Chapter 19
Tourism

Judith Köberl, Franz Prettenthaler, Stefan Nabernegg, and Thomas Schinko

Abstract Tourism ranks amongst those sectors regarded as being highly weather and climate sensitive, since lots of tourism types and activities have a strong link to the environment and to the climate itself. During snow-poor winters, such as 1989/90 and 2006/07, several Austrian regions showed noticeable drops in tourism demand—whereas extraordinary sunny, warm and dry summers, like the one in 2003, coincided with above-average tourism demand increases in lake regions. In order to assess the potential impacts of future climate change on tourism demand in Austria, we (1) use dynamic multiple regression models to quantify the sensitivity of overnight stays towards year-to-year weather for each NUTS 3 region and various seasons, (2) apply the resulting sensitivities on climate change scenarios—based on a general tourism development scenario—and (3) transform the resulting impacts on overnight stays into monetary terms using average tourist expenditures. Outcomes suggest predominantly negative impacts on winter tourism and mainly positive impacts on summer tourism, with the net impact being negative. Finally we (4) evaluate the effects of the negative tourism impacts in a macroeconomic CGE model. Resulting spillover effects to other economic sectors as well as changes in GDP and welfare are found to be even higher than the impacts on tourism. There are considerable uncertainties however, not only with respect to climate change scenarios, but also for instance regarding future tourist preferences and weather/climate sensitivities.

J. Köberl (✉) • F. Prettenthaler
Institute for Economic and Innovation Research, Joanneum Research, Graz, Austria
e-mail: judith.koberl@joanneum.at; franz.prettenthaler@joanneum.at

S. Nabernegg • T. Schinko
Wegener Center for Climate and Global Change, University of Graz, Graz, Austria
e-mail: stefan.nabernegg@uni-graz.at; thomas.schinko@uni-graz.at

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19.1 Introduction

Tourism represents a highly important economic sector in many parts of the world, generating income and employment and representing one of the fastest growing economic sectors globally. In 2012, worldwide tourism directly contributed 2.9 % to global GDP. Taking indirect and induced effects into account as well, the sector's contribution comprised 9.3 % of global GDP (WTTC 2013).

Tourism also plays an important role in the Austrian economy. In 2012 it generated 17.94 billion euros in direct value added and hence contributed 5.8 % to Austria's GDP. Taking indirect effects into account as well, the sector's contribution amounted to 22.82 billion euros or 7.4 % of total value added (Statistics Austria and WIFO 2014).

19.2 Dimensions of Sensitivity to Climate Change

The tourism industry ranks among those sectors that are regarded as being highly weather and climate sensitive, since lots of tourism types and activities—e.g. ski tourism, beach and lake tourism, or hiking tourism—have a strong link to the environment and to the climate itself (UNWTO-UNEP-WMO 2008). On the supply side, climate co-determines a region's basic suitability for offering particular tourism types or activities. On the demand side, weather (forecasts) and climate may influence a tourist's decision-making process about destination choice and when to travel. Thus, climate represents a principal driver of seasonality in tourism demand (Cooper et al. 2008). Moreover, the actual weather experienced during holidays may affect tourists' satisfaction and enjoyment and—given sufficient flexibility—even cause them to extent, shorten or cancel their vacation. Besides supply and demand, weather and climate also affect important aspects of tourism operations, including operating costs (heating, cooling, artificial snow production, irrigation, etc.), activity planning and infrastructure (Scott and Lemieux 2010). Due to the importance of weather and climate for tourism supply, demand and operations, changes in climate may directly affect tourism in various ways. Additionally, climate change may also affect tourism indirectly through impacts on environmental resources that represent important factors for tourism, such as biodiversity, landscape aesthetics or water quality and availability (UNWTO-UNEP-WMO 2008).

19.2.1 Climatic Factors

Various climatic factors are relevant for the economic performance of the tourism industry, since different tourism types require or benefit from distinct weather and climatic conditions. Snow-based tourism types, for instance, require at least sufficiently cold temperatures (for artificial snow production) or better yet, sufficiently cold temperatures together with precipitation. Hence, insufficient snow conditions may lead to noticeable demand reductions in snow-based tourism and economic losses (Hamilton et al. 2007; Dawson et al. 2009; Töglhofer et al. 2011; Steiger 2011). Cloudiness and wind speed can also affect winter tourism demand (Falk 2013; Shih et al. 2009). Moreover, inadequate amounts of natural snow and/or higher temperatures may increase the need and costs of artificial snowmaking. Beach or lake tourism, on the other hand, requires sufficiently high temperatures together with dry conditions. Additionally, it generally benefits from sunshine and the absence of strong wind. Thus, losses to this tourism type may arise from cold, cloudy and rainy weather (Castellani et al. 2010; Moreno 2010), but also from temperatures regarded as being too hot (Rutty and Scott 2010). For hiking and nature-based tourism, precipitation seems to be the dominating climatic factor (Scott et al. 2007), whereas urban tourism might be negatively affected by high temperatures (UNWTO-UNEP-WMO 2008).

19.2.2 Non-climatic Factors

Tourism is a strongly demand-driven sector. Hence, the economic consequences of climate change for particular tourism regions will not only depend on the intensity of climate change itself, but also on non-climatic factors influencing tourists' decision making processes on when and where to go, such as the ability (and willingness) of tourists to adjust their travel date (EEA 2012). Assume that a region dominated by alpine winter sports tourism faces a temporal shift in cold temperatures and snowfall away from current peak to off-peak seasons. If tourists are able and willing to adjust their travel date while deciding on the same destination, the region might not face significant economic losses. If on the other hand, tourists are not able (e.g. due to holiday regulations) or willing to adjust their travel date, but rather choose another destination, the region may suffer from considerable losses. Further non-climatic factors include tourists' preferences and sensitivities towards weather and climate. These may change over time due to changes, for example, in demography [preferences towards weather and climate vary with age; see Lise and Tol (2002)] or preferred tourism activities (different tourism activities show distinct weather and climate sensitivities).

