Analysis of the sensitivity of ski tourism demand to climate change in Switzerland[1]

Camille Gonseth & Cecilia Matasci

Abstract

Impacts of climate change on winter tourism supply have attracted considerable scientific interest in recent years. In comparison, only few studies have addressed so far the effects on demand. In this article, we analyse how snow and weather conditions currently impact the ski tourism demand using econometric models. These were estimated with two panel data samples of respectively 74 and 92 Swiss ski resorts tracked over four winter seasons. Regression results emphasize the link between weather and snow conditions and the tourism demand (overnight stays, skier visits) at Swiss ski resorts.

Keywords: climate change, tourism demand, ski industry, snow cover reduction, snowmaking

1 Introduction

One of the most noticeable effects of climate change in Switzerland is – together with glacier melting – snowpack reduction. A large amount of studies analysed the link between the snowpack and climate conditions for the country and the impacts of the abovementioned snowpack reduction on the ski industry supply (König & Abegg 1997; Ehrler 1998; Gellens et al. 2000; Elsasser & Messerli 2001; Bürki 2002; Elsasser & Bürki 2002; Beniston et al. 2003a, 2003b; Scherrer & Appenzeller 2006; Agrawala et al. 2007; Müller & Weber 2007, Marty 2008; Hoffmann et al. 2009; Uhlmann et al. 2009; Bättig et al. 2011; Serquet et al. 2011). However, only few studies analysed the impact of climate change and changes in snowpack on customers' behaviour (i. e. on the demand side) in Switzerland or in other alpine countries. Abegg (1996) analysed the impact of three consecutive snow-deficient winters on the Swiss winter tourism industry at the end of the 1980s. He found a 20% decrease in sales revenues in average for cable car companies. Nonetheless, results varied greatly depending on the region, altitude and size of the ski resorts. Lower (and generally smaller) ski domains suffered the most, whereas resorts over 1,700 meters (generally bigger ones) were somehow less affected. Töglhofer et al. (2011) analysed 185 Austrian ski resorts between 1973 and 2006 using time series regressions and panel data models in order to quantify past demand changes due to short-term climate variability. They estimated an overall change of 0.6–1.9% in overnight stays with a 1

[1] The authors gratefully acknowledge the support of the Swiss Federal Office for the Environment as well as of the Swiss National Centre of Competence in Research on Climate (NCCR Climate) which is funded by the Swiss National Science Foundation (SNF) They also would like to thank Philippe Thalmann and Laurent Vanat for their precious comments

standard deviation change in snow conditions. They also found that the number of overnight stays in higher-lying ski resorts is rather independent of local snow conditions, whereas it sometimes depends on average Austrian ones.

This article aims at answering the following questions: in recent winter seasons, what was the influence of snow conditions on skier visits at the different ski domains? How strong is the relationship between snow conditions and overnight stays? Does the lack of 'winter atmosphere' in the lowlands affect the number of skier visits? And finally, what do snowmaking capacities contribute in terms of ski resort visitation? In order to answer these questions, we have estimated panel data regression models using two samples of respectively 74 and 92 Swiss ski resorts that were tracked over four winter seasons.

