42	−0.00	−0.43	−0.01	−0.54
R^2	0.11		0.12		0.11		0.11		0.11	
# of obs	481		481		481		481		481	
Specification with weather indicators of the previous season										
ΔlnY (t)	0.81 ***	3.19	0.94 ***	3.59	0.81 ***	3.22	0.78 ***	3.06	0.74 ***	2.86
ΔlnRP (t)	−0.82 ***	−4.04	−0.80 ***	−3.95	−0.79 ***	−3.91	−0.79 ***	−3.99	−0.80 ***	−4.03
Δlntempm7 + 8 (t-1)	0.20 ***	2.63	0.17 **	2.23						
Δlntempm7 + 8sq (t-1)			−2.44 ***	−2.88						
Δlnsunm7 + 8 (t-1)					0.07	1.61				
Δlnprecipm7 + 8 (t-1)							−0.02	−1.17	−0.02	−1.05
Δlnprecip m7 + 8sq (t-1)									0.04	1.10
constant	−0.01	−0.59	0.00	0.31	0.00	−0.57	0.00	−0.47	−0.01	−0.77
R^2	0.13		0.14		0.12		0.12		0.12	
# of obs	481		481		481		481		481	
Specification with weather indicators of the previous season for the subsample of neighboring countries										
ΔlnY (t)	0.67 ***	2.82	0.76 ***	3.01	0.70 ***	3.06	0.63 ***	2.71	0.57 **	2.49
ΔlnRP (t)	−0.92 ***	−4.48	−0.91 ***	−4.39	−0.88 ***	−4.27	−0.90 ***	−4.30	−0.91 ***	−4.38
Δlntempm7 + 8 (t-1)	0.26 ***	2.70	0.23 **	2.40						
Δlntempm7 + 8sq (t-1)			−2.25 **	−1.97						
Δlnsunm7 + 8 (t-1)					0.16 ***	3.87				
Δlnprecipm7 + 8 (t-1)							−0.04 **	−2.09	−0.04 *	−1.95
Δlnprecip m7 + 8sq (t-1)									0.07	1.43
Constant	0.01	1.20	0.02 **	2.06	0.01	1.14	0.01	1.38	0.01	0.60
R^2	0.15		0.17		0.17		0.14		0.15	
# of obs	263		263		263		263		263	

Notes: ***, ** and * denote significance at the 1, 5 and 10% significance levels, temp7-8 are the average temperatures for the months July and August, sun7-8 is the average sunshine durations for the months July and August, and precip7-8 denotes the average monthly level of precipitation. The upper and middle panel contains data for 11 visitor countries, whereas the lower panel contains overnight stays of the neighboring countries. All regressions report t ratios are based on Huber/White heteroscedasticity consistent standard errors. The time period is 1967–2012.

term explain 33% of the variation in domestic visitor nights over the peak holiday season in July and August.

Fig. 3 in the appendix shows the inverted u-shaped relationship based on the quadratic specification and spline functions. One can observe a positive relationship between domestic overnight stays and changes in temperature until a certain temperature threshold, after which the positive effect decreases as temperatures rise. The finding of a non-linear relationship between temperatures and tourism demand is consistent with previous research (see, for example, Bigano et al., 2006).

Changes in sunshine duration in July and August are positively, but not significantly related to changes in domestic overnight stays. According to Serquet and Rebetez (2011), the relationship between domestic tourism demand and weather factors can be different for different summer months, with higher effects for June and August than for July. We therefore re-estimate the tourism demand model separately for the months of July and August. The separate estimates for August show that sunshine hours are significantly and positively related to domestic overnight stays in the same month (see Table 1 lower panel). Changes in precipitation have a significantly negative effect on domestic overnight stays. Column (v) shows that the effect of changes in precipitation becomes increasingly negative as precipitation increases.

This all indicates that warmer, sunnier, and drier summer seasons stimulate the overnight stays of domestic residents in the same season. Overall, the findings are consistent with Agnew and Palutikof (2006), who find a significant relationship between weather in the same month and the tourism demand of domestic visitors in the UK.

It is interesting to note that the standard determinants of tourism demand – real income and relative prices – do not have an impact on the nights domestic visitors spend on holiday.

To test how robust the estimates are to outliers and influential observations, we replicate the empirical analysis using the robust regression method. Note that this method removes extremely influential observations and then performs a weighted regression in which moderate outliers are given less weight than normal observations (Huber, 1981). Unreported results again show that our findings are not sensitive to influential observations.

For the overnight stays of foreign tourists, none of the weather indicators are significant at the 5% level (Table 2). Relative prices and real income, however, have the expected sign and are highly significant, unlike the results for domestic overnight stays. The insignificance of the weather variables in the foreign tourism demand equation may be related to the fact that static models cannot account for lagged effects. Re-estimating the tourism demand model with weather variables lagged by 1-year (one summer season) shows that temperatures are significantly and positively related to foreign overnight stays. Again, there is an inverted u-shaped relationship between temperature and foreign tourism demand (Graph 3 in the Appendix A).

Estimates for the subsample of neighboring countries (i.e., visitors from BE + LU, CH, DE, HU, IT, and NL) show that not only temperatures in July and August, but also the average duration of sunshine and

Table 3
Pooled mean group estimates of the error correction model of foreign overnight stays.