19.2.3 Identification of Potential Large-Damage Combinations

Potential large-damage combinations include temporal shifts of “favorable” climatic conditions from current peak to off-peak seasons together with tourists’ inflexibility or unwillingness to adjust their travel date. A change in tourists’ preferences resulting in remarkably higher weather sensitivities together with a pronounced change to more “adverse” climatic conditions represents another combination potentially leading to large economic damages. Summarizing, a crucial factor in determining if climate change will cause large damages to particular tourism regions is the way tourists will (be able to) adapt to these changes.

19.3 Exposure to Climatic Stimuli and Impacts Up to Now

19.3.1 Past and Current Climatic Exposure and Physical Impacts

Variations in climatic factors may affect the performance of the tourism sector. What follows are some examples for past impacts on tourism demand due to variations in climatic conditions. For past trends in climatic conditions see the online Supplementary Material.

19.3.1.1 Winter Season

Particularly snow-poor winters within recent decades, including the 1989/1990 and 2006/2007 seasons, had noticeable impacts on Austrian winter tourism demand. According to Töglhofer et al. (2011), the growth rate of overnight stays in Austrian ski areas dropped by 8.1 % points in the warm and snow-poor 1989/1990 winter season, when the number of snow days[1] was 22 % below long-term average. In the 2006/2007 winter season, a reduction in the number of snow days by 29 % compared to average conditions was accompanied by a 2.7 % point decrease in the growth rate of overnight stays. Each time, decreases in the growth rates of overnight stays were more pronounced in lower-lying areas whereas no noticeable changes were observed for higher-lying areas. Similar effects were found by Steiger (2011), who investigated Tyrolean overnight stays in the record warm and snow-scarce 2006/2007 winter season. Due to a decrease in overnight stays by 3 % relative to the preceding 3 years he estimated the economic losses of this snow-scarce season to amount to 104 million euros. The highest losses were experienced by districts with mainly low-altitude or higher located but small ski areas, whereas

[1] Days with at least 1 cm snow depth.

districts with large to extra-large ski areas at mid to high altitudes showed constant or even increasing overnight stays. Gains were also observed in the provincial capital, Innsbruck, which has the most developed offerings of non-skiing products like culture and congress tourism within Tyrol.

19.3.1.2 Summer Season

In 2003, tourism in Austria was exposed to the hottest summer since the beginning of regular recordings. Comparing summer overnight stays in 2003 to average summer overnight stays in 2002 and 2004, Fleischhacker and Formayer (2007) found a nationwide increase of 1.8 %, with the rise in domestic overnight stays (2.7 %) being almost twice as high as the rise in foreign overnight stays (1.4 %). Single tourism types were seemingly able to benefit over-proportionally from this extraordinary summer, including lake tourism (+4.4 %) and tourism in nature reserves (+2.4 %). In contrast, health and wellness tourism (−0.2 %) as well as urban tourism (−0.6 %) experienced losses compared to the average figures of 2002 and 2004.

19.3.2 Impact Chains up to Socioeconomic System

Several impact chains of climate change on tourism have been identified and are listed in Table 19.1, which makes no claims of being complete. Due to limited resources and/or (too) high assessment uncertainties, some of the presented impact chains could not be quantified within the current project.

Regarding winter tourism, a change in (natural) snow conditions may change tourism demand in regions offering snow-based tourism types. Consequently, the tourism sector's demand in products and services of upstream industries (e.g. energy sector, food sector, construction sector, etc.) would change as well. A similar impact chain, albeit triggered by different climatic factors, holds for summer tourism. Changes in precipitation and/or temperature conditions may change tourism demand in regions focused, for example, on hiking, mountain biking or lake tourism. Demand in urban tourism might also be affected by changing temperatures (e.g. by an increase in hot temperatures). The impact chains mentioned may not only be directly triggered by changes in climatic factors, but also indirectly by climate caused changes in environmental resources important for tourism. Besides, changes in temperature and precipitation conditions may affect the tourism sector's water and energy demands by altering its need for irrigation (e.g. golf courses, hotel facilities, etc.), heating and cooling or artificial snowmaking, thus modifying the sector's cost structure. Moreover, changes in the frequency and intensity of extreme events, including floods and mass movements, are likely to change the frequency and intensity of destroyed tourism facilities and/or transport infrastructure leading to business interruptions.

Table 19.1 Tourism related impact chains

Climate change parameter	Impact chain	Quantified in the model
(Natural) snow: Change in ski area's (mean) snow conditions	*Change in winter tourism demand* → Change in winter overnight stays [change in final demand] → change in tourism sector's upstream demand (e.g. energy, food, construction, etc.)	Yes
Precipitation: Change in (mean) precipitation conditions	*Change in summer tourism demand* → Change in summer overnight stays [change in final demand] → change in tourism sector's upstream demand	Yes
	Change in tourism sector's water demand → Change in irrigation needs [change in cost structure] → change in tourism sector's water demand	No
Temperature: Change in (mean) temperature conditions	*Change in summer tourism demand* → Change in summer overnight stays [change in final demand] → change in tourism sector's upstream demand	Yes
	Change in environmental resources important for tourism (demand) → Change in e.g. biodiversity, landscape aesthetics (such as glaciers), water quality, water availability, etc. → change in tourism demand [change in final demand] → change in tourism sector's upstream demand	No
	Change in tourism sector's water and/or energy demand → Change in e.g. irrigation, heating & cooling, or artificial snowmaking needs [change in cost structure] → change in tourism sector's water and/or energy demand	No
Extreme events: Change in frequency/intensity of e.g. floods, mass movements, etc.	*Business interruption* → Change in frequency/intensity of destroyed tourism facilities and/or transport infrastructure → change in frequency/intensity of business interruption → change in tourism demand [change in final demand] → change in tourism sector's upstream demand	No

19.3.3 Economic Impacts Up to Now

Some examples of past physical and/or economic impacts on tourism due to year-to-year variations in weather conditions have been quoted in Sect. 19.3.1. Averaged over a longer period of time however, e.g. 30 years, gains and losses due to climate variability are likely to compensate each other to a high degree—at least in the absence of very extreme events. Hence, in the analyses that follow we focus on impacts caused by a change in average climatic conditions rather than by a change in climate variability. We therefore refrain from providing comprehensive estimates on average annual tourism gains and losses due to climate variability in the base period 1981–2010.