2 Data

Data concerning the ski resorts contained in our two samples cover the months December to March of four successive winter seasons (2005/2006 to 2008/2009). These winter seasons display very different features. For instance, the winter season 2006/2007 was the warmest winter on records and could therefore be an indication for the winters to come, whereas winter 2005/2006 was rather a cold one. In order to illustrate tourism demand, two dependent variables were employed. Our first measure of tourism demand is similar to Töglhofer et al. (2011) since it is the number of overnight stays in hotels located in the vicinity of ski areas. Data on overnight stays are available from the statistics on tourist accommodation of the Swiss Federal Statistical Office (SFSO). The second measure of tourism demand is the number of skier visits, a ski area visitation statistics which has only comparatively recently been systematically collected in Switzerland[2]. In our attempt to model tourism demand, we considered different types of explanatory variables such as meteorological variables (weather and snowpack conditions), tourism supply related variables (individual lifts' hourly capacity and difference in altitude, maximum and average lengths of ski runs artificially snowed, hotel accommodation supply), domain characteristics (accessibility which is viewed in this paper as the time taken by car to reach the ski resort from the nearest urban centre) and macroeconomic conditions (exchange rates). Variables measured at the ski areas themselves, such as natural snow heights, weather conditions (to make it simple, sunny versus cloudy days) and the kilo meters of ski slopes with artificial snow, were provided by the Swiss National Tourist Office on a day-to-day basis. They were complemented with data from both Ski Guide ADAC and our own inquiries for the recourse to snowmaking and with data from MeteoSwiss for depicting weather conditions (temperatures and snow cover) in the lowlands. Data source on tourism transport facilities are available either from the Swiss Federal Office for Spatial Development (ARE 2000) or, for more recent information, from the umbrella organization Seilbahnen Schweiz. The sta-

[2] A precise definition of the notion of a skier visit could be found in Vanat (2010) The authors are thankful to Laurent Vanat who has kindly permitted the use of his database on Swiss skier visits for the present work

tistics on tourist accommodation from the SFSO provides all information needed on the hotel accommodation supply. The accessibility data were obtained by using the mappy website, http://fr-ch.mappy.com (accessed: 17/05/2011) which allows computing car travel time between destinations. Finally, information on exchange rates was found on the Swiss National Bank website, http://www.snb.ch (accessed: 20/05/2011).

3 Methods

The analysis of overnight stays and skier visits present strong similarities but also important differences. These prompt us to present our empirical methodologies for the two variables separately, first for overnight stays, and then for skier visits.

3.1 Overnight stays regressions

Our model of overnight stays at ski resorts is the following:

$$\ln Overn.Stays_{\text{iwm}} = a + \beta\, Snow\ Days_{iwm} + \gamma \mathbf{x}_{\mathbf{iwm}} + \Delta + \varepsilon_{iwm} \qquad (1)$$

The dependent variable is the natural logarithm of hotel overnight stays (ln *Overn. Stays*) and we would like to measure the effect of changing snow conditions on it. Our measure of snow conditions *Snow Days* is the number of days with at least 50 cm of natural snow in the upper part of the ski area. We have also checked the robustness of our results by using an alternative measure which is the number of days with at least 30 cm of snow in the lower part of the ski area[3]. The sample used to estimate equation 1 is a three-dimensional panel. Here and throughout the article, *i* indexes ski resorts, *w* winter seasons, and *m* months. In Table 1, we also use the index *t* to represent successive time periods (i. e. months * winter seasons) within the sample. In equation 1, ε_{iwm} is the idiosyncratic error term and $\mathbf{x}_{\mathbf{iwm}}$ is a vector of observed variables whose aim is to control for different characteristics of the ski resorts and their environment including the hotel accommodation supply, the level of investments in snowmaking and transport facilities as well as the macroeconomic conditions. Characteristics of the hotel accommodation supply considered are the total number of available beds *Hotel Beds*, the average number of beds per establishment *Beds/Estab,* and the share of beds in 4–5 stars hotels *4–5 * Share*. These variables should carry information on the tourism sector's size and structure at a given ski area. Our measure of snow production *Art. Snow* is the monthly average kilometers of ski slopes that are artificially snowed. It enters the model with a quadratic function as the positive marginal impact of snowmaking on the demand is probably de-

[3] Naturally, the two measures are highly correlated ($\varrho = 0\ 84$) Both figures of 30 and 50 cm are often considered in the literature as limits below which skiing is not more possible (Witmer 1986) The actual limit tends to increase with the altitude as the terrain generally becomes more uneven

Table 1: Panel data estimations of the impacts of natural and artificial snow on hotel overnight stays at ski resorts.

