DEMAND FOR DOWNHILL SKIING IN SUBARCTIC CLIMATES

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Accepted for publication in "Scandinavian Journal of Hospitality of Tourism"

Abstract

This paper investigates the determinants of ski lift revenues between 1998/1999 and 2014/2015 in 20 ski areas in Finland by differentiating amongst winter climate conditions. Results based on dynamic panel data estimations reveal that revenues depend positively on real GDP, snow depth, and an early Easter, and negatively on relative ski lift ticket prices. The magnitude of the link between ski lift revenues and snow depth is large, but ski areas in northern Finland are less sensitive to variations in natural snow depth than those in southern or central Finland. Winter seasons with low snowfall (i.e. between 30 and 75 per cent below average) lead to a reduction of 23 per cent in ski lift revenues in southern Finland, of eight per cent in central Finland, and of five per cent in northern Finland. A high amount of natural snowfall early in the winter also has a positive impact on revenues for the overall season. Despite strong investments in snowmaking facilities, even ski areas at the highest northern latitudes are not insensitive to variations in natural snowfall.

Keywords: winter tourism, Finnish ski resorts, snow depth, climate change, demand for downhill skiing.

Introduction

The demand for downhill skiing and snowboarding has entered a stagnation phase (Vanat, 2016). This holds particularly true for the European Alps and North America. For a long period of time, the Finnish downhill skiing market had been an exception. Lift ticket revenues (in constant prices) in the country increased by 2.1 per cent per year on average for the period 1996/1997 to 2014/2015 (based on aggregate data on the largest 11 ski areas for which continuous time series are available). From the 2008/2009 winter season onwards, however, ski lift revenues have stagnated in real terms.[1]

Many Finnish ski destinations have the advantage of being located at a high latitude, where relatively cold, moist, and snowy winters are less affected by extremely mild winter seasons with low snowfall (Autio & Heikkinen, 2002). That said, global warming is a major concern not only for snow-based winter tourism in moderate climate zones like the Alps, but also for winter tourism in Finland (Haanpää, Juhola, & Landauer, 2015; Tervo, 2008; Tervo-Kankare, 2011; Tervo-Kankare, Hall, & Saarinen, 2013).

The aim of this paper is to investigate the determinants of demand for downhill skiing (including snowboarding) for Finland at the ski destination level in terms of lift ticket revenues in constant prices. These factors include real income, prices, snow conditions, and calendar effects (e.g. an early Easter). Snow conditions are measured as snow depth in the early season and in the main winter months. The relationship between the revenues sales of ski lift companies and snow depth is allowed to vary across different climate zones. We use dynamic panel data models based on 20 Finnish ski areas for the period 1996/1997 to 2014/2015, which enables us to capture the growth phase in the 2000s and the stagnation phase from 2008 onwards.

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[1] The data is provided by the Finnish Ski Area Association (SHKY), http://www.ski.fi/en/.

Finnish ski areas are an interesting region in which to study the determinants of the demand for downhill skiing. First of all, the country's ski destinations are located in different climate zones, including both the high-latitude Finnish Lapland and southern Finland. Second, Finnish ski lift passes are reported to be among the cheapest in Western Europe (Vanat, 2016). Finally, few studies have investigated the demand for downhill skiing using revenue data for ski lift companies.

The biggest ski resorts are located across the Arctic Circle. The largest and the fastest-growing resort is Levi (Kittilä), which welcomes some 400,000 skiers per season (SHKY, 2016). Traditionally, the vast majority of downhill skiers in these destinations are domestic residents (Konu, Laukkanen, & Komppula, 2011), but the number of foreign skiers has recently increased (SHKY, 2016).

Many empirical studies have investigated the determinants of downhill skiing demand. Studies that focus on the relationship between the demand for downhill skiing and weather factors or climate variability include Dawson, Scott, and McBoyle (2009) and Englin and Moeltner (2004) for the US, and Pickering (2011) for Australia. Studies for Central and Western Europe include Damm, Köberl, and Prettenthaler (2014); Falk (2010); Töglhofer, Eigner, and Prettenthaler (2011) for Austria; Demiroglu, Kučerová, and Ozcelebi (2015) for Slovakia; and Gonseth (2013) for Switzerland. For the Nordic countries, relatively few studies are available. Malasevska, Haugom, and Lien (2016) investigate the role of weather factors for one ski area in Norway using daily data. Another study based on Swedish ski resorts uses aggregate monthly data (Falk & Hagsten, 2016). A recent paper by Demiroglu, Dannevig, and Aall (2016) investigates the role of climate change in the evolution of summer skiing on glaciers in Norway. However, these studies are difficult to compare due to differences in units of time (annual, monthly, or daily), aggregation levels (aggregate or ski-area level), definitions and measurements of skiing demand (skier visits or lift ticket revenues), the inclusion or exclusion of economic factors such as prices and real income, and the methodology applied (static or dynamic models, or descriptive statistics). Not surprisingly, the magnitude of the relationship between weather factors and skiing demand differs considerably between studies based on their varying dependence on natural snow depth. Examples of this dependence include Australia (Pickering, 2011), Michigan in the U.S. (Shih, Nicholls, & Holecek, 2009), and Switzerland (Gonseth, 2013), whereas examples of low sensitivity to snow depth include Austria (Falk, 2010; Töglhofer et al., 2011).