19.4 Future Exposure to and Impacts of Climate Change

19.4.1 Mid-range Climatic Scenario for Tourism

For our analyses on climate change impacts and costs of inaction, we draw on the COIN climate change data (COIN CCD), which projects an increase in mean annual temperatures of +1.05 °C (+2.02 °C), a change in annual precipitation sums of +1.4 % (−2.3 %) and a change in wet days[2] of +2.1 % (−3.5 %) between the base period 1981–2010 and the first (second) scenario period 2016–2045 (2036–2065). Regarding precipitation sum and wet days, COIN CCD indicates an increasing trend for the winter half-year and a decreasing trend for the summer half-year. Whereas in the first scenario period precipitation gains during the winter half-year dominate annual net effects, in the second scenario period the expected decline in summer precipitation becomes the dominating effect.

Regarding snow data, COIN CCD differentiates between four different elevations: 500, 1,000, 1,500, and 2,000 m. Depending on the elevation class considered, mean annual snow depth is projected to change by +1 to −21 % (−13 to −37 %) between base and first (second) scenario period, whereas the annual number of snow days is expected to change by −12 to −18 (−21 to −35) days. Within the following analyses, we consider snow conditions in ski areas and their impacts on winter overnight stays at NUTS 3 level. Figure 19.1 shows the change in the annual number of snow days on NUTS 3 level for the altitude class representative of the ski areas within the considered region.[3] For further details see Supplementary Material.

[2] Days with at least 1 mm precipitation.

[3] To decide on which altitude class (500, 1,000, 1,500 and 2,000 m) is representative for the ski areas within a NUTS 3 region, we form a transport capacity weighted (TCW) average over the mean altitudes of all ski areas within a NUTS 3 region that have more than five transport facilities or at least one cable car (Töglhofer 2011). TCW mean altitudes up to 749 m are allocated to elevation class 500, TCW mean altitudes between 750 m and 1,249 m to elevation class 1,000, etc.

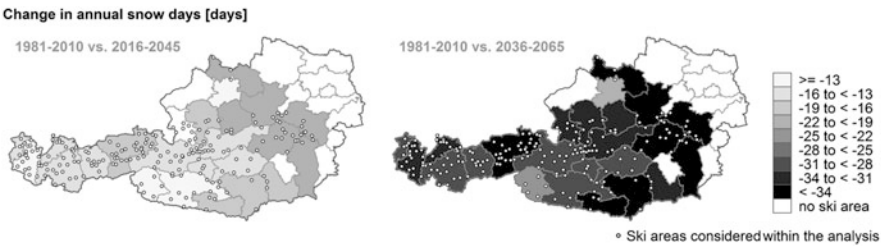

Fig. 19.1 Change in snow conditions as projected by COIN CCD at the altitude class representative of the regions' ski areas

19.4.2 High and Low Range Climatic Scenarios for Tourism

To represent (at least part of) the uncertainty range related to climatic scenarios, we additionally consider climate change data resulting from four different regional climate models of the ENSEMBLES family (http://www.ensembles-eu.org) (CNRM-RM4.5, ETHZ-CLM, ICTP-REGCM3, and SMHI-RCA), which are all based on the A1B emission scenario. Data from these four models have been edited within the ACRP-funded project "Adaptation to Climate Change in Austria" (ADAPT.AT) for the period 1951–2050 and have already been used for Austrian climate change impact assessments in Köberl et al. (2011). Due to the limited time span of edited data available, low and high-range climatic scenarios can only be derived for the first scenario period, i.e. 2016–2045. They are defined in such a way that the low-range scenario tends to cause the lowest negative (or highest positive) net impacts, whereas the high-range scenario is associated with the highest negative (or smallest positive) net impacts. Hence compared to the mid-range climatic scenario the low-range scenario represents warmer and dryer summers as well as snowier winters, whereas the high-range scenario is defined to represent colder and wetter summers as well as snow-poorer winters.

19.4.3 Specific Method(s) of Valuation and Their Implementation Steps

Various studies deal with the impacts of climate change on tourism in Austria (e.g. Breiling and Charamza 1999; Rudel et al. 2007; Steiger and Abegg 2013). Many of them focus on the supply side by examining the change in the climatic potential for particular tourism types, but do not explicitly take the relationship between weather/climatic conditions and tourism demand into account. However, since tourism is a strongly demand-driven sector, quantifying this relationship seems an essential task for assessing the (monetary) impacts of climate change and the costs of inaction. Hence, in order to assess direct impacts of climate change