	(i)		(ii)		(iii)	
	coef.	z	coef.	z	coef.	z
Long-run coefficients (elasticities)						
lnY(t-1)	1.58 ***	3.12	1.60 ***	3.10	1.74 ***	3.21
lnRP(t-1)	−2.74 ***	−6.32	−2.87 ***	−6.39	−2.75 ***	−6.14
lnRP*DCH(t-1)	−4.59 **	−2.20	−4.40 **	−2.28	−4.48 **	−2.10
lntemp7t8(t-1)	−0.08	−0.15				
lnsun7t8(t-1)			0.65 **	2.08		
lnprecip7t8(t-1)					0.26	0.96
year	−0.05 ***	−4.17	−0.05 ***	−4.32	−0.05 ***	−4.15
Error-correction coefficient						
Short-run coefficients (elasticities)	−0.13 ***	−4.56	−0.13 ***	−5.03	−0.13 ***	−4.60
ΔlnY(t)	−0.37	−1.00	−0.28	−0.79	−0.44	−1.21
ΔlnRP(t)	−0.51	−1.26	−0.47	−1.20	−0.40	−1.01
Δlntemp7t8(t-1)	0.23 ***	5.67				
Δlnsun7t8(t-1)			0.15 ***	10.52		
Δlnprecip7t8(t)					−0.01	−1.60
Constant	8.79	4.59	8.61 ***	4.99	9.39 ***	4.66
Pseudo-R^2	0.32		0.34		0.26	
# of observations	263		263		263	
# of visitor countries	6		6		6	

Notes: ***, ** and * denotes significance at the 1, 5 and 10% significance levels. The dependent variable is the change in the logarithm of foreign overnight stays for 11 visitor countries for the period 1968–2012. Long-run elasticities are directly estimated using ML.

precipitation have a positive impact on changes in foreign overnight stays. The sunshine coefficient of 0.16 means that an increase in sunshine hours by 10% over the previous summer seasons will lead to an increase in the number of foreign overnight stays in the subsequent season by 1.6%, given the impact of relative prices and real income.

In the next step, we provide estimates of the error-correction model, starting with an investigation as to whether our data is stationary. In general, weather time series are unlikely to be non-stationary, meaning that their mean and variance increase or decrease over time. In very long samples, however, temperatures can be non-stationary due to climate change. Real GDP and overnight stays, meanwhile, are non-stationary in most cases. For foreign overnight stays, we also use second-generation unit root tests, which provide reliable insight in to the possible presence of cross-sectional dependence (Pesaran, 2007). For the weather indicators, we use the standard augmented Dickey-Fuller test. For relative prices and real GDP, we apply ADF tests to each visitor country.

Based on the panel unit-root test developed by Im-Pesaran-Shin with a 1-year lag and a time trend, we find that foreign overnight stays and the real GDP of visitor countries are both integrated of order 1. In particular, the null hypothesis, that all panels contain unit roots, cannot be rejected at the 5% level (p-value: 0.35). Based on the panel unit-root test introduced by Pesaran (2007) to allow for cross-sectional dependence, we also fail to reject the null hypothesis that foreign overnight stays are characterized by a unit root. In addition, standard ADF tests indicate that real GDP is non-stationary with a I(1) process. For domestic overnight stays, however, the null of a unit root is clearly rejected, indicating that the series is stationary. Similarly, the null of a unit root is clearly rejected at the 1% level for average precipitation, sunshine duration, and temperature, which suggests that the series are all stationary.[3] The same holds true for relative prices. The Phillips–Perron test also rejects the null hypothesis of a unit root of weather variables and relative prices. Therefore, we can assume that the weather indicators, the relative price series, and domestic overnight stays are stationary. Given that foreign overnight stays and the real GDP panel are integrated of order 1, the tourism demand equation is tested for a cointegration relationship. To do this, we apply the error-correction-based cointegration test introduced by Westerlund (2007). The results show that the null hypothesis of no cointegration can be rejected at the 1% level, indicating that there is a long-run relationship between tourism demand and real income. Note that stationary (exogenous) variables, such as the weather indicators, are allowed to enter into the long-run relationship provided that two non-stationary variables are integrated of the same order. Given that domestic overnight stays are stationary, the impact of non-stationary variables, such as real domestic GDP, cannot be estimated.

Table 3 contains the results of the pooled mean group estimator in the error correction model for foreign overnight stays for the period 1968–2012. Income and price elasticities show the expected sign and are highly significant. The estimated income elasticity is about 1.6, which is consistent with the literature. Summer tourism in Austria can thus be regarded as a luxury good/service. The price elasticity is −2.74, which tends to be in the upper range of estimates found in the literature. The interaction term shows that Swiss tourists are more price-sensitive than those from the remaining visitor countries. Overall, this indicates that summer tourism in Austria is highly price-sensitive and comparable with the findings for beach holidays. The negative and significant error-correction term, meanwhile, can be interpreted as the speed of adjustment to the long-run level of foreign tourism demand following a shock in tourism demand. The speed of adjustment is low, however, at 13% per year. Overall, the estimates for the income and price elasticities are much more plausible than those based on the first difference model.

The key parameters of interest are the long- and short-run weather coefficients. We find that the long-run coefficient of sunshine hours for July and August has a significant and positive impact on nights spent by foreign tourists over the long term. This indicates that sunnier summer months (compared to the same period in the previous year) increase the number of overnight stays in the long run. The long-run elasticity of sunshine duration is quite significant at about 0.65, indicating that an increase of 10% (from 234 to 254 h on average for July and August) will lead to a 6.5% increase in foreign overnight stays. However, this effect only occurs after an adjustment process to the long-term equilibrium, which takes several years.

Unlike the results based on the first-difference regression model, we find that average temperatures in July and August are not a significant determinant of foreign overnight stays. As for average temperature, one can see that average precipitation for July and August also does not affect overnight stays from the 11 main visitor countries.