Dep. Var.: ln *Overn.Stays*$_{iwm}$	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Snow Days$_{iwm}$	0.0040**	0.0028***	0.0035*	0.0053***	0.0048***	0.0036*
	[0.0017]	[0.0010]	[0.0021]	[0.0015]	[0.0017]	[0.0020]
Art. Snow$_{iwm}$	0.0017**	0.000059	0.0056***	0.0011*	0.0015**	0.00085
	[0.00079]	[0.00035]	[0.0016]	[0.00060]	[0.00064]	[0.00068]
Art. Snow$_{iwm}^{2}$	−3.9e-06*	4.6e-07	−1.5e-05***	−2.9e-06	−4.1e-06**	−1.9e-06
	[2.0e-06]	[9.7e-07]	[3.9e-06]	[1.9e-06]	[1.9e-06]	[1.9e-06]
ln *Transp.Cap*$_{iw}$	0.23	0.21**		0.013	−0.00092	0.0068
	[0.16]	[0.097]		[0.016]	[0.016]	[0.020]
ln *Hotel Beds*$_{iwm}$	0.67***	0.55***	0.88***	0.24***	0.22***	0.17***
	[0.15]	[0.11]	[0.18]	[0.041]	[0.042]	[0.051]
*4–5 * Share*$_{iwm}$	0.17	−0.045	0.70***	−0.017	−0.067	0.073
	[0.15]	[0.23]	[0.23]	[0.057]	[0.065]	[0.093]
ln *(Beds/Estab.)*$_{iwm}$	0.22	0.16	0.23	0.13***	0.13**	0.12**
	[0.17]	[0.11]	[0.27]	[0.046]	[0.051]	[0.054]
ln *Exch. Rates*$_{iwm}$	2.19***	2.14***	1.45	−0.0018	−0.21	−0.60
	[0.79]	[0.49]	[2.33]	[0.21]	[0.29]	[0.38]
ln *Overn. Stays*$_{it-1}$				0.49***		
				[0.056]		
ln *Overn. Stays*$_{it-2}$				0.28***		
				[0.058]		
ln *Overn. Stays*$_{iw-1m}$					0.79***	0.55***
					[0.040]	[0.056]
ln *Overn. Stays*$_{iw-2m}$						0.27***
						[0.041]
Resort FE	yes	no	no	no	no	no
Resort*Month FE	no	yes	no	no	no	no
Resort*WS FE	no	no	yes	no	no	no
WS*Month FE	yes	yes	yes	yes	yes	yes
Observations	1,357	1,357	1,357	1,182	1,008	669
R-squared	0.503	0.271	0.549	0.965	0.979	0.981
Prob > F	0.11	0.30	0.00096	0.17	0.052	0.27

*Notes: Robust standard errors in brackets; *significant at 10%; **significant at 5%; ***significant at 1%. We test the joint hypothesis that the two coefficients related to artificial snow are zero (cf. the p-value of the F-statistic).*

creasing[4]. As regards transport facilities, our variable *Transp. Cap* is obtained by multiplying a ski lift, chair lift or cable car's transport capacity (persons/hour) with its difference in height (km) and then summing over all facilities located at a given ski area. Finally, macroeconomic conditions are accounted for by including *Exch. Rates,*

[4] cf Gonseth (2007) We also note that a scatterplot of ln *Overn. Stays* against our measure of snow production shows a strong nonlinear relationship

a 3-months lag weighted average of the two most important exchange rates for the Swiss winter tourism sector (i.e. CHF/EUR and CHF/GBP). The weights are ski resort specific as they represent the relative importance of tourists from the United Kingdom and the euro area at each ski resort. Models in columns (4)–(6) of Table 1 also incorporate lag values of the dependent variable *Overn. Stays* either along the time period dimension (i.e. former time periods in the panel sample) or along the winter season dimension (i.e. former winter seasons of the same month). The strength of a three-dimensional panel is the possibility to control for interacted fixed effects such as Resort x Month, Resort x WS, and WS x Month fixed effects in the application at hand (where WS abbreviates winter season). Resort x Month fixed effects capture any winter season-invariant differences in monthly visitation rates across ski resorts not picked up by the controls that may be a result of e.g. any kind of annual events (cultural, political), planned opening dates of ski areas or different origins of guests. On their side, Resort x WS fixed effects capture any winter seasons varying ski resorts characteristics not picked up by the controls such as snow-independent tourism infrastructures (swimming pools, ice rinks, etc.). Finally, WS x Month fixed effects absorb any time-varying macroeconomic conditions that are not controlled by the exchange rates related variable. In equation 1, the set of fixed effects is represented by the symbol Δ whereas the set of fixed effects specifically controlled in each regression is detailed in Table 1. Whatever the model specification, population regression coefficients α, β, γ are always estimated by Ordinary Least Squares (OLS).