Using weekly data on college students, Englin and Moeltner (2004) find that the trip demands of skiers and snowboarders are more responsive to price changes than to changes in snow depth. Studies based on daily data naturally result in large estimates of the impact of natural snow on skier visits (Damm et al., 2014; Demiroglu et al., 2015; Hamilton, Brown, & Keim, 2007; Shih et al., 2009). Gómez-Martín (2005) suggests that the data frequency at hand is crucial when estimating the tourism effects of weather. Over a longer period (say, an entire winter season), weather tends to have less of an effect on tourism flows. Despite the increasing number of studies investigating the demand for downhill skiing, there is still no consensus regarding the role of weather conditions and economic factors.

The main contribution of this paper is the initial investigation it offers into the determinants of skiing demand using a representative data set on the 20 largest ski lift companies in a Nordic country. Specifically, we investigate whether and to what extent the determinants of skiing demand vary in different locations (northern and central Finland vs. southern Finland). To the best of our knowledge, no study is available that investigates the determinants of skiing demand in high-latitude ski areas such as the Arctic Circle. Ski areas in this region are likely to be less affected by variations in snow conditions due to their high latitude, which guarantees a long season. However, ski areas in the south of Finland, which are mainly visited by day-trippers, might be more affected by varying snow depths. The structure of this study is as follows. The following section describes the downhill skiing industry in Finland. The third section introduces the empirical model, and the fourth presents the data. The fifth section lays out our findings, and the last section offers some conclusions.

The Finnish downhill skiing market, snow conditions and climate change

The more than 100 ski areas operating in Finland are concentrated in the northern and central areas of the country (Konu et al, 2011).[2] The Finnish ski market can be divided into three distinct regions, including the south, which is characterised by very small ski areas at low elevations. Skiing in southern Finland can be considered a day- or weekend-type activity that does not involve inordinate travelling costs for visitors. To some extent, this also applies to resorts located in central Finland.

The Finnish downhill skiing market is characterised by several factors: First, the Finnish climate is determined by a latitudinal gradient, the maritime climate from the Atlantic Ocean, the continental climate from Eurasia, the Scandinavian mountain range, and the Baltic Sea in southwestern Finland. The country's geographic length results in seasonal variability, with thermal winter in southwestern Finland lasting about 100 days on average and those in northern Finland enduring for about 100 days longer. In addition, the permanent snow season lasts in northern Finland 150 to 190 days (Drebs et al., 2002; Veijalainen et al., 2010). The temperature gradient is especially strong in winter, which affects the accumulation of snow in the northern and eastern parts of Finland. According to snow statistics from the Finnish Meteorological Institute (FMI), permanent snow typically comes to Lapland sometime between October and November depending on the latitude in question.[3]

Finland also has a sparse and unevenly distributed population, with an average of 18 inhabitants per square kilometre in 2014 (Statistics Finland, 2016). The population of Finland

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[2] As of March 2016, SHKY's web page (http://www.ski.fi/hiihtokeskukset) displayed 70 ski resorts.

[3] However, as an example of snow uncertainty in Lapland, the traditional mid-November start of the FIS Alpine Ski World Cup season in Levi was cancelled three times between 2004 and 2015 due to a lack of snow.

is heavily concentrated on the southwest plain, while the most important ski resorts are situated in Lapland – 800 to 1,100 kilometres away from the main market. In Lapland, for example, there are only two inhabitants per square kilometre on average. This indicates that the composition of those travelling to ski areas differs between ski areas in the north and south. While ski areas in the south attract a large share of day-trippers, visitors to northern ski areas stay longer, and thus need accommodation. Consequently, skiers spend more time and money travelling to northern resorts, although the Finnish railway company has announced a decrease in ticket prices.

The last 50 years in Finland have witnessed a decrease in the number of days with acceptable snow conditions for downhill or cross-country skiing (defined as days with at least 30 centimetres of snow). The most recent climate change scenarios run by Arctic Climate Impact Assessment (ACIA, 2004) for the Arctic Circle region predict that winter temperatures will rise by almost twice as much as those recorded in the summer (see also Jylhä et al., 2008; Nicholls & Amelung, 2015; Stroeve et al., 2012; and Tervo-Kankare, 2011). Although ACIA's projections vary significantly by the model applied and the Arctic region and season in question, the models suggest higher future winter temperatures in the Nordic countries, as well. In particular, the boundary of appropriate winter snow coverage is expected to shift northward and to higher elevations. The first frost will arrive three to four weeks later, and winter temperatures will increase by at least three degrees (Jylhä et al., 2008). Projections also indicate 40 to 60 fewer days with snow cover, with the greatest decrease expected in southwest Finland (Tervo, 2008). Tervo-Kankare et al. (2011) suggest that in Rovaniemi, a slightly snowy (read: less than 10 millimetres) or snowless Christmas is to become more frequent, with every fourth Christmas being snowless by the late 21st century. In fact, our own calculations (based on FMI's snow depth data for the early season from 10 Finnish weather stations for the period 1996-2015) show a significant downward trend, from 26 to 21 centimetres in absolute terms.

Theoretical background and empirical model

The skiing demand equation can be derived from the utility maximisation model of (outdoor) recreation demand. The starting point is an indirect utility function at the individual level: Here, consumers maximise their indirect utility, which can be attained from consumption of specific outdoor recreation activities and non-recreational activities (Phaneuf & Smith, 2005). Linear budget and time constraints are typically assumed, as most people have a limited amount of time and money to spend on travelling, engaging in leisure activities at their destination, and purchasing complementary goods (Phaneuf & Smith, 2005). Maximising utility results in the true underlying Marshallian demand, where the number of trips taken depends on the cost of travelling to the site in question (in this case, ski areas) and skiing, as well as on individual characteristics, site-specific characteristics, and factors that are common across individuals and ski areas (Englin & Moeltner, 2004; Morey, 1984). The person-specific variables include real income and socioeconomic characteristics, while the factors affecting all individuals consist of weather conditions, seasons, holidays, and events. Site-specific characteristics include ski area size, ski lift capacity, and ski lift quality.