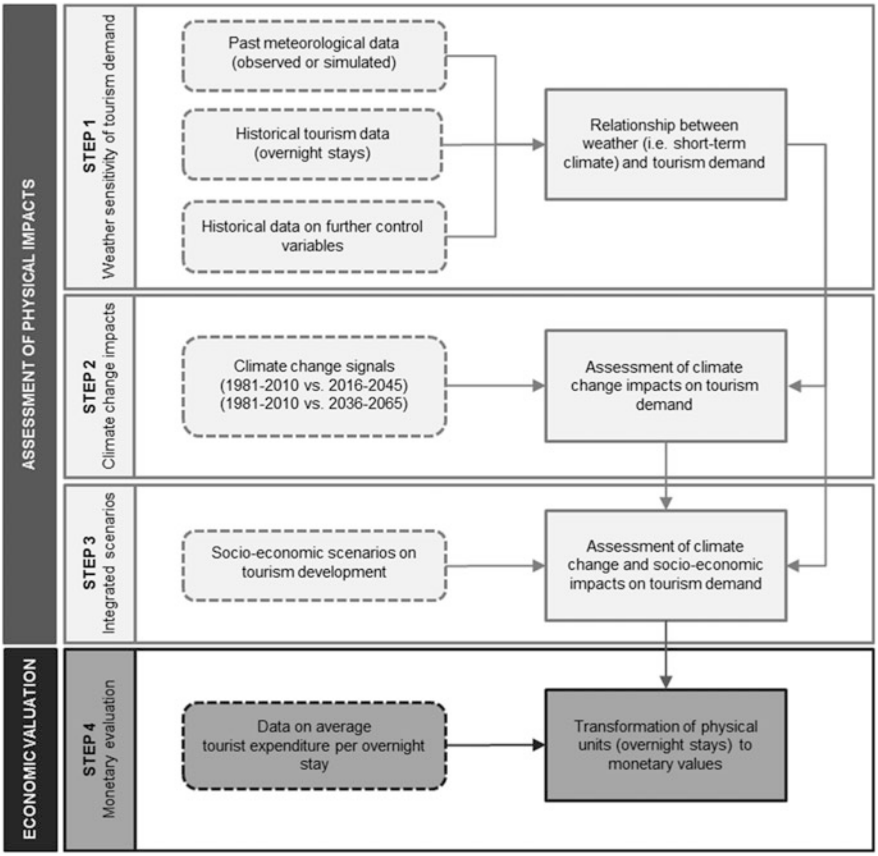

Fig. 19.2 Valuation of (direct) climate change impacts on tourism demand

on tourism demand (represented by overnight stays), we make use of a four-step-procedure illustrated in Fig. 19.2.

The first three steps comprise of physical impact assessments, where impacts are measured in overnight stays; whereas the last step includes the transformation from physical into monetary units.

STEP 1: Weather Sensitivity of Tourism Demand

In the first step, the sensitivity of tourism demand towards weather variability is quantified based on historical data for the period 1974–2006 and the method of multiple regression analysis. Different tourism types may show different sensitivities towards different weather or climatic aspects. Hence, analyses are carried out for each Austrian NUTS 3 region as well as being separated into winter season

Table 19.2 Tested weather/climatic indices

Abbreviation	Explanation
Weather indices tested within winter analyses:	
S_{mean}	Mean depth of (natural) snow at the representative mean altitudes of the region's ski areas during the winter season (cm)
S_{days}	Days with at least 1 cm (natural) snow depth at the representative mean altitudes of the region's ski areas (days/winter season)
Weather indices tested within summer analyses:	
T_{mean}	Monthly average of daily mean temperature (°C)
R_{days}	Days with at least 1 mm precipitation (days/month)
R_{sum}	Sum of precipitation (mm/month)

(November–April) and single summer months (May–October).[4] For each region and season considered, a multiple linear regression model is estimated, including (the natural logarithm of) overnight stays as the dependent variable and a weather index as one of the independent variables. Various weather indices are tested for their adequacy in representing those weather aspects to which tourists respond most sensitively. Each final region- and season-specific regression model contains the weather index that explains the biggest part of variation in overnight stays. Table 19.2 gives an overview of the weather indices tested. As mentioned in Sect. 19.2.1, there are additional meteorological parameters besides temperature and precipitation (or snow) that may influence tourism demand. However, due to the limited number of data observations available for the analyses ($n = 33$), each final region- and season-specific regression model only contains the weather index with the highest explanatory power. Given the spatial and temporal resolution of the analyses together with the tourism demand indicator applied, we assume temperature or precipitation conditions (including snow) to exhibit higher explanatory powers than, for example, humidity, wind speed or sunshine hours.

Data on meteorological parameters stem from the EWCR-Weather-Data-Set (Themeßl et al. 2009), which in turn is based on data from the Austrian Central Institute for Meteorology and Geodynamics (ZAMG). It includes several temperature and precipitation indices on a monthly basis for each Austrian municipality. We aggregate them from municipal to NUTS 3 level by forming the median over all

[4] Since some tourism types are restricted to particular times of the year (e.g. lake or skiing tourism) and Austrian NUTS 3 regions show different priorities with respect to tourism types, differentiating between NUTS 3 regions and months/seasons represents one way of accounting for potential sensitivity differences in tourism types. We tested two different temporal resolutions by conducting analyses (1) for each single month and (2) for winter and summer season. Regarding the winter half-year, analyses carried out on a seasonal basis revealed significant snow dependencies for a higher number of regions and more intuitive results than analyses carried out on a monthly basis. Concerning the summer half-year, analyses conducted on a seasonal basis indicated hardly any significant weather dependencies, contrary to monthly analyses. Hence, we finally used a seasonal resolution for winter and a monthly resolution for summer tourism analyses. Methods and results are only described for these final settings.

data points within a NUTS 3 region. Additionally, the data set includes monthly snow data for the representative mean altitudes[5] of 202 Austrian ski areas (Töglhofer 2011) from a simple snow cover model (Beck et al. 2009). We aggregate snow data from ski area to NUTS 3 (and national) level by forming weighted averages, with the ski areas' transport capacities serving as weighting factors. A higher weighting is therefore given to snow conditions in bigger ski areas. In the case of NUTS 3 regions that do not include any considered ski region, we use snow data aggregated from ski area to national level in order to account for the possibility of regions with predominantly non-snow-based tourism types (e.g. wellness & thermal spa) benefitting from poor overall snow conditions.