The results of the error-correction model for domestic overnight stays show that average temperatures have a significant impact on domestic overnight stays in the short run, but not in the long run (Table 4).

[3] Results of the unit root tests are available upon request.

Table 4
Error correction model of domestic overnight stays.

	(i)		(ii)		(iii)		(iv)	
	coef.	z	coef.	z	coef.	z	coef.	z
Long-run elasticities								
lntemp7t8(t-1)	0.32	1.13	0.68 *	1.71				
lnsun7t8(t-1)					0.35 ***	2.10		
lnprecip7t8(t-1)							0.01	0.13
Year	0.00	−1.37	0.00 *	−1.77	0.00 *	−1.76	0.00	−0.72
Error-correction coefficient	−0.38 ***	−4.31	−0.31 ***	−3.42	−0.38 ***	−4.45	−0.37 ***	−4.12
Short-run elasticities								
Δlntemp7t8(t)	0.10	1.20	0.05	0.55				
Δlntemp7t8s squared(t)			−1.63 **	−2.27				
Δlnsun7t8(t)					−0.04	−0.92		
Δlnprecip7t8(t)							−0.03	−1.38
Constant	6.78 ***	4.34	5.88	3.79	6.57 ***	4.56	6.29 ***	4.25
# of obs.	51		51		51		51	

Notes: ***, ** and * denotes significance at the 1, 5 and 10% significance levels. The dependent variable is the change in the logarithm of domestic overnight stays for the period 1961–2012. Results are obtained from the mean group estimator where only the results for the determinants of domestic overnight stays are shown.

Furthermore, we find a significant long-run impact of sunshine duration on domestic overnight stays, with a long-run elasticity of 0.35.

As a final step, we distinguish between short- and long-haul markets. One might expect tourists from long-haul destinations to book well in advance, and thus be less sensitive to weather conditions in the current season. In contrast, tourists from neighboring countries (Germany, Switzerland, and Italy) are more spontaneous and therefore more likely to be influenced by weather conditions in the current summer season. In addition, Crouch (1994) finds that tourism demand elasticities generally differ between short- and long-haul tourists, with the former being more sensitive to prices. As expected, unreported results show that tourists from neighboring countries are more sensitive to changes in sunshine hours. In particular, the long-run coefficient of sunshine is 2.13 and significant at the 1% level. The short-run coefficient of sunshine duration is 0.07 with a z-value of 2.59. For the second group (which includes more distant countries), the sunshine coefficient becomes insignificant. Overall, the results are consistent with the OLS estimates from the first difference equation (see Table 2).

One can use the empirical estimates to calculate how increases in sunshine hours and temperatures contribute to domestic and foreign overnight stays during the sample period. Over the last 50 years, there has already been a trend towards warmer temperatures and more sunshine. A regression analysis of log sunshine and log temperature against the time trend reveals that both temperature and sunshine increased annually by an average of 0.2% for the period 1960–2012 (see Graphs 1 and 2 in the Appendix A). Given the long-run elasticity of sunshine – 0.35 for domestic overnight stays and 0.65 for foreign overnight stays – the increase in sunshine duration of 15% (from 225 to 260 h on average) raised the number of domestic overnight stays by 5.5% (cumulated over the total period of 50 years) and that of foreign overnight stays by 10% (again, cumulated over the past 50 years). Expressed in absolute numbers, the increase in sunshine duration has led to 400,000 additional domestic overnight stays and 1.85 million additional foreign overnight stays in the total 50-year sample period (Table 5).

Table 5
Impact of climate change on domestic and foreign overnight stays (1960–2012).

Assumptions:	Absolute (hours or °C)	In percent
Trend increase in sunshine hours 1960–2012	35	15.6
Mean domestic overnight stays in 1000 s	8822	
Mean foreign overnight stays of neighboring countries in 1000 s	18,900	
	Elasticity	Number of additional overnight stays in 1000 s due increases in sunshine 1960–2012
Long-run impact of increase in sunshine on domestic overnight stays	0.35	400
Long-run impact of increase in sunshine on foreign overnight stays	0.65	1852

This is equal to an increase of about 45,000 overnight stays per year on average. Overall, one can conclude that the impact of climate change (in the form of increased sunshine duration) on tourism demand in Austria over the past 50 years has been quite modest.

The estimated weather elasticities can be used to calculate the impact of future global warming. Given the short-run elasticity of domestic tourism demand with respect to temperatures (0.20), a rise of 1 °C (from 18.9 to 19.9 based on long-term sample means) will cause the number of domestic visitor nights to increase by 5.3%, or 10,000 bed nights in absolute terms. For the UK, Taylor and Ortiz (2009) find that a 1 °C increase in average monthly temperature led to 45,200 additional bed nights in the period 1998–2004, while an additional hour of sun in a given month led to 3,000 additional bed nights.

Among our several robustness checks, we first investigate whether the long-run effects of sunshine on domestic and foreign tourism demand are stable over time. In order to account for the stability of the coefficients over time, we re-estimate the error-correction models for different time periods (e.g., 1960–1985, 1960–1995, 1960–2005, and 1960–2012). The results show that the long-run elasticity of sunshine on domestic and foreign tourism demand has increased over time (Graph 4 in the Appendix A). Second, we include all three weather indicators in the tourism demand equation. When all three variables are included simultaneously, only duration of sunshine remains significant. Third, we experiment with the inclusion of an interaction term between two weather variables. The combination of high temperatures and sunny summer weather, for instance, may lead to additional overnight stays. However, the interaction effects are generally not significant, indicating that the effect of sunshine is only of a direct nature. Furthermore, we include a dummy variable for US overnight stays from 2002 onwards in order to account for the terror attacks of September 11, 2001. Although the number of US overnight stays in Austria has declined significantly since 2002, the dummy variable is not significant. We also include dummy variables for the 2002 Iraq war and experiment with dummy variables for the 2008 UEFA European Football Championship, which was held in Austria and Switzerland. None of the dummy variables are significant at conventional levels.