Representative individual data on recreation and leisure trips is difficult to obtain, however, which is why we use an aggregate recreation demand model as suggested by Bergstrom and Cordell (1991). The aggregate skiing demand model assumes that full capacity is not achieved, so short-run supply can be considered as perfectly elastic (Morley, 2009). Weak separability is also assumed between skiing trips and related consumer goods. This means that income and the prices of said goods (ski rentals, accommodation, restaurant visits, etc) only influence the skiing demand function through their effect on total expenditures.

In general, related theoretical models describe individual trip decisions, while recreation demand at the aggregate level is a product of individual behaviour (Marvasti, 2013). One main limitation of aggregate recreation demand models is that income and price elasticities do not accurately reflect individual skiers. This is commonly regarded as "aggregation bias" (Moeltner, 2003). Income and price elasticities should thus be interpreted with caution, even though they are not the key parameters of interest in this study.

The aggregate demand for skiing and snowboarding is specified as a function of ski lift ticket prices, real income, early Easter holidays, and snow depth. Since the data available on the number of skier visits is incomplete, demand is measured in terms of ski lift revenues in constant prices. We also distinguish between average snow depth in the main winter months and snow conditions in the early season. This is particularly interesting because over the period 1995-2015, FMI's statistics on snow depth in December show a declining trend, whereas average snow depth from December to February is stable.

The static skiing demand model at the aggregate ski area level can be specified as follows:

$$\begin{aligned} ln\,REV_{it} &= \alpha_i + \alpha_{1,i}\, ln(P_t / CPI_t) + \alpha_{2,i}\, ln\,Y_t \; + \alpha_{3,i}\, ln\,Snowdepth_{it} \\ &+ \alpha_{4,i}\, ln\,Snowdepth_{it} \times DREG_i \; + \alpha_{5,i} EarlyEast + \varepsilon_{it} \end{aligned}, \qquad (1)$$

where *i* denotes ski areas (1...20) and *t* denotes the time period (1996/1997 to 2014/2015). *ln* represents the natural logarithm and *REV* denotes ski lift revenues for the winter season, deflated by the valued-added deflator for the corresponding period. *P* denotes ski lift ticket prices in terms of unit value (revenues divided by number of skier visits to the seven largest ski areas). Note that we do not include individual ski lift ticket prices (measured as revenues per skier visit) because this leads by definition to a correlation between the left- and right-hand variables. *CPI* denotes the consumer price index for the winter season (measured as the average from November to April). *Y* represents domestic GDP per capita in constant prices (the average for autumn and spring). *Snowdepth* refers to the average monthly snow depth at the nearest weather station. Meanwhile, two measures are employed: one for the winter season (defined as December to January) and the other for December. The latter captures the potential variance in how good snow conditions affect lift revenues in the early winter season. Furthermore, we include an interaction term between the snow depth variable and a dummy variable that equals one if a given ski lift company is located in one of the regions (*DREG*, southern Finland, or central and northern Finland). This makes it possible to test whether the relationship between snow depth and lift revenues varies across regions. The sensitivity of downhill skiing demand to natural snow conditions is expected to depend on latitude, with larger effects for southern Finland. *EarlyEast* is a dummy variable that takes the value of one when Easter Sunday falls in March, and zero otherwise. ε_{it} is the usual error term, which is assumed to be identically and independently distributed with a zero mean and constant variance, i.e. $\varepsilon_{it} \sim IID(0,\sigma^2)$. α_i denotes the ski-area fixed effect that accounts for unobservable time-invariant factors specific to certain ski areas, such as location, size, elevation, and maximum vertical distance. Since ski lift revenues, real GDP, and prices are transformed into logarithms, the coefficients can be interpreted as elasticities. While it would be preferable to use GDP weighted by the corresponding share of visitor countries, the majority of skiers and snowboarders are domestic residents (Konu et al., 2011).

The static model can be transformed into a dynamic model using an autoregressive distributive lag (ARDL) specification. After some transformations, a dynamic tourism demand equation is obtained, which can be written in the form of an error correction model:

$$\Delta \ln REV_{it} = -\phi_i \begin{pmatrix} \ln REV_{i,t-1} + \theta_1 \ln Y_t + \theta_2 \ln(P_t / CPI_t) + \theta_3 \ln Snowdepth_{it} + \\ \theta_4 \ \ln Snowdepth_{it} \times DREG_i + \theta_5 EarlyEast + \theta_{6,i} \end{pmatrix} \\ + \text{short - term differences} + v_{it} \quad , \qquad (2)$$

where i is the ski area and t is the period from 1997/1998 to 2014/2015. ϕ denotes the error correction coefficient. θ_3 and θ_4 are the key parameters used to calculate the "snow elasticity of demand" (Englin & Moeltner, 2004). Since the time period is relatively large given the small number of cross-sectional units, we use panel time-series estimators. The pooled mean group estimator (PMG) (Pesaran, Shin, & Smith, 1999) or the mean group estimator (Pesaran & Smith, 1995) can be used to estimate the error correction model applied to the panel data. The PMG estimator keeps the long-run coefficients ($\theta_1,\ldots,\theta_6$) similar across cross-sectional units, but allows short-run coefficients to vary. Assuming common long-run slopes, the PMG estimator is much more efficient than the mean group estimator. To avoid the problem of spurious regression, it is necessary to determine the order of integration of the data. This is done using panel unit root tests and standard augmented Dickey-Fuller tests.

