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Impact of Long-Term Weather on Domestic and Foreign Winter Tourism Demand†

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ABSTRACT

This study estimates the determinants of domestic and foreign tourism demand using data on 28 Austrian ski resorts for the winter seasons 1986–1987 to 2007–1908. Using the dynamic panel data analysis, we find that the effect of the weather variables (e.g. snow depth, cloudiness or sunshine) is quite small, with a change in one standard deviation of the variation over time in each weather variable, leading to a 2–3 % change in overnight stays. Furthermore, domestic tourists are more sensitive to changes in weather conditions than foreign tourists. By contrast, overnight stays of foreign visitors are much more responsive to changes in income than it is the case for domestic overnight stays. The occurrence of extreme snow-deficient winters, such as the winter of 2006–2007, in the future period will reduce overnight stays of foreign and domestic visitors by 2 and 5 %, respectively. Copyright © 2011 John Wiley & Sons, Ltd.

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Keywords: tourism demand; long-term weather; domestic and foreign tourism; dynamic panel data model; climate change; ski resorts.

INTRODUCTION

There have been a growing number of studies on how climate variability and global warming affects weather-dependent sectors, such as tourism and leisure activities (for a recent survey of the literature, see Gómez Martín, 2005; Agrawala, 2007; Becken and Hay, 2007; Becken, 2010, among others). In the European Alps between 1950 and 2000, there is a substantial trend increase in temperatures and sunshine duration in the winter season as well as a trend decline in cloudiness at both low and high altitudes (Auer *et al.*, 2007). Furthermore, long-term trends of snow depth for the period 1928–2005 show a significant reduction of snow accumulation in the Austrian Alps, particularly during the core winter months of December to February (Schöner *et al.*, 2009). In addition, temperature increases are substantially higher in the European Alps than in other regions worldwide. Similarly, climate change is expected to bring substantially higher temperatures in the winter period, which also means higher temperatures in the European Alps, relative to the global average (IPCC, 2007 chapter 11). Winter sport activities, such as downhill and cross-country skiing are strongly dependent on reliable snow conditions. Furthermore, the production of man-made snow requires low temperatures. Therefore, understanding the relationship between long-term weather and winter tourism demand based on historical data is important when considering the impact of future climate scenarios on winter tourism flows.

Despite the increasing number of studies, however, there are still important gaps in our understanding of the relationship between climate change and winter tourism demand. In particular, there is still no consensus on the extent to which long-term weather conditions influence tourism demand based on historical data. Furthermore, Taylor and Ortiz (2009) suggest that domestic tourists are more likely to be affected by weather conditions than their foreign counterparts because domestic holidays are not planned in advance. Knowledge of the different impacts on domestic and foreign

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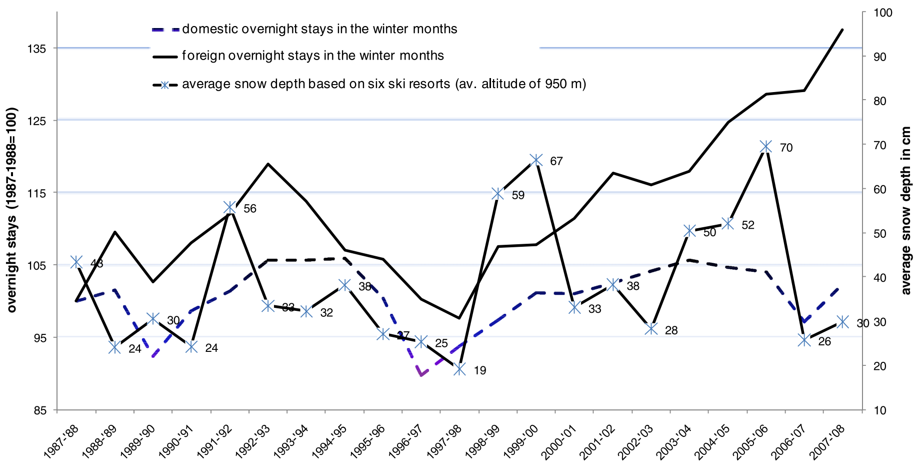

Figure 1. Relationship between overnight stays and average snow depth in the province Salzburg Notes: Overnight stays refer to the Salzburg province for the winter months. Average snow depth is calculated at the mean of six weather stations (i.e. Radstadt, Bad Gastein, Saalbach, Rauris, Krimml and Zell am See located at altitudes between 766 m and 1100 m. STAT Austria, Central Institute for Meteorology and Geodynamics Austria, author's own calculations.

visitors is important for decision makers and stakeholders. For instance, an analysis of the drivers of winter tourism demand can provide useful information to develop different marketing activities for different destination markets. Indeed, descriptive evidence for Western Austria for the last two decades shows that domestic winter tourism is more sensitive to variations in snow depth, as compared to foreign tourism. For instance, in the province Salzburg, during the snow-deficient winters 1989/1990 and 2006/2007, the number of domestic overnight stays in the winter months decreased by 9.0 and 6.6 %, as compared to the previous season, respectively. For foreign overnight stays, the decrease was much less pronounced with a decrease of 2.8 and 2.6, respectively (see also Figure 1).

In this paper, we investigate the effects of long-term weather patterns on winter tourism demand based on panel data on 28 Austrian ski resorts for the winter seasons 1986–1987 to 2007–2008. Using a dynamic panel data analysis allows us to distinguish between the short-run and long-run effects of weather on winter tourism demand. Dynamic panel data models have become increasingly popular in tourism demand research in recent years (see among others, Garín-Muñoz and Montero-Martín, 2007; Brida and Risso, 2009; Seetaram, 2010 and; Töglhofer *et al.*, 2011). The advantage of panel data over time-series data or cross-section data is that it enables one to control for unobserved individual characteristics and a much larger sample size, thus leading to greater statistical significance of the results.

The paper adds to the existing literature in two main areas. First, it distinguishes between overnight stays by foreign and domestic visitors. We are thus able to assess whether the determinants of the number of nights spent by domestic visitors are the same as those for foreign visitors. Given that an average of about 25 % of all overnight stays in Austria's winter season can be attributed to domestic residents, it is important to investigate whether the impact of weather is different between domestic and foreign visitors. To our knowledge, no study has investigated the impact of weather on winter tourism demand while distinguishing between domestic and inbound tourism.[1] Agnew and Palutikof (2006) investigate the impact of weather on both domestic and outbound tourism. Second, it introduces some new weather variables, such as the proportion of days with clear skies and cloud cover. The underlying empirical motivation to include

[1]However, there are some studies that distinguish between domestic and foreign tourism demand that include all seasons (e.g. Garín-Muñoz, 2009 among others). However, these studies do not account for weather effects.

sunshine or cloudiness is that, in the Austrian Alps, there has been a significant trend increase in sunshine duration from 1950 onward (Auer *et al*., 2007). Although the relationship between weather and tourism demand measured as overnight stays based on Austrian ski resorts has been addressed by Falk (2010) and Töglhofer *et al*. (2011), a comprehensive analysis that accounts for weather variables other than snow depth and temperatures is not available. These studies also do not distinguish between foreign and domestic tourists.