Before continuing with the methodology description, we want to shortly discuss relevance, adequacy and limitations of the weather indices tested. Firstly, only considering natural snow depths for quantifying the snow sensitivity of tourism demand is somehow suboptimal in light of current snowmaking coverage.[6] However, actual past total snow depths are hard to reconstruct, since this would require information on how long, to what extent and with which technology snowmaking has been utilized in Austria's single ski areas. Secondly, using a threshold of 1 cm snow depth for constructing the index S_{days} instead of the frequently applied 30 cm (e.g. Steiger and Abegg 2013) is due to limitations of the snow cover model deployed in the generation process of the EWCR-Weather-Data-Set. As pointed out in Töglhofer (2011, p. 64) "[. . .] *the model performs better with lower threshold definitions and higher ones may be more vulnerable to biased model outputs*". Hence, in light of the snow data's limitations and particularities we follow Töglhofer (2011) in preferring a threshold of 1 cm snow depth for quantifying the snow sensitivity of winter tourism demand. Thirdly, the relevance of S_{mean} might seem questionable from a theoretical point of view. By taking averages over a whole winter season, critical snow conditions during particular periods (e.g. Christmas) may be masked by high snow depths during other periods. Moreover, after exceeding a certain threshold, further variations in snow depths may be irrelevant for skiers' behaviours. Nevertheless, when empirically testing the suitability of several snow indices for measuring weather sensitivities/risks in the skiing industry, Töglhofer (2011) found S_{mean} to rank among those suitable. The weather indices tested within summer season analyses rank among those quite common in the literature (see e.g. Agnew and Palutikof 2006; Castellani et al. 2010; Rosselló-Nadal et al. 2011). Nonetheless, they also encounter limitations, such as the masking of potential extreme events due to the use of averages (T_{mean}) and sums (R_{sum}).

To control for other influencing factors besides weather conditions, the inclusion of further explanatory variables is tested. Due to the limited number of observations

[5] Mean altitudes of all the ski area's transport facilities (except drag lifts), weighted by transport capacities.

[6] Almost 60 % of Austrian ski slopes are equipped with snowmaking facilities (Professional Association of the Austrian Cable Cars 2013).

(n = 33), we restrict the amount of explanatory variables simultaneously entering the regression model to four. The additionally tested variables include:

- **(Natural logarithm of) lagged overnight stays**: Overnight stays not only enter the regression model as the dependent but also as an explanatory variable, albeit lagged by one period. Taking such dynamic effects into account decreases the risk of spurious regressions and allows the consideration of expectations and habit persistence of tourists (Song and Witt 2000). Data stem from Statistics Austria.
- **(Natural logarithm of) GDP per capita**: The gross domestic product per capita of the most important tourist-sending countries, weighted by the countries' shares in overnight stays, is used to approximate income levels. Data originate from the OECD. Since the original index turned out to be integrated of order 1, we use its first differences for regression analyses.
- **Easter**: The dummy variable "Easter" indicates if the holy week falls mainly into March. The timing of Easter is expected to influence tourism demand for two reasons: (1) it co-determines ski season length as most ski areas usually close shortly afterwards and (2) the later Easter falls, the higher the probability of either poor/insufficient snow conditions and/or lack of motivation for skiing holidays.
- **Feast days**: The variable "feast days" indicates the number of feast days falling on a week day.
- **Year**: The variable "year" represents the year of the observation and serves the purpose of capturing unexplained trends.

For each considered region and season, various model specifications are tested, differing with respect to the kind of weather index applied as well as the kind and total number of explanatory variables included (see Supplementary Material for further details). The final model specification is selected based on both, the fulfillment of various diagnostic tests—including normally distributed residuals and the absence of functional form misspecification—and the Bayesian Information Criterion (BIC) (Schwarz 1978). If the BIC decides on a final model that does not include a weather index, or the estimated coefficient of the finally selected weather index does not fulfill the criterion of statistical significance at the 10 % level, we assume the weather sensitivity of tourism demand in the considered region and season to be negligible, i.e. zero.

STEP 2: Climate Change Impacts on Tourism Demand

After quantifying how sensitively overnight stays respond to changes in particular weather indices (STEP 1), the impacts of long-term average changes in these weather indices are assessed. For this purpose, the region- and season-specific weather sensitivities are applied to climate change signals (1981–2010 vs. 2016–2045 and 1981–2010 vs. 2036–2065). Results of STEP 2 show the pure impacts of changing "average weather" conditions without considering any socioeconomic changes—and are given as percentage change in overnight stays.

STEP 3: Integrated Scenario
STEP 3 additionally takes scenarios on future tourism development into account. Future scenarios on the region- and season-specific evolution of overnight stays are based on the extrapolation of past trends into the future, using ETS (**E**xponen**T**ial **S**moothing) and ARIMA (**A**uto**R**egressive **I**ntegrated **M**oving **A**verage) models. These scenarios indicate an increase of nationwide annual overnight stays by 17 % (39 %) between 2008 and 2030 (2050). Assuming that these tourism development scenarios do not account for climate change, overnight stays projected for 2030 and 2050 are subsequently corrected for the climate change impacts quantified in STEP 2. Comparing climate-change-corrected to uncorrected future overnight stays indicates the impacts of climate change under consideration of tourism development.

STEP 4: Monetary Evaluation
In the last step, physical impacts are translated into monetary terms using average tourist expenditure per overnight stay. According to T-MONA (Tourismus MONitor Austria), tourists spent 135 € per winter overnight stay and 108 € per summer overnight stay on average in 2009 (Töglhofer 2011). As in the entire study, all prices are measured in real terms. Regarding the future development of (real) tourist expenditures per overnight stay, we assume a growth rate of 0.8 % per annum. Since the derived scenario on the evolution of overnight stays suggests an annual nationwide growth rate of about 0.8 %, this results in a growth rate of total (real) tourist expenditures of 1.6 %, which is comparable to real GDP growth as assumed by the SSP (see Chap. 6). Figure 19.3 summarizes the costing method applied within tourism.