Data and descriptive statistics

We focus on the 20 largest ski areas for which data is available in the period 1997/1998 to 2014/2015. The five ski areas in the south generated about €5.5 million in lift ticket revenues, whereas those in central and northern Finland accounted for €8.3 and €31.1 million, respectively (based on SHKY's data for 2014/2015). In the north, ski areas are typically large and at higher elevations with a higher vertical drop. The highest peak stations are Levi (500 metres a.s.l.) and Ylläs (700 metres a.s.l.). However, elevation is less important in high-latitude areas.

The outcome variable is lift ticket revenues, which are provided by SHKY and deflated by the value-added deflator. Lift ticket revenues are measured including VAT. Since the changes in VAT rates were quite small over the sample period (one percentage point each in 2010 and 2013), we do not adjust the revenues and prices accordingly. The consumer price index, the

GDP deflator, and GDP in nominal prices for the winter season are drawn from the Eurostat database. GDP in current prices is deflated by the GDP deflator. Since a detailed price index at the ski area level is not available for the total sample of 20 ski areas, we use the implicit deflator of the seven largest ski areas as a proxy for ski lift ticket prices. In order to get an idea of the quality of the price index, we compared the official price index for recreational and sporting services against the corresponding unit values. Unreported results show that ski lift ticket prices essentially match the price index for recreational and sporting services. Since we employ a dynamic model, the sample period runs from 1998/1999 to 2014/2015. For some ski areas, no revenue data is available for earlier years. Therefore, the estimation sample is based on unbalanced panel data with 326 observations.

The Finnish Meteorological Institute provides daily figures for all of its weather variables, including temperature and snow depth.[4] For the daily snow depth data, which is aggregated at the monthly level, we use two different measures: One refers to the December-January period, and the other covers only December as an indicator of snow conditions in the early season. The nearest weather station is assigned to each ski resort (see Table 1 in the appendix).

Table 2 presents descriptive statistics for the variables over time while distinguishing between the two subsamples. Lift ticket revenues in the south of Finland (Panel A) are generally more volatile than those in other Finnish areas, with the standard deviation indicating a strong decline in winter seasons with low snowfall. The unweighted median changes in lift ticket revenues in constant prices (deflated by the GDP deflator for the winter season) for the three subsamples (southern, central, and northern Finland) are 2.8 per cent, 1.7 per cent, and 3.1 per cent, respectively. The standard deviation of changes in lift ticket prices in the south (24.2) is much higher than in northern Finland (5.9).

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[4] Since weather data for some weather stations contains partial gaps, FMI has provided interpolated snow depth data using the lat-lon hila model.

Table 2. Descriptive statistics

Panel A. Ski lift revenues in constant prices and snow depth

	change in lift ticket revenues in constant prices, % (median)			snow depth of the nearest weather station Dec-Jan, cm			snow depth of the nearest weather station Dec, cm		
Season	south	central	north	south	central	north	south	central	north
1997-98	16.3	23.5	10.6	18.3	25.3	41.6	10.9	17.0	31.0
1998-99	10.3	-1.9	-2.7	20.9	19.2	36.6	9.7	10.5	27.7
1999-00	1.7	6.7	6.6	21.2	36.8	45.2	17.2	31.2	35.7
2000-01	-10.2	-4.8	5.1	12.6	13.5	21.6	2.3	3.9	12.7
2001-02	19.5	15.4	1.6	17.0	23.9	32.8	13.8	18.3	25.6
2002-03	15.9	-0.9	0.8	28.2	42.0	43.4	22.1	35.5	33.3
2003-04	-2.7	7.4	9.0	17.8	21.2	27.2	7.1	8.5	16.6
2004-05	8.6	8.7	1.7	16.6	29.2	40.0	11.1	19.4	28.3
2005-06	8.1	-3.4	3.5	24.3	31.0	36.9	20.7	23.4	29.2
2006-07	-42.0	-22.7	0.9	7.5	8.8	30.5	0.6	2.5	20.6
2007-08	-8.6	12.5	16.4	6.0	9.8	28.0	1.2	4.2	20.7
2008-09	39.1	9.9	2.9	10.9	20.8	37.5	5.9	17.3	33.8
2009-10	8.4	-2.4	-9.2	26.0	23.6	30.4	7.8	9.4	23.8
2010-11	18.2	4.2	-4.6	39.1	44.8	36.6	23.0	27.3	26.7
2011-12	-23.1	-11.7	5.9	19.3	31.0	35.3	1.7	13.2	23.3
2012-13	27.9	19.2	4.7	35.4	33.5	39.3	26.7	23.7	29.9
2013-14	-57.7	-33.2	-2.3	5.4	14.6	39.6	2.9	15.1	33.6
2014-15	19.8	4.0	4.2	17.8	30.6	41.9	5.9	16.1	31.0
Average*	2.8	1.7	3.1	19.1	25.5	35.8	10.6	16.5	26.9
Standard deviation.	24.2	14.1	5.9	9.2	10.3	6.3	8.3	9.3	6.3

Panel B. Real GDP, prices and early Easter

Season	change in relative prices, %	change in GDP in constant prices, %	Early Easter in March Dummy
1997-98	0.9	6.0	0
1998-99	0.6	5.2	0
1999-00	2.6	4.7	0
2000-01	3.9	4.4	0
2001-02	1.3	1.1	1
2002-03	2.3	1.8	0
2003-04	2.7	3.2	0
2004-05	-2.2	4.3	1
2005-06	4.1	2.4	0
2006-07	3.1	4.3	0
2007-08	-1.2	4.8	1
2008-09	-4.1	-6.2	0
2009-10	2.5	-3.3	0
2010-11	5.4	4.8	0
2011-12	-0.9	0.4	0
2012-13	0.5	-2.7	1
2013-14	-0.2	0.1	0
2014-15	3.2	-0.4	0
Average*	1.4	1.9	0.2
Standard deviation	2.4	3.4	0.4

Source SHKY, Statistics Finland, Eurostat and Finnish Meteorological Institute (FMI). * Calculated as unweighted means.