3.2 Skier visits regressions

Our model of skier visits at ski areas is the following:

$$\ln Skier\ Visits_{iw} = a_i + \beta\, Snow\ Days_{iw} + \gamma \mathbf{x}_{\mathbf{iw}} + \varepsilon_{\mathrm{iw}} \qquad (2)$$

The dependent variable is the natural logarithm of skier visits (ln *Skier Visits*) and we are interested in identifying and measuring the effect of changing snow conditions *Snow Days* on it. The measures of snow conditions are unchanged compared to the previous section. In equation 2, α_i represents a set of unobserved ski resorts' characteristics that do not change over time (e.g. landscape, orientation, etc.) and ε_{iw} is the idiosyncratic error term. This time, our sample is a more classical two-dimensional panel of winter seasons (2005/2006 to 2008/2009) where the month dimension is absent. This is due to the fact that information on monthly skier visits at ski areas is not available for Switzerland. Otherwise, the set of ski resorts remains essentially the same as for the overnight stays' analysis. Skier visits depend on day trippers as well as on tourists staying at the ski resort. In building the skier visits model, we have therefore to account for factors influencing both types of visitors which was not the case in the overnight stays' analysis. Accordingly, variables included in the skier visits model are slightly different from those presented in the previous section. In the $\mathbf{x}_{\mathbf{iw}}$ vector, we continue to control for the hotel accommodation supply and the transport and snowmaking facilities[5]. However, the vector of controls now includes new variables accounting for such aspects as accessibility and weather conditions. The accessibility factor is dealt with by using a dummy variable *Access* that takes the value 1 whenever it takes more than 90 minutes by car to reach the ski area from the nearest urban centre. As remote ski areas attract less day trippers, we expect a negative coefficient for this variable. Two variables, *W Atm.* and *Sunny Days*, describe weather conditions that might influence the number of skier visits. The first one is a measure of the winter atmosphere in the lowlands. It sums monthly average temperatures deviations from monthly normal temperatures across December to March.[6] Positive values of the variable indicate a relatively mild weather in the lowlands that should theoretically be negatively correlated with the number of skier visits. Therefore, we expect the associated coefficient to be negative. However, the detrimental effect on ski area visitation should be smaller for ski areas that are more distant from densely inhabited city agglomerations. It is simple to test whether such a reduced effect actually happens by adding a term interacting the variables *W Atm.* and *Access* to the model (*W Atm. * Access*). A significantly positive coefficient on the interaction term would then support the reduced effect hypothesis. The second variable describing weather conditions (*Sunny Days*) informs about the percentage of sunny days among the total number of operating days. We expect a positive impact of this variable on skier visits and therefore a positive associated coefficient. Four standard panel data estimators are used to estimate the skier visits linear panel data model. The pooled OLS estimator is used in columns (1)–(3) of Table 2 whereas the random effects, first-difference and fixed effects estimators are used successively in columns (4)–(6).