19.4.4 Range of Sectoral Socio-economic Pathway Parameters That Co-determine Climate Impact

The climate change independent evolution of both overnight stays and (real) tourist expenditures per overnight stay co-determine climate impacts by co-determining the overall tourism volume exposed to climate change. Both parameters are influenced by various factors, including the economic development in important tourist-sending countries, the evolution of transportation costs, the alteration of tourists' preferences, etc. With the future evolution of both variables being highly uncertain, we carry out some sensitivity analyses by assuming a reduction

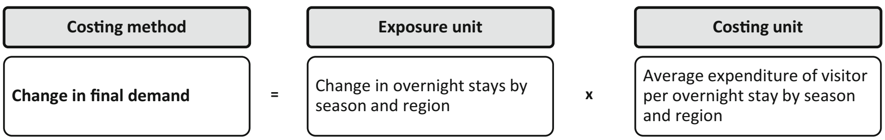

Fig. 19.3 Costing method applied and respective measurement units for tourism

Table 19.3 Average annual climate-triggered economic impacts on tourism demand arising from socioeconomic development and climate change in the future (in M€)

Future economic impact relative to Ø 1981–2010		Climate change		
		Low-range	Mid-range	High-range
Ø 2016–2045	Costs	75	104	213
	Benefits	54	37	15
	Net effect	−21	−67	−199
Ø 2036–2065	Costs	n.a.	316	n.a.
	Benefits	n.a.	106	n.a.
	Net effect	n.a.	-210	n.a.

Not adjusted for rounding differences

(increase) in the growth of both parameters by 25 % compared to our reference assumptions.

Changes in socioeconomic factors may not only affect the tourism sector's exposure, but also its sensitivity towards climate change. Altered tourist preferences or changes in holiday regulations could for instance manifest themselves in altered weather sensitivities. Hence, we carry out some sensitivity analyses by assuming a reduction (increase) in future region- and season-specific weather sensitivities of tourism demand by 25 % compared to those historically observed.

19.4.5 Monetary Evaluation of Impacts

19.4.5.1 Direct Sector Impacts (Costs and Benefits) Without Feedback Effects from Other Sectors

Table 19.3 illustrates the final outcome of the applied four-step-procedure, aggregated from NUTS 3 to national and from monthly/seasonal to annual level.[7] It shows the average annual economic impacts on future tourism demand due to changes in average climatic conditions, differentiating between up to three different climate change scenarios (see Sects. 19.4.1 and 19.4.2). Note that potential impacts due to changes in climate variability are not taken into account.

Assuming socioeconomic pathway parameters as in the reference scenario[8] and a change in the climate as indicated by the mid-range scenario, average annual climate-triggered future economic losses in the tourism field are estimated at 104 million euros (316 million euros) in the first (second) scenario period, of which 101 million euros (291 million euros) are attributable to the winter season.

[7] For interim results and further details see Supplementary Material.

[8] i.e. an average annual nationwide growth rate of overnight stays of about 0.8 %, an annual growth rate of real tourist expenditures per overnight stay of 0.8 %, and weather sensitivities of tourism demand as observed in the past.

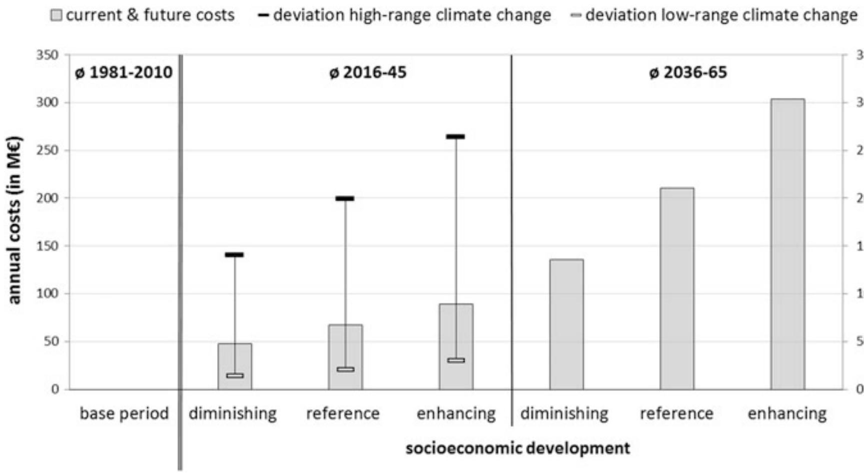

Fig. 19.4 Average annual climate-triggered costs in tourism arising from socioeconomic development and climate change (in M€)

Average annual climate-triggered future economic benefits, on the other hand, are estimated at 37 million euros (106 million euros), of which 32 million euros (90 million euros) are attributable to the summer season. Hence, an average annual future net loss of almost 70 million euros or 0.3 % (210 million euros or 0.7 %) is expected compared to a situation without climate change.

Whereas net impacts aggregated to national and annual level seem rather small due to counteracting effects, impacts on particular regions during specific seasons may be more pronounced. In the case of Carinthia, results for the winter season suggest average annual climate-triggered future economic losses of almost 3 % (over 6 %) in the first (second) scenario period. Assuming climate change according to the high-range scenario, these losses rise to almost 7 % (about 10 %).

A graphical illustration of the average annual climate-triggered economic net impacts on tourism demand is provided in Fig. 19.4, which additionally illustrates the effects of altered socioeconomic pathway assumptions (see Sect. 19.4.4). Since the analysis only considers impacts due to changes in average climatic conditions, annual net impacts in the base period equal zero.