The higher volatility of ski lift revenues in southern Finland compared to northern Finland likely reflects the higher degree of uncertainty in southern snow conditions. For the total sample, the average annual GDP growth rate was 1.9 per cent per year, with stagnation from 2010/2011 onwards. The average snow depth at the nearest weather station during December and January was 19 centimetres in areas in the south, 26 centimetres in central Finland, and

36 centimetres in the north. It is important to note that the relative difference in snow depth between the early season and the average is more pronounced in the south of Finland than in the other areas. This reflects the shorter southern snow season.

Figure 1 in the appendix shows that higher snow depth in the December-January period leads to a higher growth rate in lift revenues. Meanwhile, Figure 2 shows that the growth in lift ticket revenues is higher when Easter comes early. The correlation between the change in ski lift revenues and the change in snow depth seems to be highest among ski lift companies in southern Finland (r=0.82, p<0.01), followed by those located in central Finland (r=0.47, p<0.01). For northern Finland, the correlation is weak and only significant at the 10 per cent level (r=0.14, p=0.07). This again indicates that revenues are more sensitive to snow depth in the south of Finland than in other areas.

Empirical results

Before the results of the dynamic panel data model are reported, panel unit root tests are conducted. The results of the panel unit root tests developed by Im, Pesaran, & Shin (2003) show that revenues in constant prices for the different ski destinations are all integrated of order one (see Table 4 in the appendix). Unreported results show that lift ticket revenues are stationary in first differences. Similarly, standard augmented Dickey-Fuller tests show that relative prices and real GDP are integrated of order one and stationary in first differences. Furthermore, panel unit root tests for the snow variable reveal that snow depth at the 10 weather stations was stationary in most cases. Given that the dependent variable and at least one explanatory variable are integrated of order one and the remaining variables are stationary, we employ the error-correction model applied to panel data.

Table 3 shows the results of the pooled mean group estimator for the determinants of ski lift revenues for the winter season, deflated by the GDP deflator. It includes the long-run coefficients and the error-correction coefficient. The variables in first differences are restricted to the contemporaneous period and are not reported.

Table 3. Results of the dynamic panel data model on the determinants of ski lift revenues

	specification (i) with snow depth measured as average December to January								
	coeff		z	coeff		z	coeff		z
ln real GDP per capita	1.61	***	7.40	1.69	***	7.59	1.58	***	7.05
ln relative prices	-0.76	**	-2.43	-1.04	**	-3.26	-0.75	**	-2.32
ln snow depth Dec-Jan	0.19	***	6.63	0.27	***	7.64	0.25	***	8.97
ln snow depth Dec-Jan Dummy region south	0.13	**	2.56						
ln snow depth Dec-Jan Dummy region central				-0.06		-1.32			
ln snow depth Dec-Jan Dummy region north							-0.09	*	-1.72
Dummy early Easter	0.09	***	3.95	0.10	***	4.15	0.09	***	4.11
error-correction coefficient	-0.57	***	-8.05	-0.55	***	-7.56	-0.56	***	-7.89
constant	-6.17	***	-7.73	-6.60	***	-7.28	-5.93	***	-7.48
# observations	326			326			326		
# of ski areas	20			20			20		
Log Likelihood	384.1			382.1			382.3		
	specification (ii) with snow depth measured as average of December								
	coeff		z	coeff		z	coeff		z
ln real GDP per capita	1.61	***	8.01	1.70	***	8.29	1.64	***	7.72
ln relative prices	-0.28		-1.08	-0.48	*	-1.78	-0.50	*	-1.81
ln snow depth Dec	0.11	***	5.06	0.14	***	6.59	0.14	***	6.40
ln snow depth Dec Dummy region south	0.08	***	2.59						
ln snow depth Dec Dummy region central				-0.04		-1.17			
ln snow depth Dec Dummy region north							-0.04		-1.20
Dummy early Easter	0.09	***	4.43	0.10	***	4.50	0.09	***	4.11
error-correction coefficient	-0.57	***	-8.18	-0.55	***	-8.29	-0.55	***	-8.28
constant	-5.96	***	-7.67	-6.37	***	-7.80	-6.04	***	-7.68
# observations	326			326			326		
# of ski areas	20			20			20		
Log Likelihood	355.9			353.9			353.9		

Note: ***, ** and * denote significance at the 1 %, 5 % and 10 % level. The dependent variable is the change in the log number of ski lift revenues in constant prices. Estimated by the pooled mean group estimator. Coefficients can be interpreted as long-run elasticities. Short run elasticities are not reported but available upon request.

Since the relationship between ski lift revenues and snow conditions is expected to differ between southern, central, and northern Finland, interaction terms between the location and snow depth variables are introduced. The upper panel (i) shows the estimation results when snow depth is measured as the average for December and January, while the lower panel (ii) includes snow depth for December as proxy for the early season. The latter specifications offer insights into how important early snow is to ski resorts' revenues over the entire season, as prior studies have suggested. For the total sample, the dynamic panel model uses data from 326 observations of 20 ski areas for the period 1997/1998 to 2014/2015. The panel cointegration test, which is based on the significance of the error-correction coefficient developed by Westerlund (2007), shows that the null hypothesis of no cointegration can be rejected at the one per cent level in all cases. This indicates a long-run relationship between lift ticket revenues, real GDP, relative prices, an early Easter, and snow conditions. The long-run coefficients can be directly interpreted as long-run elasticities.