Several studies have investigated the relationship between winter tourism and both weather and climate factors (see, e.g., Harrison *et al*., 1999; Holden, 2000; Maddison, 2001; Fukushima *et al*., 2002; Englin and Moeltner, 2004; Moeltner and Englin, 2004; Hamilton *et al*., 2007; Müller and Weber, 2008; Shih *et al*., 2009; Bark *et al*., 2010; Pickering *et al*., 2010; Töglhofer *et al*., 2011). These studies are difficult to compare, since they are situated in different geographical locations (longitude, latitude, and altitudes), and they are based on different data frequencies (i.e. annual, monthly, and daily data), different levels of aggregation (i.e. individual or resort-level data), and different measures of winter tourism demand (i.e. lift ticket sales, skier visits, number of days ski lifts have been in operation and overnight stays) and are also characterized by large differences in sample sizes. More importantly, not all studies control the economic variables affecting tourism demand, such as income and tourism prices.

The literature agrees that winter tourism demand is positively related to snow depth (Fukushima *et al*., 2002; Shih *et al*., 2009; Bark *et al*., 2010; Falk, 2010; Pickering *et al*., 2010; Töglhofer *et al*., 2011). However, there is no agreement on the magnitude of the effect of snow on winter tourism demand. Studies that use skier visits or lift ticket sales find a strong impact of snow depth on tourism demand (e.g. Shih *et al*., 2009; Bark *et al*., 2010; Pickering *et al*., 2010). Using data on two ski resorts at low elevations in Michigan, Shih *et al*. (2009) found that natural snow depth is the only local weather variable having a significant impact on lift ticket sales. In particular, the results show that an increase in snow depth by one inch (=2.54 centimetres) leads to an increase in lift ticket sales by 7 and 9 %. Using skier visits for 11 Australian ski resorts for the period 1990–2007, Pickering *et al*. (2010) found that the amount of natural snow explains 57 % of the variation in skier visits over time. Similarly, based on data for Snowbowl, the largest ski resort in Arizona, Bark *et al*. (2010) found that snowpack and season length (measured as open days) explain 77 % of the variation in skier visits over the period 1981–1982 to 2005–2006. Using daily and annual data for two ski resorts, Hamilton *et al*. (2007) found a strong correlation between skier attendance and snow depth based on data for 7–9 winter seasons. The same holds true for Harrison *et al*. (1999), who investigated the relationship between snow and number of days of operation based on low altitude ski areas in Scotland.

However, few studies are available for the most important ski markets in the world, such as France, Austria, Switzerland and only selective evidence for the USA. Using a dynamic panel data approach and controlling for income and prices, Töglhofer *et al*. (2011) investigated the impact of snow cover on visitor nights. Using data for 185 Austrian ski resorts for the winter seasons between the period 1973–2007, the authors found that the impact of snow depth on tourism demand is very small on the average. Falk (2010) found similar results using data for 28 Austrian ski resorts for the winter season 1997–1998 to 2005–2006.

Furthermore, there is no consensus on the impact of the remaining weather variables. Some studies found that temperatures are negatively related (Fukushima *et al*., 2002; Englin and Moeltner, 2004; Shih *et al*., 2009). However, Moeltner and Englin (2004) showed that average daily temperatures are not significantly related to the number of skier visits. Shih *et al*. (2009) found that the impact of the other variables, such as temperature, wind chill and snowfall (as compared to snow depth), is not clear cut. Finally, some studies found a non-linear effect between weather conditions and tourism flows (e.g. Maddison, 2001; Englin and Moeltner, 2004).

Most of the previous literature on the impact of weather on winter tourism demand uses average temperatures and a measure of snow depth and/or snow fall. A notable exception is that by Shih *et al*. (2009), who introduced wind chill as an additional weather variable.

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With that said, temperature and snow depth are not the only applicable weather variables: De Freitas (2003) suggested that tourism is influenced by a number of weather conditions, including aesthetical factors (e.g. sunshine, solar radiation, high visibility and cloud cover) and physical factors (wind and rain). In particular, the author suggests that aesthetical factors, such as sunshine, high visibility and low cloud cover, all increase the attractiveness of sites, thus stimulating tourism demand. In this paper, we try to fill this gap by providing empirical evidence on the relation between sunshine and cloud cover on winter tourism demand.

The structure of this study is given as follows: Section 2 introduces the empirical model, while Section 3 presents the data and descriptive statistics. Section 4 presents the empirical results, and Section 5 gives the conclusion.

EMPIRICAL MODEL

To obtain the empirical model, the standard tourism demand model is augmented by weather variables that belong to the noneconomic determinants of tourism demand (Cho, 2010). The standard demand factors are prices relative to the respective country of origin or the destination country's competitors and the income of the visitor countries (Crouch, 1992, 1995; Lim, 1997; Song and Li, 2008). Econometric models relating winter tourism demand to weather conditions often include temperature and snow depth, or snowpack, as the most important weather parameter. In addition, sunshine and cloud cover may also affect tourism demand (de Freitas, 2003). Long-run tourism demand is specified as follows:

$$\begin{aligned} 1nD_{it} = {} & \alpha_1 1nGDPcap_{it} + \alpha_2 1nP_{it} + \alpha_3 1nsnow_{it} \\ & + \alpha_4 temp_{it} + \alpha_5 1ncloud_{it} + \alpha_6 1nsun_{it} \\ & {}_{+\mu i} + \varepsilon_{it}, \end{aligned}$$

where *i* and *t* denote the ski resort and time (i.e. annual data for the winter season), respectively. ln denotes the natural logarithm, and *D* represents output, which is measured as the number of total overnight stays of visitors during the winter season (November to April). GDPcap is the gross domestic product per capita in constant purchasing power parities (ppp), weighted by the share of overnight stays of the major countries of origin. P is the price index of accommodation prices; snow is a measure of snow depth for the five-month period between November and March; temp represents the average temperatures for the period November to March; cloud is measured on a 1–10 scale for the four-month period December to March; and sun is measured as the percentage of days with clear skies during the winter season (December to March).