5. Conclusions

In this study, we investigate the impact of weather (measured as average temperatures, sunshine duration, and precipitation) on tourism demand in the peak summer holiday season (July and August) for Austria. In particular, we assess the impact of weather on nights spent by domestic and foreign visitors over very long time periods (1960–2012 for domestic and 1967–2012 for foreign visitors). Using both static and dynamic tourism-demand models, we find that sunshine duration – and to a lesser extent, temperatures – has a strong and robust influence on the number of both domestic and foreign overnight stays in the summer season in Austria. For domestic visitors, we find that higher temperatures and more sunshine hours in the current summer season have a positive impact on overnight stays in the same months. Furthermore, there is a non-linear effect between temperatures and domestic tourism demand, with temperatures having a less positive impact above a certain threshold. In addition, we find that sunshine and domestic tourism demand are linked not only by short-run effects, but by a significant long-run relationship, as well. For foreign overnight stays, we find that weather patterns in July and August affect visitor nights only after a 1-year lag. In particular, we find a significant relationship between sunshine duration and temperatures in the preceding summer season and foreign visitor nights, with larger effects for visitors from neighboring countries.

Overall, the short-run effects of higher temperatures and sunshine hours on tourism demand are not very large. A one-standard-deviation increase in temperatures in July and August (equal to 1 °C) will increase the number of domestic overnight stays by 1.3%. A 30% increase in sunshine duration (equivalent to the increase witnessed in the record summer season of 2013 in Austria) will cause the number of domestic overnight stays to increase by 2.1%. The long-run effects of sunnier summer seasons on domestic and foreign overnight stays are much larger – with long-run elasticities of 0.35 and 0.65, respectively – but these effects occur over an adjustment period of several years. The findings further show that real income and relative prices are not relevant to the demand for domestic tourism, but are important determinants of foreign tourism demand.

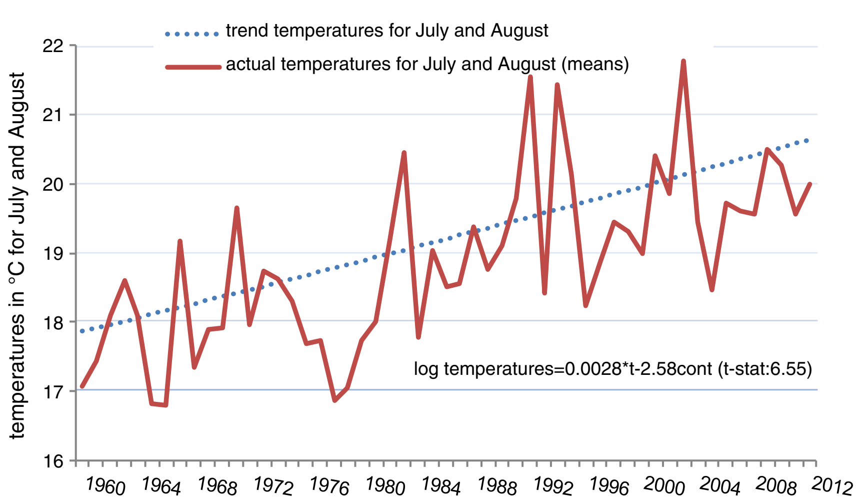
Calculations based on the estimates suggest that the 35-hour increase in sunshine over the last 50 years (equivalent to an increase of 0.7 h of sunshine per year) has increased the number of domestic overnight stays by 5.5%, cumulated over the total period. For foreign overnight stays, the corresponding increase is 10% (again, cumulated for the total period).

The estimates suggest that Austria's tourism industry will benefit from a warmer and sunnier climate. In particular, domestic residents are more likely to spend their holidays in their home country during warmer and sunnier summer months. There are also positive effects on foreign overnight stays, but these effects only occur in the subsequent summer seasons. In addition, tourism demand in Austria will likely benefit from the declining attractiveness of the climate in major competing tourist destinations in southern Europe. While the effects of climate change are not that large, one can nevertheless conclude that the estimates are useful in predicting future tourism demand based on changes in weather conditions and climate.

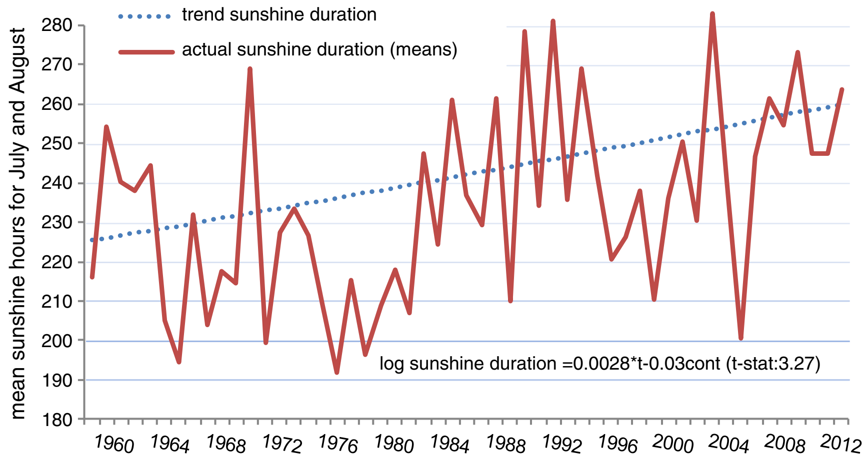
The paper has some limitations. First, it investigates the impact of average monthly temperatures, precipitation, and sunshine on overnight stays in the summer months of July and August. It thus ignores the distribution of weather factors within individual months. It is well known that working with averages hides extreme weather events, such as heat waves, thunderstorms, and floods (Gössling and Hall, 2006; Gössling et al., 2012). Furthermore, we only provide aggregated effects of weather on tourism demand, which are likely to differ between mountain, lake, and city destinations. Another limitation is that differences in local weather conditions (e.g., between mountain and lowland regions) are not considered in the analysis. Local weather conditions in the eastern part of Austria, for example, are known to differ significantly from those in the western part in some summers. However, the weather data from the different stations in western and eastern Austria exhibits very high correlation, exceeding 0.9. Finally, our research is limited to Austria; in order to generalize our findings, this study needs to be replicated for other Alpine countries (Italy, France, and Switzerland).