The key result provided by Table 3 is that natural snow depth is positive and highly significant. The interaction terms between the snow depth variables and the dummy variable for different locations are significant for ski areas in the south and weakly significant for those in northern Finland, with opposite signs indicating that the importance of snow depth differs across locations. The interaction term between the snow depth variables and the dummy variable for ski areas in the south of Finland is 0.13 with a z-value of 2.56, reflecting that skiing demand is significantly more sensitive to snow depth in the south than in the other ski areas. The corresponding total long-run elasticity is 0.32 (based on specification i, calculated as 0.19+0.13). This implies that an increase in average snow depth by 10 per cent compared to the previous season will cause lift ticket revenues to rise by three per cent. The corresponding elasticity for ski areas in northern Finland is 0.16 (+0.25-0.09). This indicates that the ski areas at higher latitudes are much less sensitive to variations in natural snowfall. For ski areas in central Finland, the corresponding snow depth elasticity is 0.21 (see specification i). Overall, the results clearly show that the magnitude of the relationship between snow depth and lift ticket revenues depends on the location, with higher latitudes correlating with lower sensitivity.

In order to obtain an idea of the revenue impact of winter seasons with extremely low snowfall, we calculate the decline in snow depth on ski lift revenues using snow depth data for the winter season 2007/2008. In the south of Finland, this season witnessed the lowest snow depth in 20 years (which was similar to the situation in Sweden; see Brouder and Lundmark, 2011). The 2000/2001 and 2006/2007 winter seasons were also characterised by low natural snow cover in Finland. In these seasons, the decline in snow depth amounted to 30 per cent in northern and central Finland, and about 75 per cent in the south for each season compared to the sample average. Calculations show that these winter seasons led to a reduction in lift ticket revenues of about 23 per cent (calculated as 0.75*(0.19+0.13)) in the south of Finland and about five per cent in the north (calculated as the snow depth elasticity of 0.16 multiplied by the 30 per cent reduction in snow depth).[5] In central Finland, the decline was about eight per cent (calculated as the snow depth elasticity of 0.27 times the 30 per cent reduction).

In terms of revenue, winter seasons with extremely low snowfall lead to revenue losses of €1.3 million in the south, €0.7 in central Finland, and €1.5 million in northern Finland in a given winter season.[6] However, the calculations only reflect the direct effect on the ski lift companies; the indirect losses suffered by complementary companies (ski schools, restaurants, hotels, etc.) are much higher.

The sensitivity of lift ticket revenues to changes in snow cover is somewhat surprising in light of the widespread use of snowmaking facilities in Finnish ski areas. According to a survey of ski lift companies, 96 per cent are equipped with snowmaking facilities, and 19 per cent stockpile (or farm) snow.[7] One explanation for this sensitivity is that tourists prefer large amounts of natural snow, which make off-piste skiing possible. Another explanation is that winter tourists prefer the “real” winter feeling that comes with snow-covered trees and grounds (Tervo-Kankare et al., 2011).

Furthermore, lift ticket revenues are sensitive to a lack of snow not only in the main winter season, but also in the early season (specification ii). This indicates that revenues for an overall winter season are higher when winter arrives early. Here, the snow depth coefficients are again highest for ski areas in the south (with an elasticity of 0.19) and lower in the other

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[5] Elasticities that are statistically significant at the 10 per cent level or better are used to calculate the effects.

[6] Assumptions are 75 per cent decline in snow depth in the south and 30 per cent and in central and north Finland with elasticities of 0.32, 0.27 and 0.16, respectively. Total revenues are € 5.6 million in the south, € 32 million in the north and € 8.3 in central Finland.

[7] Personal correspondence with SHKY.

regions. Note that the strong dependence of lift revenues on snow depth in the early season in southern Finland is a threat to local ski lift operators, as snow depth in December clearly trended downwards at the 10 weather stations over the sample period. The ski resorts affected thus need to offer winter sport activities that do not require snow.

Our results are difficult to compare with previous studies for a number of reasons. For Swiss ski areas, for instance, Gonseth (2013) uses a different measure of snow depth (number of days with 50 centimetres or more); for Sweden, Falk and Hagsten (2015) employ aggregate monthly data on lift ticket revenues. For Austria, Falk (2010) and Töglhofer, Eigner, and Prettenthaler (2011) utilise overnight stays at ski resorts as the outcome variable, which is an imperfect proxy of skiing demand. The latter studies find that variations in natural snow depth have a small impact on overnight stays. An analysis of the extremely warm winter season of 2006/2007, during which the number of persons transported uphill declined significantly, presents an exception (Steiger, 2011). The main finding of this study is that the sensitivity of lift ticket revenues with respect to natural snow conditions is more pronounced than indicated by a recent study of Swedish data (Falk & Hagsten, 2016).

Economic factors such as GDP and relative prices also have a significant impact on skier visits. While the long-run GDP coefficient measures income elasticity, the long-run relative price coefficient captures the elasticity of relative ski lift ticket prices in a given ski area. Income elasticity is about 1.6, and the price elasticities range between -0.75 and -1.04. It appears that price elasticity is consistent with earlier studies on the demand for snow-based winter tourism (e.g. Falk & Hagsten, 2016). Income elasticities greater than one are frequently interpreted to be associated with superior or luxury goods, and income elasticities lower than one with necessity goods.