19.4.5.2 Macroeconomic Effects

For the macroeconomic model, we first had to identify tourism relevant sectors in the Austrian Input-Output (IO) table, since this database does not contain a specific tourism sector. Based on Statistics Austria (2012) we classified the following five NACE-sectors as tourism relevant (with their tourism specific shares given in brackets): *accommodation, food and beverage service activities* (75.4 %); *travel agencies* (100 %); *creative arts and entertainment activities* (46.8 %); *libraries,*

Table 19.4 Implementation of baseline and climate change scenario for Tourism in the macroeconomic model

	2008	2030		2050	
Change relative to base year (2008)	Private consumption (M€)	Baseline	Climate change	Baseline	Climate change
Change in private demand (total tourism sector)		+43.8 %	+43.3 %	+101.5 %	+100.07 %
Thereof:					
Accommodation	15,277	+43.7 %	+43.3 %	+100.8 %	+99.8 %
Travel agencies	1,413	+43.8 %	+43.3 %	+101.5 %	+100.1 %
Entertainment activities	942	+43.5 %	+43.3 %	+100.1 %	+99.4 %
Cultural activities	178	+43.5 %	+43.3 %	+100.1 %	+99.4 %
Sport activities	1,336	+43.5 %	+43.3 %	+100.1 %	+99.4 %

Note: baseline scenario = reference socioeconomic development without climate change; climate change scenario = reference socioeconomic development and mid-range climate change; quantified climate impact chains: change in summer (temperature, precipitation) and winter tourism demand (snow)

archives, museums and other cultural activities (46.8 %); *sports, amusement and recreation activities* (46.8 %).

In the first step of linking the top-down CGE model to the detailed tourism sector model, we calibrated the CGE model such that it replicated the climate change independent development of tourism demand—hereafter labeled as "baseline"—as indicated by sectoral analysis for the scenario periods 2016–2045 and 2036–2065. Since we followed a comparative static CGE modelling approach, we looked at the mean of simulated annual tourism demand for the two scenario periods, represented by the years 2030 and 2050. To replicate the sectoral model's baseline we proportionately translated these developments into changes in private final demand (cf. Fig. 19.3) for domestic tourism services, relative to the IO table base year 2008 within the CGE model. In the second step, climate change impacts—i.e. climate induced deviations from the baseline—were also modelled as demand shocks in the CGE model.[9]

Table 19.4 shows the change in private consumption in the tourism relevant sectors relative to the base year according to both the baseline scenario and the mid-range climate change scenario. While the rest of the economy is assumed to grow by 1.65 % p.a. (see Chap. 6), i.e. +43.33 % from 2008 to 2030 and +98.84 % from 2008 to 2050, growth rates in the tourism specific parts of the tourism relevant sectors reflect tourism demand development as indicated by sectoral analysis. As

[9] Note that, unlike Schinko et al. (2014), we did not consider climate change impacts on production structures of the tourism relevant NACE-sectors.

shown in Table 19.4, tourism relevant sectors show a somewhat stronger baseline growth than the rest of the economy. Climate change lowers this growth, however.

Negative climate change impacts on tourism demand, i.e. a lower private consumption of tourism-relevant services in the climate change scenario compared to the baseline (see Table 19.4), lead to a higher disposable income of private households for the consumption of other goods and services. Note that in the Austrian IO table all domestic tourism services consumed either by residents or foreign tourists are treated as if they were consumed by residents only. Thus, we had to adjust the domestic disposable income resulting from climate change impacts downwards to correct for that accounting error.[10]

Lower demand for tourism-specific services in the climate change scenario, combined with the necessary adjustment of disposable income, leads to reduced annual gross output values in tourism-relevant as well as other sectors. These annual changes are illustrated in Table 19.5 and include quantity as well as relative price effects. Total effects are negative in both scenario periods, but about three times higher in 2036–2065 than in 2016–2045. Besides the tourism relevant sectors, relatively high reductions in sectoral gross output value are also found for the sectors of food production, beverages and agriculture, since they form major intermediate inputs into the tourism relevant sectors.

Summing up across all sectors, the changes in gross value added lead to a GDP effect of −0.03 % in the first and −0.06 % in the second scenario period (without the effects of altered tax revenues and expenditures for subsidies). The vast majority of the GDP effect can be attributed to reductions in output quantity, and only a smaller share to changes in prices.

In addition to direct climate change impacts on the Austrian tourism sector we consider overall macroeconomic effects on the Austrian economy. Results for the mid-range climate scenario show that, given the model settings, impacts on the macroeconomic indicators "welfare" and "GDP"[11] are negative in both periods. Compared to the baseline, annual welfare (GDP) is 92 million euros (102 million euros) lower on average in 2016–2045 and 310 million euros (339 million euros) lower in 2036–2065. This is due to increased unemployment (0.02 % points in 2016–2045 and 0.04 % points in 2036–2065) triggered by negative climate change impacts on the Austrian tourism sector and macroeconomic feedback effects. Assuming climate change according to the low and high-range scenario (see Sect. 19.4.2), impacts on welfare (GDP) within the first scenario period range from −43 million euros to −269 million euros (−43 million euros to −271 million euros).

Overall, reduced economic output and increased unemployment rates under the mid-range climate change scenario (compared to the baseline) trigger a reduction in government budget of 38 million euros in 2016–2045 and 127 million euros in

[10] For this purpose, we applied the fraction of foreign overnight stays reported by Statistics Austria for 2008, i.e. 0.73.

[11] See Chap. 7 for characterization.