There are several possible avenues for future research. One could involve a closer examination of the heterogeneity of weather impacts across different locations within a country. Perry (1972) and Smith (1993) suggest that towns may benefit from wet summer days due to tourists leaving nearby golf courses and swimming pools in order to visit them. The availability of data on overnight stays at the community level would also make it possible to investigate separately the relationship between weather and tourism for mountain, lake, and city destinations. Future work should also employ data on extreme weather episodes, such as floods and heat waves, rather than average measures of rainfall and temperature.

Appendix A



Graph 1. Actual and trend change in sunshine hours 1960–2012. Source: ZAMG. HISTALP.



Graph 2. Actual and trend change in summer temperatures 1960–2012. Source: ZAMG. HISTALP.

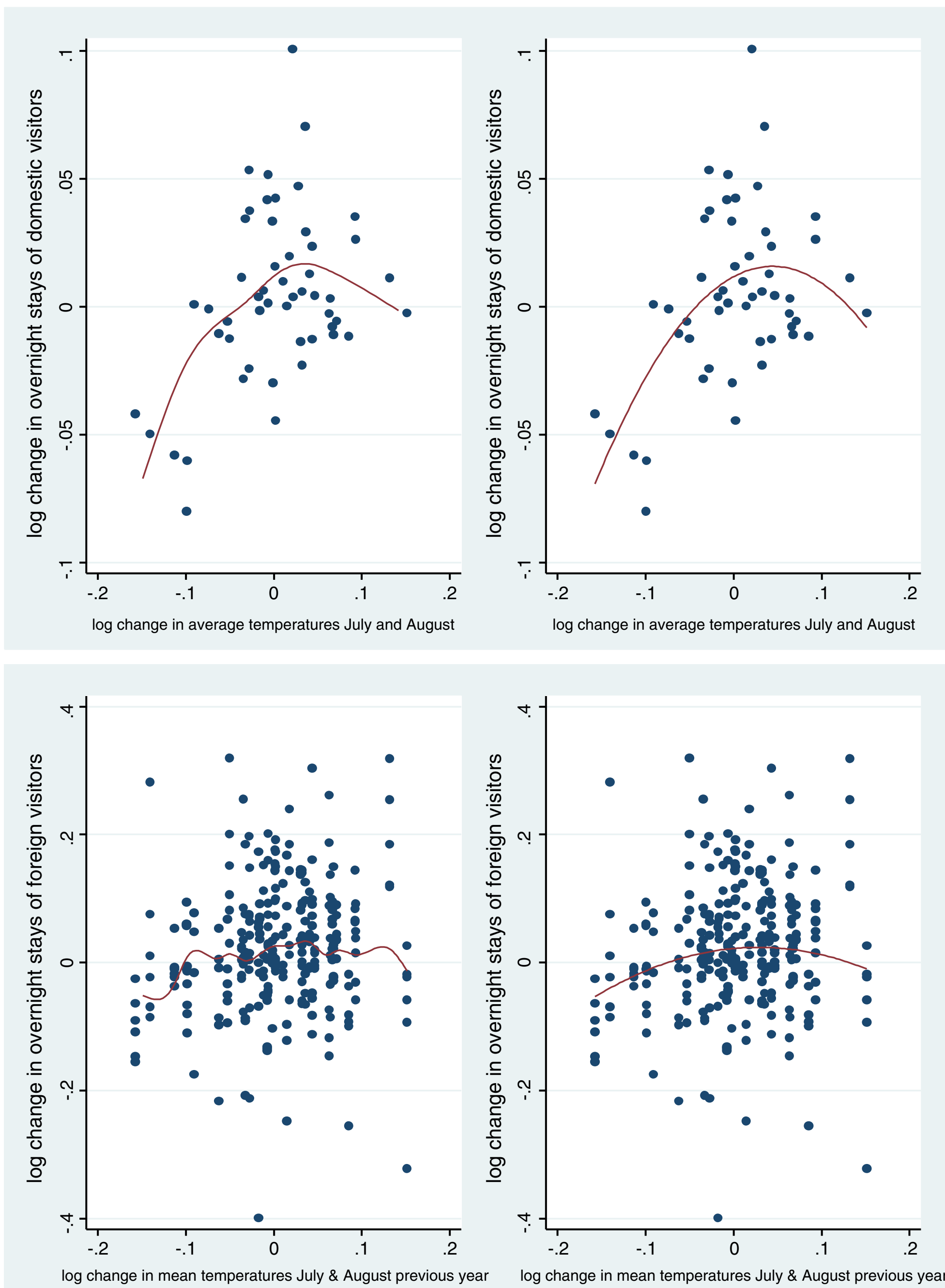
Table 6
Evolution of temperatures, overnight stays, real GDP and relative prices (1960–2012).