When Easter comes early (i.e. in March) we find a significant ($p<0.01$) increase in ski lift ticket revenues of nine to 10 per cent**.** This suggests that an early Easter has a positive impact on total revenues in the same season. Basically, the timing of Easter can have either a positive or negative effect on ski revenues. In principle, a late Easter lengthens the season, possibly leading to higher ski revenues for the whole season. On the other hand, a late Easter with warmer and sunnier weather can turn people's attention from winter to spring activities. This can make it more difficult for ski resorts to attract visitors, leading to a decline in ski lift revenues. Spring can also induce substitutes for skiing trips, such as flights to the south. Warmer and sunnier days can also decrease slope quality and cause icy morning slopes. As the day goes on, snow can even start to melt and turn to slush. While our results support the finding that an early Easter is favourable to the performance of ski lift companies, Easter only fell in March four times during the sample period (see Table 2, last row). This conclusion is thus rather tentative and requires additional research.

Several robustness checks are performed to assess the sensitivity of the results. First, we investigate whether a nonlinear relationship exists between lift revenues and snow depth (Englin & Moeltner, 2004). It is possible that the impact of snow depth on ski lift revenues declines in magnitude as snow depth increases. Unreported results show that the squared term is not significantly different from zero. Second, we include snow depth in the south of Finland as an explanatory variable for ski lift revenues in central and northern Finland. This makes it possible to test the so-called backyard hypothesis (Hamilton et al., 2007). However, unreported results show that lift revenues in ski areas in northern and central Finland are not affected by a lack of snow in the south, but rather by variations in snow depth in ski areas themselves. Third, we include a time trend to account for macroeconomic factors, but find that the correlation between this trend and relative prices is 0.95. Given the very high degree of multicollinearity, we are unable to isolate the effects of the time trend from those of the relative prices. Finally, temperature variables have never been significant at conventional significance levels and are therefore not included in the final specification.

Conclusion and implications

This study explores the demand for downhill skiing in 20 ski destinations in Finland. It focuses in particular on the relationship between snow depth and skiing demand. The results of dynamic panel data models show that ski lift revenues depend on real income, relative ski lift ticket prices, snow depth in the main winter months and the early season, and the early Easter effect. Ski destinations located at high latitudes are less sensitive to variations in snow depth. Poor snow conditions are particularly a threat to ski lift operations in the southern part of Finland, but global warming is also a major concern for ski destinations in northern latitudes. Here, climate change scenarios project a strong increase in winter temperatures and a decline in snow cover for the Arctic Circle region.

Our results have several implications for ski lift companies, winter tourists, destination marketing organisations (DMOs), and government institutions. Given that Finland features a large longitudinal profile and significant climate differences between its northern and southern regions, different strategies are required depending on the latitude at hand. Areas in southern Finland in particular should undertake actions to reduce their dependence on natural snowfall. Some advisable strategies include developing non-snow-based leisure activities and consolidating lift transport capacity. Modernising snowmaking facilities is also an option, but seems very unfavourable due to the high levels of energy and water consumption and the ecological impacts involved (Kaján & Saarinen, 2013). Meanwhile, Finnish ski areas could benefit from deteriorating snow conditions in competing markets such as the European Alps. This would require DMOs and ski lift companies to refine their marketing strategies to attract more long-distance travellers. This potential should not be overestimated, however: Skiers might simply delay their travel decisions until snow conditions improve in their home countries, resulting in an unwillingness to fly abroad. Increased air travel is also problematic due to the attendant rise in greenhouse gas emissions.

Another strategy for ski lift companies could be to introduce flexible or value-based pricing (e.g. Hinterhuber & Liozu, 2014; Talluri & Van Ryzin, 2005). Companies are already using package pricing and a number of revenue management practices (Pellinen, 2003). Ski lift operators could implement price premiums in periods of high demand (e.g. around Christmas and during early Easter seasons) and discounts when demand is low (under poor snow conditions, for example). Although today's lift operators use some forms of strategic pricing, there is still room for fine-tuning and modifications. For instance, price discounts could be introduced when not much snow has fallen in the early winter season.

The results of this study indicate that the prospects of major Finnish ski areas will remain quite modest unless people living in the country's large southern agglomerations gain better access to these destinations. From the skier perspective, the declining natural snow depth projected by ACIA (2004) for Finland's southern ski areas will imply longer travel distances from the populated parts of Finland to the north, along with negative environmental impacts similar to those seen in Sweden (Moen & Fredman, 2007). Another threat to the domestic ski industry is the increased demand for long-haul trips. Statistics show that the number of domestic trips in general has increased by a third in the last 10 years, while trips to destinations abroad have doubled over the same period (Statistics Finland, 2015). Consequently, government institutions could create better transportation infrastructure and connections between northern and southern Finland by paying attention to environmentally friendly modes of transport as suggested, for example, by Gössling and Hall (2008).

This study has several limitations. For instance, the time period of 18 years is relatively short. Future research should use a longer time span or monthly data. Second, we focus solely on downhill skiing, whereas husky, reindeer, and snowmobile safaris are known as important activities for foreign visitors to Finland in the winter season (TEM, 2012). For Finnish residents, on the other hand, cross-country skiing is the most important winter sport activity. Unfortunately, reliable data on frequency patterns in these activities is difficult to obtain.

Acknowledgements

The authors would like to thank Mr. Harry Lindfors, Executive Director of SHKY, for providing data and helpful comments on an earlier version of this paper. We would also like to thank Mr. Asko Hutila from the Finnish Meteorological Institute (FMI) for providing the snow depth data for this study.