4 Results

4.1 Overnight stays regressions

Regression results obtained with the different model specifications are displayed in Table 1. The coefficient on *Snow Day* is significantly different from zero at the .10 significance level in all models. The coefficient value ranges from 0.0028 to 0.0053. This means that one additional day with "good" snow conditions increases the number of monthly overnight stays by 0.28% to 0.53%. The results derived for the impact of natural snow is therefore robust to very different model specifications. Moreover, it is also rather robust to the choice of the variable describing natural snow conditions. With the alternative measure described above (the number of days with at least 30 cm of snow in the lower part of the ski area), the coefficient value

[5] The hotel accommodation supply is given by the average number of available beds during the winter season; the transport facilities related variable is the same to the one used in the overnight stays' analysis; the snowmaking variable is not based anymore on data from the Swiss National Tourist Office In this section, it represents the ski slopes' length concerned with snowmaking at each ski area

[6] In fact, this summation is made for four meteorological stations located in the lowlands (Zürich, Bern, Basel and Geneva) For a given winter season, these four values are then averaged in order to obtain the value for the *W Atm.* variable

Table 2: Panel data estimations of the impacts of weather conditions, natural and artificial snow on skier visits.

Dep. Var.: ln ***Skier Visits***$_{iw}$	**Pooled OLS**	**Pooled OLS**	**Pooled OLS**	**Random effects**	**First-diff.**	**Fixed effects**
Snow Days$_{iw}$	0.0042***	0.0039**	0.0032**	0.0032**	0.0037***	0.0030**
	[0.0015]	[0.0017]	[0.0012]	[0.0014]	[0.0012]	[0.0014]
Sunny Days$_{iw}$	0.0022	0.0026	0.0025	0.0017	0.0032**	0.0014
	[0.0026]	[0.0027]	[0.0018]	[0.0012]	[0.0015]	[0.0011]
W Atm.$_{w}$	−0.0063*					
	[0.0035]					
Access$_{i}$	−0.049	−0.045	−0.079**	-0.044		
	[0.082]	[0.082]	[0.037]	[0.080]		
W Atm.$_{w}$**Access*$_{i}$	0.0019	0.0024	0.0092**	0.0049*	0.0049*	0.0059**
	[0.0036]	[0.0037]	[0.0043]	[0.0029]	[0.0026]	[0.0029]
Art. Snow$_{iw}$	0.0068	0.0068	0.0016	0.0037	0.0031	0.0015
	[0.0043]	[0.0043]	[0.0012]	[0.0036]	[0.0056]	[0.0038]
Art. Snow$_{iw}^{2}$	−7.1 e-05***	−7.1 e-05***	−0.000014*	−0.000034*	−0.000020	−0.000011
	[0.000026]	[0.000026]	[7.8e-06]	[0.000020]	[0.000029]	[0.000019]
ln *Transp. Cap*$_{iw}$	1.06***	1.06***	0.16***	1.06***	0.37*	0.31*
	[0.082]	[0.083]	[0.056]	[0.074]	[0.19]	[0.18]
ln *Hotel Beds*$_{iw}$	−0.0051	−0.0044	−0.00038	0.013	0.017	0.0091
	[0.039]	[0.039]	[0.013]	[0.031]	[0.066]	[0.050]
ln *Skier Visits*$_{iw-1}$			0.80***			
			[0.061]			
resort FE	no	no	no	no	yes	yes
WS FE	no	yes	yes	yes	yes	yes
observations	235	235	169	235	165	235
R-squared	0.904	0.904	0.969	0.90	0.548	0.494
Prob > F	2.7e-06	2.4e-06	0.091	0.006	0.43	0.33
Prob > chi2 (Hausman test) 0.3318						

*Notes: Robust standard errors in brackets; Standard errors are clustered at the ski resort level; *significant at 10%; **significant at 5%; ***significant at 1%. We test 1/ the joint hypothesis that the two coefficients related to artificial snow are zero (cf. the p-value of the F-statistic) and 2/ the random effects model against the fixed effects model using the Hausman test (cf. the p-value of the chi-squared statistic).*