We use the total numbers of visitor nights and nights split up into the overnight stays of domestic and foreign visitors as the dependent variables. The corresponding long-run relationships for nights spent by foreign visitors and domestic residents are:

$$\begin{aligned} 1nFD_{it} = {} & \alpha_{11} 1nFGDPcap_{it} + \alpha_{21} 1nP_{it} + \alpha_{31} 1nsnow_{it} \\ & + \alpha_{41} temp_{it} + \alpha_{51} 1ncloud_{it} + \tilde{\mu}_i + \tilde{\varepsilon}_{it}, \\ 1nDD_{it} = {} & \alpha_{12} 1nDDPcap_{it} + \alpha_{22} 1nP_{it} + \alpha_{32} 1nsnow_{it} \\ & + \alpha_{42} tamp_{it} + \alpha_{52} 1ncloud_{it} + \tilde{\mu}_i + \tilde{\varepsilon}_{it}. \end{aligned}$$

FD and DD denote foreign and domestic overnight stays, respectively. The long-run specification for domestic overnight stays includes the same weather variables but includes domestic GDP per capita as the measure for income. The corresponding demand equation for foreign visitors contains the weighted GDP per capita of the visitors' home countries, FGDPcap. We anticipate positive demand and negative price elasticities, and natural snow depth is expected to have a positive effect on winter tourism. With respect to the remaining weather variables (i.e. temperature, sun and cloudiness), it is not clear a priori what the effects are. Sunshine is a very important weather element. Good weather in a given winter season may lead to an increase in the number of overnight stays. Gómez Martín (2005) suggests that most skiers prefer sunny weather and pleasant temperatures. However, snow suffers from sun and thereby reduces tourism demand. Temperatures also have indirect effects on tourism demand because warm winters lead to less snow (Breiling and Charamza, 1999). In addition, the determinants of domestic and foreign tourism are likely to be different. Domestic tourism is more

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likely to be influenced by weather than foreign tourism because it does not need to be planned as far in advance (Taylor and Ortiz, 2009). Furthermore, since winter sport activities have a luxury character, one can expect the corresponding income elasticity to be greater than one, especially for overnight stays of foreign tourists (Garín-Muñoz, 2009). However, domestic visitors may regard winter sport activities as a basic necessity or normal good rather than a luxury item. Therefore, we expect low-income elasticities for domestic visitors.

We use a dynamic specification because of habit persistence or partial adjustment. It is well known that winter tourists tend to adjust their travel behaviour based on past snow conditions. Since panel data is used, unobserved heterogeneity can be explicitly captured by resort-specific effects. The panel error correction model can be written as:

$$\Delta y_{it} = \tilde{\alpha}_i\left(y_{i,t-1} - \beta_i' x_{i,t-1}\right) + \sum_{j=1}^{m-1} \theta_{ij}\Delta y_{i,t-1} + \sum_{j=0}^{n-1} \gamma_{ij}\Delta x_{i,t-1} + \mu_i + \varepsilon_{it},$$

where Δ denotes the first difference operator. $x_{i,t}$ is the vector of explanatory variables, and y_{it} is the dependent variable. β'_i are the long-run parameters, and α_i are the error-correction parameters measuring the speed of adjustment. θ_{ij} and γ_{ij} are the short-run parameters, μ_i is the individual effect, and ε_{it} is the error term. The pooled mean group estimator introduced by Pesaran *et al*. (1999) can be used to estimate the error correction model. In the pooled mean group estimator, β'_i is restricted to being similar across ski resorts, while the error correction term α_i and the short-run parameters θ_{ij} and γ_{ij} are free to vary across ski resorts. The short-run coefficients are obtained by taking the averages of the individual time-series estimates. The parameter estimates of this model are consistent and asymptotically normal for either non-stationary, I(1), or stationary, I(0), variables. In addition, we employ the mean group (MG) estimator, which is obtained by estimating each equation separately by OLS and then taking their average (Pesaran and Smith, 1995). The homogeneity of long-run coefficients is tested implementing a joint test. The appropriate lag length is chosen using the Schwarz Bayesian Criterion. The first step is to apply panel unit root tests in order to test for possible non-stationarity. We use both panel unit root tests that neglect cross-sectional dependence (i.e. Im *et al*., 2003), as well as unit root tests that account for cross-sectional dependence (Pesaran, 2007). In the second step, we test whether or not a cointegrating relationship exists among overnights stays, output, prices, and weather variables.

DATA

This study uses annual panel data on 28 Austrian ski resorts for the winter seasons from 1986–1987 to 2007–2008, resulting in 560 observations. The dependent variable is the number of overnight stays, as published by Statistics Austria. The number of overnight stays refers to the winter season (November to April) and covers hotels and similar establishments, private accommodations and apartments. The selection of ski resorts is based on their proximity to weather stations in terms of elevation, distance and data availability (see Table 1 for a list of the included ski resorts). Note that we do not include ski resorts with a large share of day visitors or those who are not staying at the ski resort. Data on overnight stays at the resort level is matched with weather data from 19 stations.

Four weather elements are extracted on a monthly basis from the annual yearbook of the Central Institute for Meteorology and Geodynamics (ZAMG Austria). These consist of average monthly temperatures in Celsius (°C), maximum monthly snow depth in centimetres, percentage of days with clear skies, and cloud cover, which are measured on a scale of 1 to 10 (with 1 indicating clear skies and 10 denoting 100 % cloud cover). This data is then averaged over the winter season, taking means over a five-month period for snow depth and temperatures and over a four-month period from December to March for the remaining weather indicators. An alternative measure of snow depth is the average of the period November through January, which captures the effects of the timing of snow, a factor seen as very important in the literature (Breiling and Charamza,

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Table 1. List of included ski resorts

Arlberg (St. Anton, Lech & Zürs)
Bad Aussee
Bad Mitterndorf & Tauplitz
Damüls, Mellau, Schoppernau
Ehrwald, Lermoos, Berwang
Galtür
Gastein Valley (Bad Hofgastein, Bad Gastein, Dorfgastein & Großarl)
Ischgl
Kals/Matrei
Kappl
Kaprun
Kitzbühel (Aurach close to Kitzbühel, Kirchberg in Tirol, Kirchdorf in Tirol, Kitzbühel, Jochberg & Reith close to Kitzbühel)
Klösterle
Lundgau area (Mariapfarr, Mauterndorf & Sankt Michael/Lungau)
Ramsau
Rauris
Serfaus, Fiss & Ladis
Saalbach, Hinterglemm & Leogang
Salzburg Sportwelt (Altenmarkt/Pongau, Eben/Pongau, Filzmoos, Flachau, Kleinarl, Radstadt, Wagrain & Sankt Johann/Pongau)
See
Seefeld
Sillian
Sölden & Obergurgl
St. Jakob (St. Jakob/Defereggen valley)
Schladming area (Rohrmoos-Untertal, Schladming, Pichl-Preunegg & Haus)
Warth
Zell am See
Ziller valley (Aschau, Finkenberg, Fügen, Fügenberg, Gallzein, Gerlos, Gerlosberg, Hainzenberg, Hippach, Kaltenbach, Mayrhofen, Ramsau/Ziller valley, Zell am Ziller, Zellberg & Wald/Pinzgau)

1999). However, preliminary regression results show that the impact of snow depth does not depend on the time of measurement.