	Average temperatures July and August in °C	Average sunshine July and August in hours	Average precipitation July and August in mm	Foreign overnight stays in million (sum)	Domestic overnight stays in million	Relative prices IT to AT	Relative prices AT to foreign countries (mean)	Domestic GDP in constant prices	Foreign GDP in constant prices
1960	17.1	216.1	131.4	n.a.	7.5	0.7	n.a.	n.a.	0.30
1961	17.4	254.1	98.9	n.a.	8.3	0.7	n.a.	n.a.	0.32
1962	18.1	240.4	93.2	n.a.	8.5	0.7	n.a.	n.a.	0.33
1963	18.6	238.0	118.6	n.a.	8.9	0.7	n.a.	n.a.	0.35
1964	18.1	244.4	104.1	n.a.	9.4	0.7	n.a.	n.a.	0.37
1965	16.8	205.0	126.0	n.a.	9.4	0.7	n.a.	n.a.	0.39
1966	16.8	194.4	195.8	n.a.	9.1	0.7	n.a.	n.a.	0.41
1967	19.2	231.9	87.9	23.0	9.2	0.7	0.84	0.39	0.42
1968	17.4	203.8	159.6	25.9	8.5	0.7	0.85	0.41	0.44
1969	17.9	217.4	122.9	27.4	8.4	0.7	0.85	0.43	0.47
1970	17.9	214.6	166.4	31.7	8.6	0.7	0.84	0.44	0.49
1971	19.7	269.0	101.4	36.9	8.9	0.7	0.85	0.45	0.51
1972	18.0	199.4	125.9	39.4	8.9	0.7	0.88	0.47	0.53
1973	18.7	227.3	93.0	38.5	8.8	0.8	0.94	0.50	0.56
1974	18.6	233.6	116.5	36.6	8.8	0.9	0.97	0.50	0.57
1975	18.3	226.8	136.6	38.4	8.8	0.9	0.97	0.50	0.57
1976	17.7	209.0	108.7	36.8	8.6	1.0	0.99	0.52	0.59
1977	17.7	191.8	120.5	34.6	8.9	1.1	1.04	0.54	0.60
1978	16.9	215.3	109.8	35.2	8.8	1.1	1.04	0.56	0.62
1979	17.0	196.5	106.4	37.0	8.9	1.0	1.02	0.58	0.64
1980	17.7	208.9	112.9	37.5	9.0	1.0	0.99	0.58	0.65
1981	18.0	217.8	127.0	37.7	9.0	0.9	0.93	0.59	0.66
1982	19.2	207.0	109.0	34.9	9.0	0.9	0.95	0.59	0.66
1983	20.5	247.4	80.7	32.4	9.0	0.9	0.97	0.61	0.67
1984	17.8	224.4	105.0	31.0	8.6	0.9	0.97	0.64	0.70
1985	19.0	261.0	151.7	29.1	8.5	0.9	0.95	0.66	0.71
1986	18.5	236.8	109.9	29.3	8.8	0.9	1.03	0.68	0.73
1987	18.6	229.1	122.7	28.0	8.4	0.9	1.09	0.70	0.75
1988	19.4	261.4	137.6	29.1	8.6	0.9	1.07	0.72	0.78
1989	18.8	209.9	139.9	30.5	8.9	0.9	1.05	0.75	0.80
1990	19.1	278.6	98.5	29.2	9.1	0.9	1.06	0.76	0.81
1991	19.8	234.1	121.1	32.5	9.8	0.8	1.03	0.77	0.81
1992	21.6	281.1	86.0	32.1	9.7	0.9	1.05	0.79	0.82
1993	18.4	235.6	155.0	30.5	9.3	1.1	1.09	0.79	0.82
1994	21.4	268.9	98.3	27.6	9.3	1.1	1.10	0.82	0.84
1995	20.1	241.8	120.1	25.1	9.2	1.2	1.15	0.84	0.86
1996	18.2	220.5	123.5	23.2	8.6	1.1	1.11	0.87	0.88
1997	18.8	226.4	143.4	21.7	8.4	1.0	1.05	0.90	0.91
1998	19.5	238.0	124.2	22.2	8.5	1.0	1.05	0.93	0.93
1999	19.3	210.4	140.6	21.9	8.8	1.0	1.03	0.96	0.96
2000	19.0	236.1	129.1	20.7	8.8	1.0	1.00	1.00	1.00
2001	20.4	250.5	94.6	20.6	8.8	1.0	1.00	1.01	1.02
2002	19.9	230.4	178.5	21.0	8.6	1.0	1.00	1.03	1.03
2003	21.8	283.0	95.9	21.1	8.8	1.0	1.02	1.05	1.05
2004	19.5	240.6	108.1	20.6	8.3	1.0	1.04	1.08	1.08
2005	18.5	200.4	172.9	20.3	8.3	1.0	1.04	1.11	1.10

Table 6 (*continued*)