ranges from 0.00081 to 0.0045 (i.e. a 0.081% to 0.45% increase in monthly overnight stays for every additional snow day) and is significant in four out of the six regressions. Another interesting regression result concerns the impact of snowmaking on overnight stays. First, we note that some of the included variables are useful controls, especially ln *Transp. Cap* and lagged dependent variables – in fact, they are useful in case snowmaking investments complement those for transport facilities or if investments decisions in snowmaking respond to past visitation rates suffering major setbacks. At the .10 significance level, only two models reject the null hypothesis that both the coefficient on *Art. Snow* and the coefficient on the square of *Art. Snow* are zero.[7] In these two models, we can reject the hypothesis that the relationship between overnight stays and snowmaking is linear (i. e. the coefficient on the square of *Art. Snow* is significantly different from zero). Taking estimation results from model (3), we can predict a 0.56% increase in the number of monthly overnight stays with a change in *Art. Snow* of one kilometer given that its initial value is zero. For initial values of 10, 30, and 50 km, predicted percentage changes in the number of overnight stays are equal to resp. 0.53%, 0.47% and 0.41%. As regards the control variables, ln *Hotel Beds* is significant in all regressions in contrast to the other two hotel accommodation supply related variables which are significant in only one (*4–5 * Share*) resp. three regressions (ln *Beds/Estab*).

The variable depicting exchange rates is positive and significant in regressions (1)–(2), a result that we expected since a weakening of the Swiss currency should positively impact the foreign demand for winter holidays in Switzerland. However, this result does not hold whenever lagged values of the dependent variable are added to the model.

4.2 Skier visits regressions

Concerning skier visits, regression results obtained with different model specifications and different estimators are displayed in Table 2. The coefficient on *Snow Day* is significantly different from zero at the .05 significance level in all regressions. The coefficient value ranges from 0.0030 to 0.0042.

This means that one additional day with "good" snow conditions increases the number of skier visits by 0.30% to 0.42%. Values of the coefficient are slightly lower when using the alternative measure depicting snow conditions. In this case, the coefficient value ranges from 0.0017 to 0.0029 (i. e. a 0.17% to 0.29% increase in skier visits for every additional snow day) and is significantly different from zero at the .10 significance level in all regressions. According to the Hausman test, we should prefer estimation results from the random effects estimator to the ones obtained with the fixed effect estimator[8]. Using the former estimation results, a one kilometer increase in the snowmaking variable is estimated to increase skier visits by resp. 0.37%, 0.30%, 0.17% and 0.03% for initial values of snowmaking of 0, 10, 30, and 50 km. As regards weather conditions at ski areas, their impacts were not easily pinned down with our models, estimators and data as five out of six regressions found no significant impact of the variable *Sunny Days* on skier visits.Things are different for weather conditions in the lowlands whose impact on skier visits is estimated to be significantly negative in column (1) of Table 2. As they vary only according to winter seasons, their absolute effect is however estimated in this sole regression because it is the only one that does not include winter season dummies. We also found that

[7] cf the p-values of the F-statistics (Prob>F) in Table 1 Note also that it is not so surprising to find that snowmaking is not significant in model (2) which controls for Ski Resorts x Month effects since more than 80% of the *Art. Snow* variable's total variation lie across this dimension

[8] The statistics of the Hausman test fails to reject the null hypothesis that the random effects and fixed effects estimates are significantly different In that occurrence, random effects estimates are preferred because they should be more precise

weather conditions in lowlands impact skier visits differently depending on whether ski areas are located far from urban centers or not. In column (4) of Table 2, we can see that the negative effect on skier visits of the *W Atm.* variable is decreased by 0.0049 whenever the variable *Access* takes on the value 1[9].