Real GDP per capita is measured as GDP in constant purchasing power parities per capita. It is drawn from the OECD Economic Outlook database and the New Cronos database for the new EU member states. Weighted real GDP per capita is calculated as the weighted average of domestic real GDP per capita of the 13 most important visitor countries. The weights are fixed based on the proportions of overnight stays for the year 1996, which is the sample midpoint value (see Table 2).

Table 2. Composition of the number of overnight stays by country of origin (percentages)

Austria	18
Belgium	3
Switzerland	4
Germany	58
Denmark	1
France	1
Finland	0
Hungary	0
Italy	1
Netherlands	11
Sweden	1
United Kingdom	2
United States	0
Total	100

Note: Data refer to the year 1996. Percentages are calculated for the major 13 visitor countries in terms of the number of overnight stays. Data are calculated as the unweighted mean across 28 resorts. Source: Statistics Austria, own calculations.

Table 3 shows the time evolution of the variables (i.e. number of overnight stays aggregated across the selected resorts, average weighted real GDP per capita of the major visitor countries, and the price index of accommodations). In addition, we distinguish between domestic and foreign overnight stays, as well as between domestic and foreign GDP per capita with 1995 as the base year. For example, the total number of overnight stays for the resorts that are included in the sample increased between the winter seasons 1985–1986 and 2007–2008. However, when overnight stays are broken down into domestic and foreign overnight stays, one can see that domestic overnight stays are rather stable, whereas foreign overnight stays grow steadily over time. This indicates a stagnant domestic market.

Table 4 contains four different elements of weather. It is evident that snow-deficient winters, such as 1989–1990 and 2006–2007, are also characterized by relatively high average temperatures and a higher-than-average number of days with clear skies. By contrast, the winters with high levels of snow depth, such as 1998–1999

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Table 3. Descriptive statistics for overnight stays, weighted GDP per capita and accommodation prices

Winter season	Total overnight stays	Domestic overnight stays	Foreign overnight stays	Weighted GDP per capita	Foreign GDP per capita	Domestic GP per capita	Price index
	(millions)	(millions)	(millions)	(1995=100)	(1995=100)	(1995=100)	(1995=100)
1985–1986	17.6	3.6	14.0	79.2	79.3	79.1	n.a.
1986–1987	16.4	3.5	12.8	80.4	80.7	80.4	67.5
1987–1988	18.2	3.5	14.8	83.1	83.2	83.1	68.9
1988–1989	18.4	3.5	14.9	86.4	86.3	86.3	71.2
1989–1990	18.5	3.2	15.3	90.4	89.8	90.3	73.7
1990–1991	18.3	3.3	15.0	93.9	92.8	94.0	78.3
1991–1992	20.1	3.4	16.7	95.6	95.0	95.5	82.0
1992–1993	20.1	3.5	16.6	95.2	95.2	95.0	89.3
1993–1994	19.8	3.5	16.3	97.9	97.7	97.8	95.0
1994–1995	19.7	3.5	16.2	100.0	100.0	100.0	100.0
1995–1996	19.2	3.3	15.8	101.6	102.3	101.4	101.8
1996–1997	18.2	3.0	15.2	104.0	104.7	103.9	104.6
1997–1998	19.2	3.1	16.0	106.7	108.6	106.3	105.8
1998–1999	19.7	3.3	16.5	109.4	112.6	108.9	106.2
1999–2000	20.4	3.4	17.0	113.3	116.3	112.9	107.9
2000–2001	21.3	3.4	17.9	114.9	117.4	114.6	110.1
2001–2002	21.9	3.4	18.5	115.4	119.0	114.9	112.1
2002–2003	21.5	3.4	18.1	115.6	119.9	115.0	113.9
2003–2004	22.5	3.5	19.0	117.3	122.9	116.5	115.5
2004–2005	22.2	3.4	18.7	119.2	127.0	118.1	118.3
2005–2006	22.3	3.4	18.9	123.1	131.2	122.0	120.2
2006–2007	22.2	3.1	19.1	126.5	135.1	125.3	122.3
2007–2008	23.8	3.2	20.6	128.5	137.6	127.1	126.3

Sources: STAT Austria, Central Institute for Meteorology and Geodynamics Austria, author's own calculations. The number of ski resorts was 28. Data on the weighted real GDP per capita of the major visitor countries refers to the respective calendar year.

and 2005–2006, are associated with low temperatures and few days with clear skies.

When comparing time series data on overnight stays with snow depth data, one can see that domestic winter tourism is more sensitive to variations to snow depth as compared to foreign tourism. For example, during the snow-deficient winters 1989/1990 and 2006/2007, the number of domestic overnight stays (aggregated over the 28 ski resorts) in the winter months decreased by 7.9 and 8.1 %, respectively, compared to the previous season. However, for foreign overnight stays, one can observe a slight increase with 2.7 and 1.1 %, respectively (compare Tables 3 and 4).

Bivariate correlation of changes in the variables show that changes in temperatures and changes in snow depth are significantly and negatively correlated, indicating that warm winters are associated with lower levels of snowpack.[2] However, the magnitude of the correlation coefficient is quite moderate, and the size of variance inflation factors indicates that the problem of multicollinearity is not serious. Furthermore, it is not surprising that changes in cloud cover and changes in the share of days with clear skies are highly correlated, because both measures depend on each other per definition. Therefore, in the empirical part of the paper, we include either the share of days with clear skies or cloud cover rather than both variables simultaneously into the regression equation. Furthermore, the correlation coefficients show that the annual growth rates of overnight stays are significantly and positively related to annual percentage changes in snow

[2]The results of the correlations are available in a working paper version of this paper.

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Table 4. Descriptive statistics for weather indicators

Winter season	Average monthly snow depth	Cloudiness	Avg. days with clear skies	Average temperatures
	(cm)	index (1–10)	(%)	(°C)
1985–1986	n.a	n.a	n.a	n.a
1986–1987	74.0	n.a	n.a	n.a
1987–1988	72.3	5.0	5.2	−1.9
1988–1989	51.4	3.8	7.0	−1.0
1989–1990	39.9	3.5	13.0	−1.0
1990–1991	50.3	4.3	8.2	−2.7
1991–1992	80.2	4.2	9.8	−2.5
1992–1993	55.0	4.0	10.4	−1.9
1993–1994	55.4	5.4	3.9	−1.2
1994–1995	61.8	5.3	3.9	−1.2
1995–1996	43.5	4.6	5.8	−3.1
1996–1997	56.7	4.2	7.0	−1.3
1997–1998	38.1	4.6	7.2	−1.0
1998–1999	87.0	5.1	5.0	−3.0
1999–2000	84.9	5.0	5.0	−2.8
2000–2001	50.0	5.3	5.7	−0.8
2001–2002	48.3	4.5	5.2	−2.0
2002–2003	48.6	4.2	10.1	−2.0
2003–2004	67.1	5.0	6.3	−2.0
2004–2005	65.2	4.4	6.6	−3.4
2005–2006	85.6	4.8	5.3	−4.1
2006–2007	34.2	4.4	9.8	0.2
2007–2008	65.2	4.3	7.5	−1.9