Table 19.5 Sectoral and total effects of quantified climate change impacts in sector Tourism, average annual effects relative to baseline (for periods 2016–2045 and 2036–2065)

	Ø 2016–2045			Ø 2036–2065		
Changes in M€ p.a. relative to baseline	Gross output value	Inter-mediate demand	Net value added	Gross output value	Inter-mediate demand	Net value added
Losing sectors	**−177**	**−88**	**−89**	**−590**	**−294**	**−296**
Accommodation	−58	−21	−37	−182	−66	−116
Travel agencies	−7	−5	−2	−22	−17	−5
Entertainment activities	−3	−1	−2	−8	−2	−6
Cultural activities	−0	−0	−0	−2	−1	−1
Sport activities	−4	−1	−2	−12	−5	−7
Food products	−4	−3	−1	−14	−10	−4
Beverages	−3	−2	−1	−10	−8	−3
Agriculture	−2	−1	−1	−8	−4	−3
All other sectors	−96	−53	−43	−332	−182	−150
Total effect (all sectors)	**−177**	**−88**	**−89**	**−590**	**−294**	**−296**
GDP at producer price			−0.03 %			−0.06 %
. . .thereof price effect			−0.00 %			−0.01 %
. . .thereof quantity effect			−0.02 %			−0.06 %

Note: baseline scenario = reference socioeconomic development without climate change; climate change scenario = reference socioeconomic development and mid-range climate change; quantified climate impact chains: change in summer (temperature, precipitation) and winter tourism demand (snow)

2036–2065 (see Table 19.6). Decreasing labour tax revenues and expenditures caused by higher unemployment especially contribute to the reduction in government budget. In addition, reduced GDP causes a relatively strong reduction in revenues from value added tax.

19.4.6 Qualitative Impacts (Non-monetarised)

Some climate change impacts on tourism are rather hard to quantify. This particularly pertains to impacts due to climate induced changes in tourism relevant environmental resources, including alterations in the landscape (shrinking glaciers, dried-up lakes, etc.), loss in biodiversity, or increased safety risks in alpine terrain

Table 19.6 Effects of quantified climate change impacts in sector Tourism on government budget, average annual effects relative to baseline (for periods 2016–2045 and 2036–2065)

Changes in M€ p.a. relative to baseline	Ø 2016–2045	Ø 2036–2065
Revenues	**−38**	**−127**
Production tax	−2	−6
Labour tax	−18	−59
Capital tax	−6	−18
Value added tax	−13	−43
Other taxes	−0	−1
Expenditures	**−38**	**−127**
Unemployment benefits	+20	+68
Transfers to households net of other taxes	−58	−195
Government budget in baseline (p.a.)	**149,066**	**206,459**
Climate change impact on government budget	−0.03 %	−0.06 %

Note: baseline scenario = reference socioeconomic development without climate change; climate change scenario = reference socioeconomic development and mid-range climate change; quantified climate impact chains: change in summer (temperature, precipitation) and winter tourism demand (snow)

due to melting permafrost. In addition, some of the potential climate change impacts listed in Table 19.1 could not be quantified in the present project due to resource limitations. These include climate change induced alterations in water and/or energy demand as well as losses due to business interruptions following natural disasters.

19.4.7 Sector-Specific Uncertainties

The four-step-procedure described in Sect. 19.4.3 exhibits various critical assumptions, limitations and uncertainties that have to be considered when interpreting the model results:

- **Extreme events**: The method applied focuses on changes in mean weather conditions rather than on changes in weather extremes. This may lead to an underestimation of climate change impacts.
- **"Weather memory" of tourists:** Steiger (2011) found an enduring effect of the extraordinary snow-poor winter season 2006/07 in some Tyrolean districts. Especially in the case of several consecutive periods of adverse weather conditions, this kind of "weather memory" may intensify climate change impacts considerably. However, the procedure applied does not consider such "weather memory" effects.
- **Weather sensitivities**: Climate change impacts are assessed on the basis of past weather sensitivities observed for the period 1974–2006. However, especially

with respect to natural snow conditions, sensitivities might have changed systematically over time due to the introduction and expansion of artificial snowmaking during the last decades. Using two different panel data approaches, Töglhofer et al. (2011) found some evidence that the sensitivity of overnight stays in 185 Austrian ski areas towards natural snow conditions may have decreased over time. Hence, the snow sensitivities applied for impact assessment may be somewhat overestimated. Moreover, weather sensitivities might be subject to future change, for instance due to tourists' changing preferences. Hence, applying historically observed sensitivities for assessing climate change impacts bears uncertainties.

- **Evolution of socioeconomic parameters:** The region- and season-specific future development of overnight stays and the evolution of tourist expenditures per overnight stay are affected by a whole range of factors (including costs of travel, terrorism and war, tourist preferences, etc.), and are therefore highly uncertain.
- **Tourist preferences**: Principally, we assume tourist preferences about holiday destinations, tourism types, weather/climatic conditions, etc., to remain constant over time. However, tourist preferences are actually subject to constant change. We partially account for this fact within sensitivity analyses, but overall, the future evolution of tourist preferences remains a highly uncertain factor.
- **Climate change in tourist-sending countries / competing destinations**: Climate change in tourist-sending countries or competing destinations and its impacts on tourism in Austria are not taken into account. Comparably cooler alpine destinations may benefit from increasing heat waves in nearby cities or the Mediterranean (Serquet and Rebetez 2011; Amelung and Viner 2006). Moreover, changes in the snow reliability of competing destinations may affect tourism demand in Austrian ski areas.
- **Day visitors**: Due to data availability, present analyses focus on overnight guests. However for some regions, day visitors are also of high importance and climate change may affect them too. Müller and Weber (2008), who estimate the economic effects of climate change on tourism in the Bernese Oberland (Swiss), expect climate induced impacts on revenues related to daily visitors during winter (summer) to be about one third smaller (higher) than those related to overnight stays.

19.5 Summary of Climate Costs for Tourism and Conclusions

Our analysis of potential climate change impacts on tourism demand in Austria indicates predominantly negative effects on winter tourism and mainly positive effects on summer tourism, with net impacts being negative. Although results suggest nationwide effects to be rather small, some regions may suffer from considerable impacts within particular seasons of the year. The macroeconomic evaluation shows negative effects on GDP and welfare, about 50 % higher than direct tourism impacts. The strongest negative spillover effects emerge for the food and beverage production sectors as well as the agriculture sector, because of the high relevancy of their inputs into the tourism sector. Overall, results have to be interpreted with caution, since they are subject to a range of uncertainties.

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