5 Discussion

According to our estimates, every additional day where natural snow conditions allow skiing increases the number of monthly overnight stays in the 0.28% to 0.53% range and winter season skier visits in the 0.30% to 0.42% range. These two sets of results are not directly comparable as they are derived from different models, i. e. monthly versus seasonal. In particular, we expect partial effects on overnight stays to be lower at a more aggregated level. We verified this assumption by re-estimating Equation 1 using winter seasonal data. Doing so, we obtain a new set of estimated responses of overnight stays to snow conditions which are lying in the 0.24% to 0.45% range. Compared to the skier visits regressions, the estimated coefficient on *Snow Day* is smaller when using the first-diff., random and fixed effects estimators. For the whole winter season, we have therefore found a slightly greater impact of snow conditions on skier visits than on overnight stays which is not a surprising result per se. In fact, tourists should be less sensitive to snow conditions than day trippers (Harrer 1996; Luthe 2009) who only influence skier visits statistics. On the other hand, the relationship between tourism demand and snowmaking is not as clear as with natural snow. This difficulty could stem from our sample that covers only four winter seasons and also from the imperfect and error-prone measures of snowmaking that we have used in this paper. Still, our results indicate in four out of six regressions that snowmaking has a positive effect on skier visits. Moreover, the marginal effect is declining as the level of snowmaking investments increases. We expect a one kilometer increase in the snowmaking variable to increase skier visits by 0.37%, 0.30%, 0.17% and 0.03% for initial values of snowmaking of 0, 10, 30, and 50 km. One additional strength of our analysis was the possibility to test for the impacts of weather conditions on skier visits. We found no significant impact of weather conditions at ski areas (i. e. percentage of sunny days each winter season) in five out of six regressions. This surprising result might be due to the lack of relevance of the variable that we chose. Indeed, *Sunny Days* does not provide any information about when sunny days occurred during the winter season which might be more important than the overall number of these days. Another explanation of this result could be that day trippers rely on weather forecasts and meteorological bulletins rather than on actual weather conditions to set out on their journey though weather forecasts

[9] As a robustness check, we ran the regressions with the number of days with a snow cover averaged over the cities of Zurich, Bern, Basel and Geneva replacing the average temperature deviations based statistics that we used in Table 2 The main effect of the variable is positive and significant in regression (1) whereas the interaction term is negative in all regressions though significantly only in regressions (4)–(6) In regression (1), an increased winter feeling as measured by a one day increase in the alternative variable is expected to raise the number of skier visits by 0 16% for close to city agglomerations ski areas and by a reduced 0 076% for more remote ski areas

discrepancies are not as large as sometimes thought (Doctor & Scaglione 2007). Better results were found with the variable depicting weather conditions in lowlands although its absolute effect cannot be estimated whenever the regression includes winter season dummies. Because of the interaction term coefficient between the variables *W Atm.* and *Access* being positive and significant, we estimate the difference in partial effects for "close" and "remote" ski areas to amount to roughly 0.5% of the number of skier visits.

6 Conclusions

Without any doubt, more investigations need to be undertaken before communicating any firm conclusions to the different tourism stakeholders that could be interested in the results of such econometric studies. First, additional efforts need to be provided in order to base statistical inferences on more comprehensive, accurate and relevant data (e. g. obtain better data on skier visits or on snowmaking investments and use). Second, models should also be improved in order to explain changes in demand at the local level that arise due to differences in snow conditions between low- and higher-lying ski areas and/or between ski areas across the Alps. From this point of view, some of our results could still be flawed by some kind of (omitted variable) bias because of the visitation rates at some ski areas being also dependent on snow conditions at other places.

References

Abegg, B. 1996: *Klimaänderung und Tourismus*. Zürich.

Agrawala, S., B. Abegg, S. Jetté-Nantel, F. Crick & A. de Montfalcon 2007: *Climate change in the European Alps: Adapting Winter Tourism and Natural Hazards Management*. Paris.

ARE 2000: *Statistique ITT – Evolution des installations de transport touristiques*. Berne.

Bättig, M., N. Rom & R. Dettli 2011: *Anpassung an die Klimaänderung im Berggebiet Fallstudie Saastal*. Zürich.

Beniston, M., F. Keller & S. Goyette 2003a: Snow pack in the Swiss Alps under changing climatic conditions: an empirical approach for climate impacts studies. *Theoretical and Applied Climatology* 74: 19–31.