Notes: Unweighted averages across the 19 weather stations observed. Cloudiness ranges between 1 and 10, where 1 denotes completely clear skies and 10 indicates 100 % overcast. Sources: STAT Austria, Central Institute for Meteorology and Geodynamics Austria, author's own calculations.

depth and cloud cover. There is a significant negative correlation between changes in sunshine (i.e. days with clear skies) and changes in overnight stays. Changes in average temperatures and the growth rate of overnight stays are negatively related but only significant at the 10 % level. By contrast, changes in GDP per capita and prices are not significantly related to overnight stays. However, evidence based on first-differenced data (i.e. growth rates) should be interpreted with caution because they neglect the long-run properties of the data. This will be addressed in the next section.

ESTIMATION RESULTS

Before we present the estimation results, we investigate the order of integration of the series. In the first step, we use panel unit root tests of the "first generation" introduced by Im *et al.* (2003), referred to hereafter as IPS, as well as that by Levin *et al.* (2002) and Breitung (2000). The results of the Breitung panel unit root test show that the null-hypothesis of a common unit-root cannot be rejected at the at 5% significance level for either the three dependent variables or the five independent variables.[3] The results of the Pesaran (2007) panel unit root test with cross-sectional dependence also show that real GDP per capita, the price index of accommodations and overnight stays are I(1) variables, whereas the weather variables are stationary, i.e. I(0) variables. Unreported results show that these variables are not integrated of order (2). Furthermore, the panel cointegration test introduced by Kao (1999) reveals that the three I(1) variables are cointegrated.

[3]The results of the panel unit root tests are available in a working paper version of this paper.

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Table 5. Pooled mean group estimations of the determinants of overnight stays

Dependent variables:	Δ ln overnight stays			Δ ln overnight stays of foreign visitors			Δ ln overnight stays of domestic residents		
Explanatory variables:	coef.		z	coef.		z	coef.		z
error correction term	−0.436	***	−8.87	−0.441	***	−8.76	−0.385	***	−7.10
Long-run coefficients:									
ln average maximum snow depth	0.072	***	4.07	0.043	*	1.91	0.132	***	6.01
ln cloudiness	0.246	***	4.67	0.273	***	4.19	0.434	***	7.54
average temperatures	0.037	***	6.10	0.037	***	4.70	0.025	***	3.32
ln weighted GDP per capita at 2000 ppp	1.646	***	12.35						
ln weighted foreign GDP per capita at 2000 ppp				2.253	***	10.86			
ln weighted domestic GDP per capita at 2000 ppp							0.192	*	1.65
ln price index accommodations	−0.912	***	−8.63	−1.139	***	−7.43	−0.653	***	−6.89
Short-run coefficients:									
Δ ln average maximum snow depth	0.004		0.73	0.004		0.45	0.007		0.64
Δ ln cloudiness	−0.071	**	−2.31	−0.092	***	−2.68	0.040		0.87
Δ average temperatures	−0.010	***	−6.63	−0.009	***	−5.87	−0.001		−0.20
Δ ln weighted GDP per capita at 2000 ppp	−1.346	***	−4.12						
Δ ln weighted foreign GDP per capita at 2000 ppp				−1.468	***	−3.91			
Δ ln weighted domestic GDP per capita at 2000 ppp							−1.953	***	−3.52
Δ ln price index accommodations	0.891	***	4.14	1.277	***	4.78	−1.079	**	−2.54
Δ ln overnight stays	−0.204	***	−4.67						
Δ ln foreign overnight stays				−0.217	***	−5.58			
Δ ln domestic overnight stays							−0.165	***	−3.63
Constant	3.721	***	8.20	2.799	***	7.89	4.664	***	6.77
Cox-Snell pseudo R^2	0.19			0.16			0.22		
Nagelkerkes Pseudo-R^2	0.20			0.17			0.24		

Notes: ***, **, and * denote significance at the 1, 5 and 10 % levels, respectively. This table represents Pooled Mean Group estimates for a panel of 28 ski resorts between the period 1987–1988 to 2007–2008.

The results of the pooled mean group estimations are presented in Tables 5 and 6.[4] The difference between Tables 5 and 6 is that the latter includes the share of days with clear skies instead of cloud cover. In addition, each table contains estimates of the determinants of total overnight stays, foreign overnight stays, and domestic overnight stays. We report the maximum likelihood pseudo R^2 for each model as an indicator of the model fit. We provide both the Nagelkerke pseudo-R^2 and Cox-Snell pseudo-R^2. The pseudo R^2 for the different specifications is around 0.2. Note that Nagelkerke pseudo R^2 ranging between 0.2 and 0.4 is considered satisfactory. The error-correction term is negative and strongly significant as expected, supporting a cointegration relationship among the level variables.

The dynamic panel data estimations show that winter tourism demand is significantly and positively related to snow depth and cloud cover in the long run (see Table 5). The long-run coefficient of 0.072 indicates that the number of overnight stays increases by 0.7 % when snow depth increases by 10 % (from 58 cm to 64 cm, based on sample averages). The short-run coefficient of snow depth is not significant and indicates that a snowy winter does not increase the number of overnight stays in the current year. Separate estimates of domestic and foreign nights spent show that domestic

[4]The results of the MG and DFE estimators are available upon request.

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Table 6. Panel error-correction estimates of the determinants of number of overnight stays (alternative specification)