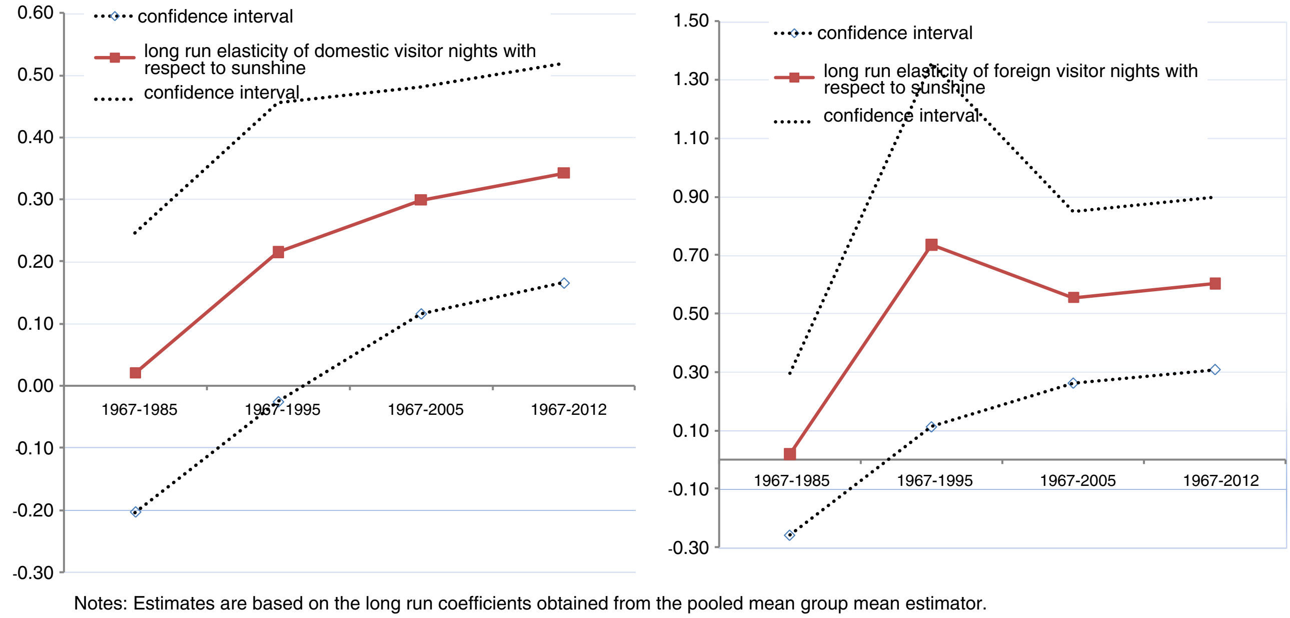
	Average temperatures July and August in °C	Average sunshine July and August in hours	Average precipitation July and August in mm	Foreign overnight stays in million (sum)	Domestic overnight stays in million	Relative prices IT to AT	Relative prices AT to foreign countries (mean)	Domestic GDP in constant prices	Foreign GDP in constant prices
2006	19.7	246.8	128.1	19.0	8.2	1.0	1.04	1.14	1.14
2007	19.6	261.6	135.2	19.6	8.6	1.0	1.05	1.17	1.17
2008	19.6	254.8	137.9	19.8	8.9	1.0	1.08	1.17	1.17
2009	20.5	273.1	148.9	19.9	9.0	1.0	1.10	1.12	1.12
2010	20.3	247.5	172.0	20.0	9.0	1.0	1.06	1.15	1.15
2011	19.6	247.5	120.1	20.0	9.1	1.0	1.06	1.17	1.17
2012	20.0	263.6	150.9	20.4	9.2	1.0	1.03	1.19	1.17

Source: ZAMG. HISTALP, OECD stats. World Bank development indicators.



Notes: The plot is calculated based on estimates in Table 1 upper panel column and Table 2 middle panel column 2.

Graph 3. Predicted relationships between growth of domestic overnight stays and foreign overnight stays in July and August and change in average summer temperatures.



Graph 4. Change in the long-run elasticities of foreign tourism demand with respect to sunshine duration.

References

Agnew, M.D., & Palutikof, J. (2006). Impacts of short-term climate variability in the UK on demand for domestic and international tourism. *Climate Research*, *31*, 109–120.

Álvarez-Díaz, M., & Rosselló-Nadal, J. (2010). Forecasting British tourist arrivals in the Balearic Islands using meteorological variables. *Tourism Economics*, *16*(1), 153–168.

Amelung, B., Nicholls, S., & Viner, D. (2007). Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research*, *45*(3), 285–296.

Amelung, B., & Viner, D. (2006). Mediterranean tourism: Exploring the future with the tourism climatic index. *Journal of Sustainable Tourism*, *14*(4), 349–366.

Auer, I., Böhm, R., Jurkovic, A., Lipa, W., Orlik, A., Potzmann, R., et al. (2007). HISTALP — historical instrumental climatological surface time series of the Greater Alpine Region. *International Journal of Climatology*, *27*, 17–46. http://dx.doi.org/10.1002/joc.1377.

Becken, S. (2013a). A review of tourism and climate change as an evolving knowledge domain. *Tourism Management Perspectives*, *6*, 53–62.

Becken, S. (2013b). Measuring the effect of weather on tourism: A destination- and activity-based analysis. *Journal of Travel Research*, *52*(2), 156–167.

Becken, S., & Wilson, J. (in press). The impacts of weather on tourist travel. *Tourism Geographies* (in press).

Bigano, A., Hamilton, J. M., & Tol, R. (2006). The impact of climate change on holiday destination choice. *Climate Change*, *76*(3–4), 389–406.

Coombes, E. G., & Jones, A. P. (2010). Assessing the impact of climate change on visitor behaviour and habitat use at the coast: A UK case study. *Global Environmental Change*, *20*, 303–313.

Cortés-Jiménez, I., & Blake, A. (2011). Tourism demand modeling by purpose of visit and nationality. *Journal of Travel Research*, *50*, 408–416.

Crompton, J. L. (1979). Motivations for pleasure vacation. *Annals of Tourism Research*, *6*, 408–424.

Crouch, G. I. (1994). Demand elasticities for short-haul versus long-haul tourism. *Journal of Travel Research*, *33*(2), 2–7.