Beniston, M., F. Keller, B. Koffi, S. Goyette 2003b: Estimates of snow accumulation and volume in the Swiss Alps under changing climatic conditions. *Theoretical and Applied Climatology* 76: 125–140.

Bürki, R. 2002: *Klimaänderung und Wintertourismus im Obertoggenburg*. St. Gallen.

Doctor, M. & M. Scaglione 2007: *Étude de l'influence des prévisions météorologiques sur l'affluence aux remontées mécaniques en Valais pour la saison hivernale 2006–2007*. Sierre.

Ehrler, C. 1998: *Klimaänderung und alpine Schneedecke*. Zürich.

Elsasser, H. & R. Burki 2002: Climate change as a threat to tourism in the Alps. *Climate Research* 20: 253–257.

Elsasser, H. & P. Messerli 2002: The Vulnerability of the Snow Industry in the Swiss Alps. *Mountain Research and Development* 21: 335–339.

Gellens, D., K. Barbieux, B. Schadler, E. Roulin, H. Aschwanden & F. Gellens-Meulenberghs 2000: Snow cover modelling as a tool for climate change assessment in a Swiss Alpine catchment. *Nordic Hydrology* 31: 73–88.

Gonseth, C. 2007: Do snowmaking investments improve the financial situation of the ski area operation companies in the perspective of climate change? In: Borsdorf, A., J. Stötter & E. Veulliet (eds.): *Managing Alpine Future –Proceedings of the Innsbruck Conference October 15–17*. Innsbruck: 87–94.

Harrer, B. 1996: *Wirtschaftsgeographische Auswirkungen einer veränderten ökologischen Situation – Konsequenzen für den Wintertourismus in Deutschland.* Schriftenreihe des Deutschen Wirtschaftswissenschaftlichen Instituts für Fremdenverkehr an der Universität München 47. München.

Hoffmann, V. H., D.C. Sprengel, A. Ziegler, M. Kolb & B. Abegg 2009: Determinants of corporate adaptation to climate change in winter tourism: An econometric analysis. *Global Environmental Change-Human and Policy Dimensions* 19: 256–264.

König, U. & B. Abegg 1997: Impacts of Climate Change on Winter Tourism in the Swiss Alps. *Journal of Sustainable Tourism* 5: 46–59.

Luthe, T. 2009: *SkiSustain – Vulnerability to global change and sustainable adaptation of ski tourism.* Outdoor Sports and Environmental Science. Institute of Oudoor Sports and Environmental Science German Sports University Cologne, Cologne.

Marty, C. 2008: Regime shift of snow days in Switzerland. *Geophysical Research Letters* 35: 5. doi:10.1029/2008GL033998

Müller, H. & F. Weber 2007: *Klimaänderung und Tourismus: Szenarienanalyse für das Berner Oberland 2030*. Berne.

Scherrer, S. C. & C. Appenzeller 2006: Swiss Alpine snow pack variability: major patterns and links to local climate and large-scale flow. *Climate Research* 32: 187–199.

Serquet, G., C. Marty, J.P. Dulex & M. Rebetez 2011: Seasonal trends and temperature dependence of the snowfall/precipitation-day ratio in Switzerland. *Geophysical Research Letters* 38: 5. doi:10.1029/2011GL046976.

Töglhofer, C., F. Eigner & F. Prettenthaler 2011: Impacts of snow conditions on tourism demand in Austrian ski areas. *Climate Research* 46: 1–14.

Uhlmann, B., S. Goyette & M. Beniston 2009: Sensitivity analysis of snow patterns in Swiss ski resorts to shifts in temperature, precipitation and humidity under conditions of climate change. *International Journal of Climatology* 29: 1048–1055.

Vanat, L. 2010: *2010 International report on mountain tourism – Overview of the key industry figures for ski resorts. Preliminary issue.* Geneva.

Witmer, U., P. Filliger, S. Kunz, & P. Kung 1986: *Erfassung, Bearbeitung und Kartierung von Schneedaten in der Schweiz.* Geographica Bernensia G25. Berne.