Dependent variables:	Δ ln overnight stays			Δ ln overnight stays of foreign visitors			Δ ln overnight stays of domestic residents		
	coef.		z	coef.		z	coef.		z
error-correction term	−0.442	***	−8.54	−0.449	***	−8.41	−0.395	***	−6.61
Long-run coefficients:									
ln average maximum snow depth	0.085	***	4.79	0.077	***	3.43	0.125	***	6.97
ln proportion of days with clear skies	−0.047	***	−3.40	−0.036	*	−1.78	−0.075	***	−7.75
average temperatures	0.037	***	6.39	0.041	***	5.25	0.025	***	3.80
ln weighted GDP per c. at 2000 ppp	1.546	***	12.02						
ln weighted foreign GDP per c. at 2000 ppp				1.904	***	8.61			
ln weighted domestic GDP per c. at 2000 ppp							0.276	**	2.56
ln price index accommodations	−0.819	***	−8.07	−0.910	***	−5.65	−0.748	***	−9.61
Short-run coefficients:									
Δ ln average maximum snow depth	−0.001		−0.08	−0.006		−0.69	0.003		0.24
Δ ln proportion of days with clear skies	0.005		0.58	0.007		0.55	−0.031		−1.34
Δ average temperatures	−0.010	***	−7.13	−0.011	***	−5.95	0.002		0.30
Δ ln weighted GDP per capita at 2000 ppp	−1.348	***	−4.56						−3.62
Δ ln weighted foreign GDP per capita at 2000 ppp				−1.466	***	−4.23			
Δ ln weighted domestic GDP per capita at 2000 ppp							−2.007	***	
Δ ln price index accommodations	0.833	***	3.87	1.104	***	3.86	−1.281	***	−2.99
Δ ln overnight stays	−0.155	***	−3.53						
Δ ln foreign overnight stays				−0.171	***	−4.44			
Δ ln domestic overnight stays							−0.126	***	−3.02
Constant	3.995	***	7.89	3.321	***	7.72	5.063	***	6.39
Cox-Snell pseudo R^2	0.24			0.21			0.22		
Nagelkerkes Pseudo-R^2	0.25			0.22			0.24		

Notes: ***, **, and * denote significance at the 1, 5, and 10 % levels, respectively. This table represents Pooled Mean Group estimates for a panel of 28 ski resorts between the period 1987–1988 to 2007–2008.

visitors are more responsive to changes in snow depth than foreign visitors, with long-run elasticities of 0.132 and 0.043, respectively. Note that the latter snow depth coefficient is only significant at the 10 % level. Töglhofer *et al*. (2011) also found a very small effect of the average snow depth on overnight stays based on 185 ski resorts for the winter seasons 1972–1973 to 2006–2007.

The results on the relationship between snow and tourism demand are difficult to compare with other previous studies for several reasons. For instance, using monthly or daily data, it is difficult to control for income and price effects, and this leads to an omitted variable bias. Shih *et al*. (2009) found a strong correlation between snow depth and lift ticket sales with an increase in lift tickets sales between 7 and 9 % due to an increase in snow depth of 2.54cm (=one inch) based on daily data for two ski resorts in Michigan.

Winter tourism demand depends partly on snow, but other weather conditions are also significant. Cloudiness has a positive impact with a coefficient of 0.246 and a z-value of 4.67 (Table 5). We find a similar effect when cloud cover is measured as the proportion of days with clear skies. The coefficient is −0.047 with a z-value of 3.40 (Table 6). This clearly shows that the average days with clear skies has a negative impact on tourism demand, but the magnitude of the effect is quite small: A 10 % increase in the share of days with clear skies leads to a decrease of 0.5 % in the number of

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overnight stays. The relationship between temperatures and winter tourism demand is not clear cut. Average temperatures have a significant and positive impact on tourism demand in the long run, but a significant and negative impact in the short run. This indicates that cold winters lead to an increase in overnight stays in the current year but not in the following year. However, again, the size of the effect is very small. The positive long-run effect of average temperatures on winter tourism demand is somewhat surprising, since one would expect *a priori* that an increase in temperatures reduce winter tourism demand. Töglhofer *et al.* (2011) also found that the impact of temperatures on overnight stays is not clear cut based on very similar data. One explanation would be that higher frequency data are needed to disentangle the underlying relationship. In fact, Shih *et al.* (2009) and Hamilton *et al.* (2007) found a negative relationship between local temperatures and current skier activity based on daily and monthly data, respectively.

The estimated elasticity of GDP per capita with respect to overnight stays is 1.65, suggesting that a 1 % increase in GDP per capita results in a 1.65 % increase in the number of overnight stays (Table 5). For domestic tourism, we find a low-income elasticity of 0.19, indicating that domestic winter tourism only marginally increases when there is an improvement of general economic conditions in the home country. By contrast, the corresponding output effect is much larger for international overnight stays, with an elasticity of 2.25 as compared to that of domestic foreign overnight stays with 0.19 (Table 5). This indicates that international tourism demand is highly elastic with respect to income, whereas domestic tourism demand is inelastic. This reflects the fact that foreign visitors regard winter tourism as a luxury good rather than a necessity good. Overall, this is consistent with Garín-Muñoz (2009) who found that income elasticities are larger for international visitors than for domestic visitors based on data for Spanish province of Galicia. The low-income elasticities for domestic tourism might be one reason for the stagnant domestic demand for winter tourism in Austria in the last 20 years. Furthermore, the price elasticity of foreign tourists is higher in absolute terms, as they are more sensitive to changes in the cost of accommodations than are domestic tourists.

To give further insights into the magnitude of the effects, we calculate the effects of a one standard deviation increase in the explanatory variable. This is a common way to estimate the magnitude of relationships when the variables are scaled differently. The magnitude of the estimated coefficients suggests that an increase of one standard deviation (measured as one standard deviation over time) in snow depth (equal to a increase of 21 cm or 36 %, given a mean value of 58 cm) is associated with an increase in overnight stays of about 3 %. This is largely consistent with the study of Töglhofer *et al.* (2011), who found that overnight stays increase between 1.4 and 1.6 per for a one standard deviation increase mean snow depth. Furthermore, we find that the corresponding increases in domestic and foreign overnight stays due to a one standard deviation increase in average snow depth are 5 and 2 %, respectively. Similarly, an increase of one standard deviation in cloudiness increases the number of total overnight stays by 2 percent (1 percent for foreign overnight stays and 3 percent for domestic overnight stays). An increase of one standard deviation in the percentage of days with clear skies leads to a 4 % decrease in the number of overnight stays of foreign tourists, and 6 % for domestic tourists. For total and foreign tourism demand, we find that the income effect is much larger than the impact of the different weather variables. An increase of one standard deviation in the GDP per capita of the visitors' countries (equivalent to 14 %) leads to an average increase in total overnight stays of 23 %, and 31 % for foreign overnight stays. By contrast, an increase of one standard deviation in domestic GDP per capita raises the number of domestic overnight stays by only 3 %. Overall, this indicates that weather conditions play a larger role for domestic tourism than income, but that economic factors are more important for foreign tourists.

To sum up, we find that the impact of long term weather conditions on winter tourism demand is very small. This is consistent with Töglhofer *et al.* (2011). The high sensitivity of domestic winter tourists to snow conditions is consistent with Unbehaun *et al.* (2008), who find that natural snow cover is the most

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important motivation of destination choice based on a survey of 540 Viennese skiers. In particular, the authors find that natural snow cover is much more important in determining destination choice than the size of the ski area, waiting time at lifts, or quality of accommodation and the amount of technical snow. Another possible explanation of the higher sensitivity of domestic winter tourists to natural snow is that they probably consist of a higher share of advanced skiers/snowboarders or ski tourists and off-piste skiers for which snow conditions are a more important factor. However, it is not possible to compare domestic and foreign tourists, since the survey does not include the latter. Based on a survey of 241 domestic and foreign tourists in the resort Eilat/Israel, Mansfeld, Freundlich and Kutiel (2007) also find that domestic tourists are more sensitive to weather conditions than foreign tourists.