Day, J., Chin, N., Sydnor, S., & Cherkauer, K. (2013). Weather, climate, and tourism performance: A quantitative analysis. *Tourism Management Perspectives*, *5*, 51–56.

De Freitas, C. R. (2003). Tourism climatology: Evaluating environmental information for decision making and business planning in the recreation and tourism sector. *International Journal of Biometeorology*, *48*, 45–54.

Denstadli, J. M., Jacobsen, J. K., & Lohmann, M. (2011). Tourist perceptions of summer weather in Scandinavia. *Annals of Tourism Research*, *38*(3), 920–940.

Finger, R., & Lehmann, N. (2012). Modeling the sensitivity of outdoor recreation activities to climate change. *Climate Research*, *51*, 229–236.

Giles, A.R., & Perry, A. H. (1998). The use temporal analogue to investigate the possible impact of projected global warming on the UK tourism industry. *Tourism Management*, *19*(1), 75–80.

Goh, C. (2012). Exploring impact of climate on tourism demand. *Annals of Tourism Research*, *39*(4), 1859–1883.

Gómez Martín, M. B. (2005). Weather, climate and tourism: A geographical perspective. *Annals of Tourism Research*, *32*(3), 571–591.

Gössling, S., & Hall, C. M. (2006). Uncertainties in predicting tourist flows under scenarios of climate change. *Climatic Change*, *79*(3–4), 163–173.

Gössling, S., Scott, D., Hall, C. M., Ceron, J., & Dubois, G. (2012). Consumer behaviour and demand response of tourists to climate change. *Annals of Tourism Research*, *39*, 36–58.

Hamilton, J. M., Maddison, D. J., & Tol, R. S. J. (2005). Effects of climate change on international tourism. *Climate Research*, *29*, 245–254.

Huber, P. (1981). *Robust statistics*. New York: John Wiley & Sons.

Jørgensen, F., & Solvoll, G. (1996). Demand models for inclusive tour charter: The Norwegian case. *Tourism Management*, *17*(1), 17–24.

Kaján, E., & Saarinen, J. (2013). Tourism, climate change and adaptation: A review. *Current Issues in Tourism*, *16*(2), 167–195.

Kozak, M. (2002). Comparative analysis of tourist motivations by nationality and destinations. *Tourism Management*, *23*, 221–232.

Kulendran, N., & Dwyer, L. (2012). Modeling seasonal variation in tourism flows with climate variables. *Tourism Analysis: An Interdisciplinary Journal*, *17*(2), 121–137.

Lise, W., & Tol, R. S. J. (2002). Impact of climate on tourist demand. *Climatic Change*, *55*(4), 429–449.

Lohmann, M., & Kaim, E. (1999). Weather and holiday destination preferences: Image, attitude and experience. *Revue de Tourisme*, *54*(2), 54–64.

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

Otero-Giráldez, M. S., Álvarez-Díaz, M., & González-Gómez, M. (2012). Estimating the long-run effects of socioeconomic and meteorological factors on the domestic tourism demand for Galicia (Spain). *Tourism Management*, *33*(2), 1301–1308.

Pang, F. H., McKercher, B., & Prideaux, B. (2013). Climate change and tourism: An overview. *Asia Pacific Journal of Tourism Research*, *18*(1–2), 4–20.

Perry, A. (1972). Weather, Climate and Tourism. *Weather*, *27*, 199–203.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, *94*, 621–634.

Pesaran, M. H., & Smith, R. P. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, *68*, 79–113.

Richardson, R. B., & Loomis, J. B. (2005). Climate change and recreation benefits in an Alpine National Park. *Journal of Leisure Research*, *37*(3), 307–320.

Rossello-Nadal, J., Riera-Font, A., & Cardenas, V. (2011). The impact of weather variability on British outbound flows. *Climatic Change*, *105*, 281–292.

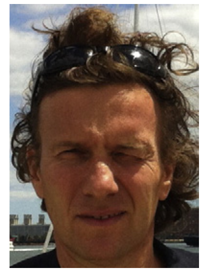
Schlenker, W., & Roberts, M. J. (2008). Nonlinear effects of weather on corn yields. *Review of Agricultural Economics*, *28*(3), 391–398.

Scott, D., & Jones, B. (2006). The impact of climate change on golf participation in the Greater Toronto Area (GTA): A case study. *Journal of Leisure Research*, *38*(3), 363–380.

Scott, D., Jones, B., & Konopek, J. (2007). Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: a case study of Waterton Lakes National Park. *Tourism Management*, *28*(2), 570–579.

Serquet, G., & Rebetez, M. (2011). Relationship between tourism demand in the Swiss Alps and hot summer air temperatures associated with climate change. *Climatic Change*, *108*, 291–300.

Smith, K. (1990). Tourism and climate change. *Land Use Policy*, *7*(2), 176–180.
Smith, K. (1993). The influence of weather and climate on recreation and tourism. *Weather*, *48*, 398–404.
Song, H., & Li, G. (2008). Tourism demand modelling and forecasting: A review of recent research. *Tourism Management*, *29*(2), 203–220.
Song, H., & Witt, S. F. (2000). *Tourism demand modeling and forecasting: Modern econometric approaches*. Oxford: Elsevier.
Song, H., Witt, S. F., & Li, G. (2009). *The advanced econometrics of tourism demand*. Routledge.
Taylor, T., & Ortiz, R. (2009). Impacts of climate change on domestic tourism in the UK: A panel data estimation. *Tourism Economics*, *15*(4), 803–812.
Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of` Economics and Statistics*, *69*(6), 709–748.



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