Given the results based on historical data, it is natural to ask what is the impact of future climate conditions on winter tourism. Based on data for the winter seasons 1986–1987 to 2007–2008, we find that the number of nights spent are sensitive to snow depth and cloud cover. One can use the results of the model to predict the impact of future climate change scenarios on the number of overnight stays. Predicting future visitor nights spent requires the prediction of future snow accumulation. Climate change scenarios include estimates of possible temperature and precipitation change rather than precise estimates of future snow accumulation and sunshine or cloud cover. The OECD study reveals that global warming and its associated climate change are likely to bring substantially higher temperatures, shorter snow covered periods, and more precipitation during winter in Alpine regions (OECD 2007). It is expected that there will be a reduction of snowfall as temperatures rise. In the European Alps, the reduction in snowfall may be as high as 30 % by 2020 (Agnew and Viner, 2001).

Since the relationship between temperatures and winter tourism demand is not clear cut, we use snow depth for the predictions. The question we want to address is that what would happen if extreme weather events, such as the exceptionally warm winter 2006/2007, occur more often? Winter 2006/2007 was associated with a reduction of average natural snow depth of about 25 cm across the estimation sample (unweighted average) compared to the total sample. The calculations show that a reduction of average natural snow depth for a given future winter period of about 25cm will lead to a reduction of the number of overnight stays of 3 %, given the long-run elasticity of winter tourism demand of 0.072. The corresponding effects for domestic and foreign tourists are 5 and 2 % respectively. This, again, indicates that the impact of possible future occurrence of extremely snow-deficient winters on overnight stays will be quite small. This is consistent with Hamilton *et al*. (2005) who suggested that changes in tourism demand induced by climate change are much smaller than those of economic growth and population change. However, one should take into consideration that hotels and other accommodation facilities also accommodate non-skiers, so that the impact of snow deficient winters is expected to be larger on skier visits and lift ticket sales.

We conduct several robustness checks, initially applying quadratic temperature and snowpack functions. Gössling and Hall (2006) point out that the assumption of a linear relationship is not appropriate in assessing the influence of weather conditions and/or climate change on travel flows. This might hold particularly true at very high levels of snow and/or low temperatures. The hypothesis is that good snow conditions and low temperatures stimulate tourism demand up to a certain threshold, beyond which it will remain constant or even decrease. However, unreported results indicate that the squared term of temperatures does show the expected negative sign and is not significantly different from zero. This also holds true for the squared term of snow depth. We also experiment with various interaction terms, including, for instance, an interaction effect between temperatures and cloud cover or the share of days with clear skies. The underlying hypothesis is that the effect of sunshine is positive at lower temperatures and negative at higher temperatures. However, the interaction term is not significant in most of the cases.

Another point refers to the timing of snow. It is important to have snow early in the winter season. However, using maximum snow depth for December leads to almost similar results. Furthermore, winter tourism shows a strong seasonal pattern, resulting in a concentration of

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demand not only during Christmas and New Year's holidays but also during Carnival and Easter holidays. Early Easter holidays are usually associated with an increase in nights spent in a given winter season. Therefore, we include a dummy variable that equals one if Easter is early in the year and zero otherwise. However, the early Easter dummy variable is never significant and is therefore left out in the final regressions. Another point is that the impact of weather on winter tourism demand differs in ski areas with slopes above 2000 meters. It is likely that high altitude resorts benefit from poor snow conditions because skiers and snowboarders switch from ski areas at low and medium altitudes to high altitude ski areas. Unreported results show that domestic skiers are again more sensitive to snow, and other weather conditions when high altitude ski resorts are excluded from the estimation sample.

Another factor is cross-sectional dependence. The corresponding tests that are developed by Pesaran (2007) reject the null hypothesis of cross-sectional independence at the 5 % level. To account for cross-sectional dependence, we subtract the average value of the series over time from each ski resort. The correlated mean group estimator is then obtained by averaging the coefficients of these regressions. Unreported results show that snow depth, cloudiness, and the number of days with clear skies are again significant.

Finally, we test whether local tourism demand depends not only on local snow depth but also on snow depth in large metropolitan areas that are located close to the ski areas (see also Hamilton *et al.*, 2007). However, the coefficients of average snow depth for Munich and Vienna, representing the largest metropolitan areas in the region, are never significant at conventional levels in the demand equation for foreign and domestic overnight stays. Note that snow conditions at the home town are likely to be more relevant for day trippers than for overnight guests.

DISCUSSION AND IMPLICATIONS

The results provide useful guidance for ski lift companies and policymakers who have little knowledge about the relation between weather and domestic and international tourism. These implications should also be applicable to many other mountain regions in the European Alps. The results can be used to set goals for future tourism demand and then disaggregated by domestic and foreign visitors. For inbound tourism, we find that the GDP per capita in the countries of origin are the most important factor in determining tourism demand. Therefore, future demand will be largely determined by the expected economic growth of the countries that are home to the majority of visitors.

Another important aspect often mentioned in the literature is that winter sport activities, such as downhill skiing, have reached the end of their life cycle (Weiermair and Fuchs, 1999; Tuppen, 2000; Hudson, 2003). This means that many ski resorts are in the stage of consolidation, or perhaps even in the stagnation phase, despite the increase in the popularity of snowboarding since the 1990s. The findings show that domestic winter tourism is stagnating. Therefore, ski resorts with a high share of domestic tourists are particularly vulnerable. Buhalis (2000) suggests that different stages of the destination life cycle require different marketing strategies. Ski resorts with a share of domestic tourists must seek new markets, and there is a need for a better understanding of the behavior of domestic and foreign winter tourists.

The results of this study can also be taken into consideration in new marketing campaigns or existing marketing strategy reviews. The empirical findings clearly show that the determinants differ between domestic and international tourists. Income and prices are more relevant for foreign tourists, whereas weather conditions are more important for domestic tourists. In particular, inbound winter tourism is characterised by high-income elasticity, indicating that it is regarded as a luxury good. As foreign tourists will gain a higher market share, tourism authorities and marketers need long-term strategies. Long-term marketing campaigns aimed at addressing international tourists should account for the fact that there is a high proportion of non-skiers/non-boarders visiting ski resorts (Hudson, 2003). Therefore, it is important to emphasize non-winter sport-related activities. Given that foreign tourists are less sensitive to weather conditions, one can conclude that foreign tourists are not solely interested in snow-based activities but are also in travelling

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to experience the charm of traditional villages, traditional Alpine atmosphere, mountain scenery, high-quality hotels, restaurants and bars and nightlife. Overall, marketing campaigns should target foreign skiers and non-skiers in a different ways.

Overall, this suggests that future tourism marketing strategies should be different for domestic and international visitors. From a marketing perspective, it is important for businesses and tourism bureaus to increasingly focus on international tourists rather than on domestic tourists. This can be justified by the low-income elasticity of domestic demand, indicating that the domestic market is saturated. For the domestic market, short-term and low-cost marketing strategies are most appropriate. Given the higher weather sensitivity of domestic winter tourism, ski lift companies in typically snow-rich regions and/or at higher altitudes should emphasize general climate conditions, such as average natural snow depth in order to attract more domestic tourists. Climate information is important, since it is often needed in advance of the trip (Scott and Lemieux, 2010). This material can be presented not only on tourism brochures and advertising material but also on the company's website. Websites already provide a lot of relevant information to winter sport tourists, such as ski trail maps, real-time information about the share of open runs, and links to webcams showing current conditions, weather data and weather forecasts (Buhalis, 2000; Scott and Lemieux, 2010). A review of the relevant ski resorts show that the key facts, such as the altitude of slopes (e.g. share of runs over 2000 metres), current weather and weather forecasts is already available to many but not to all, providers. It is important that ski lift companies not only provide links to actual weather conditions and forecasts but also up-to-date information on snow cover and snow quality. Finally, since domestic tourism is not very price sensitive, discounts may be not effective to attract more domestic visitors during the winter period. Another strategy to attract more domestic winter sport tourists is to extend the ski area. Won *et al*. (2008) suggest that ski lift companies planning to attract more advanced skiers, which are likely more abundant among domestic skiers, should provide a variety of new and challenging slopes. However, extensions of ski areas are problematic because of environmental concerns.

A full understanding of the different behavior of domestic and foreign winter tourists requires an investigation of the different dimensions of tourist satisfaction (e.g. for a recent contribution, see Matzler *et al*., 2008). Ideally, this analysis should take into account that the dimensions of tourist satisfaction differ by nationalities and/or by characteristics of the winter tourists (e.g. non-skiers/snowboarders, intermediate and advanced skiers/snowboarders and young and older people).

Note that snow conditions at the home town are likely to be more relevant for day trippers than for overnight guests.

CONCLUSION

Climate change is seen as a major threat to the winter tourism sector. As previously mentioned, several studies document a warming trend with less natural snow, more sunshine and less cloud cover in the European Alps over the last 50 years. Therefore, it is important to study the historical relationship between weather variables and winter tourism demand. In this paper, we have investigated the impact of weather elements on winter tourism demand by distinguishing between the number of nights spent by domestic residents and visitors from abroad. The distinction between domestic and foreign visitors is important because the two groups are likely to differ in their travel behavior due to climate variability.

Using a dynamic panel data approach based on 28 Austrian ski resorts for the winter seasons from 1986–1987 to 2007–2008, we find that winter tourism demand is significantly related to weather conditions, such as the amount of natural snow, sunshine and cloudiness. The key result is that the overnight stays of domestic visitors in the winter months are more sensitive to changing weather conditions (e.g. natural snow depth, sunshine and cloudiness) than those of foreign visitors. The opposite holds for the impact of prices and income. Specifically, foreign tourism has an income elasticity greater than one, whereas the income elasticity of domestic tourism is much lower than one. According to the results, a 10 % decrease in snow depth reduces the number of foreign overnight stays

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by 0.7 percent and that of domestic overnight stays by 1.3 percent. Sunshine, measured as the share of days with clear skies, has a negative impact on tourism demand with larger effects on visitor nights of domestic residents than those of foreign visitors. Similarly, cloud cover has a positive effect with more cloud cover leading to an increase in domestic tourism and to lesser extent of foreign tourism.

Overall, the magnitude of the relationship between the weather variables and tourism demand is quite small. One explanation is the huge investment resorts have made in snowmaking equipment in the last 20 years. In fact, published data show that 27 out of 28 ski areas included in the sample have snowmaking systems, with snowmaking covering about 55 % of skiable terrain on the average for the year 2005. An alternative, but less convincing, explanation is related to the measure of tourism demand used in the study. Although overnight stays are widely used, skier visits or lift ticket sales might be more suitable to ascertain the direct short-run and long-run impact of weather on skiing demand. The reason is that the output of ski lift companies is much more responsive than the number of overnight stays to variations in snow depth. However, own calculations based on a sample of ski resorts for which company reports are available show that overnight stays during the winter months are a good proxy for lift ticket sales, at least in ski resorts with a low share of day trippers.

Given the results in the relationship between long-term weather and tourism demand, it is natural to ask what the implications of future climate change for winter tourism are. Climate change is expected to bring substantially higher temperatures, which is even higher in the European Alps, relative to the global average. In addition, there is a trend decline in the amount of snow and duration of snow and number of days with snowfall, which is likely to continue in the future. It is obvious from the results that in winters with less snow, there will be a decrease in overnight stays on the average. Similarly, an increase in sunshine (or a corresponding decrease in cloudiness) will lead to a decrease in winter tourism demand. However, the magnitude of the effects will be very small. Even increased occurrences of extreme weather events such as the mild winter 2006/2007 in the European Alps will lead to very small decreases in tourism demand.

The modeling approach used in the study could be applied, not only to other destinations, but also to a wide range of other contexts. For example, the impact of weather on summer tourism in mountain regions is an important area of research, which is left for future investigations. Higher temperatures and more sunshine make mountain resorts more attractive for international and domestic visitors. In particular, hiking, walking and other mountain-related sport activities will benefit from global warming and more sunshine. Mountain regions could also benefit because warm places in Southern Europe has become too hot. Overall, it is expected that good summer weather leads to an increase in domestic and inbound tourist activity. An interesting question is whether the impact of higher temperatures is similar for international and domestic tourists. Another interesting area of future work is to quantify the pattern of tourism demand by nationality rather than between domestic and international tourists. Cortés-Jiménez and Blake (2011) find that income elasticities vary substantially by nationality. In principle, the data allow the further division of overnight stays and arrivals by nationality.

Furthermore, the availability of monthly overnight stays from 2000 onward for all Austrian resorts allows for a study of the dynamic adjustment of tourism demand to weather in much more detail. Higher frequency data allows the investigation of the effects of intraseasonal closures in snow-deficient winters on overnight stays. Finally, we believe that for the most important ski markets in the world, there are still few studies investigating the relationship between long-term weather patterns and winter tourism demand. For example, there is no empirical evidence on the relationship between output and long term weather for France, Italy, Switzerland and the USA. One can use skier visits or ski lift ticket sales and/or turnover of ski lift operators, and the latter of which is often available in the annual accounts and/or the business review. However, such an analysis would exclude small lift companies, because they do not have to provide a detailed annual account.

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