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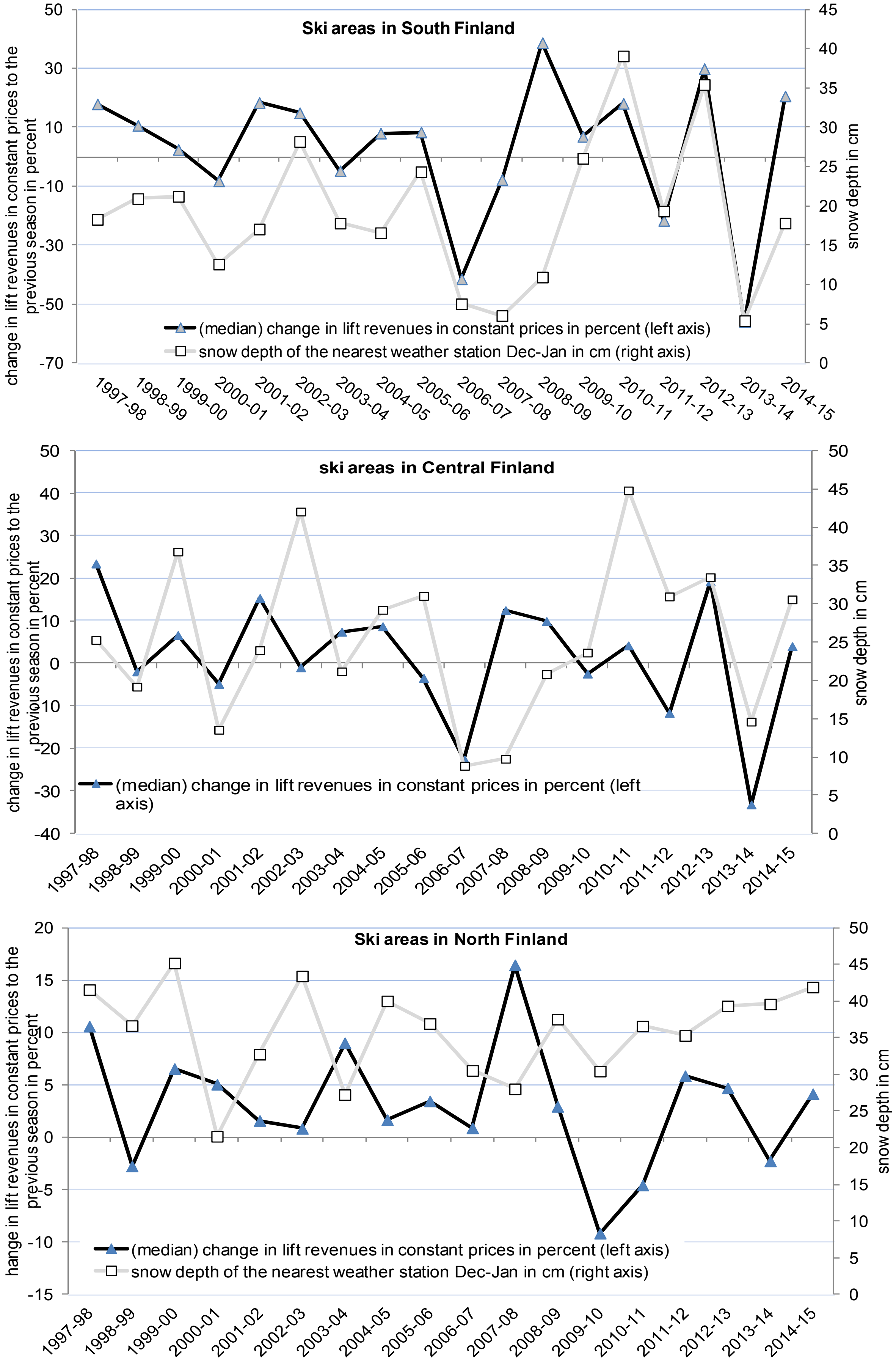
Appendix

Table 1. Assignment of ski destinations to the nearest weather station.

Ski destination	www-address	Municipality	location	# of lifts	Weather station
Himos	himos.fi	Jämsä	central	15	Lahti, Laune
Iso-Syöte	syote.fi	Pudasjärvi	north	8	Pudasjärvi
Kasurila	kasurila.com	Siilinjärvi	central	6	Sotkamo, Saviaho
Koli	koli.fi	Lieksa	central	8	Sotkamo, Saviaho
Laajis Laajavuori	laajis.fi	Jyväskylä	central	6	Jämsä, Halli Lentoasema
Levi	levi.fi	Kittilä	north	27	Muonio, Alamuonio
Messilä	messila.fi	Hollola	south	9	Lahti, Laune
Ounasvaara	ounasvaara.fi	Rovaniemi	north	5	Rovaniemi, Lentoasema
Peuramaa Ski	peuramaa.fi	Kirkkonummi	south	5	Lahti, Laune
Pyhä	pyha.fi	Pelkosenniemi	north	9	Salla, Värriötunturi
Ruka	ski.ruka.fi	Kuusamo	north	21	Kuusamo, Kiutaköngäs
Ski Saariselkä	ski.saariselka.fi	Inari	north	5	Inari, Saariselkä Matkailukeskus
Salla	ski.salla.fi	Salla	north	6	Salla, Värriötunturi
Sappee	sappee.fi	Pälkäne	south	8	Hämeenlinna, Lammi Pappila
Tahko	kuopiotahko.fi	Kuopio	central	15	Sotkamo, Saviaho
Talma Ski	talmaski.fi	Sipoo	south	7	Lahti, Laune
Ukkohalla-Paljakka	ukkohalla.fi	Hyrynsalmi, Puolanka	north	11	Sotkamo, Saviaho
Vihti Ski Center	vihtiski.fi	Vihti	south	10	Hämeenlinna, Lammi Pappila
Vuokatti	vuokatti.fi	Sotkamo	north	9	Sotkamo, Saviaho
Ylläs	yllas.fi	Kolari	north	28	Muonio, Alamuonio

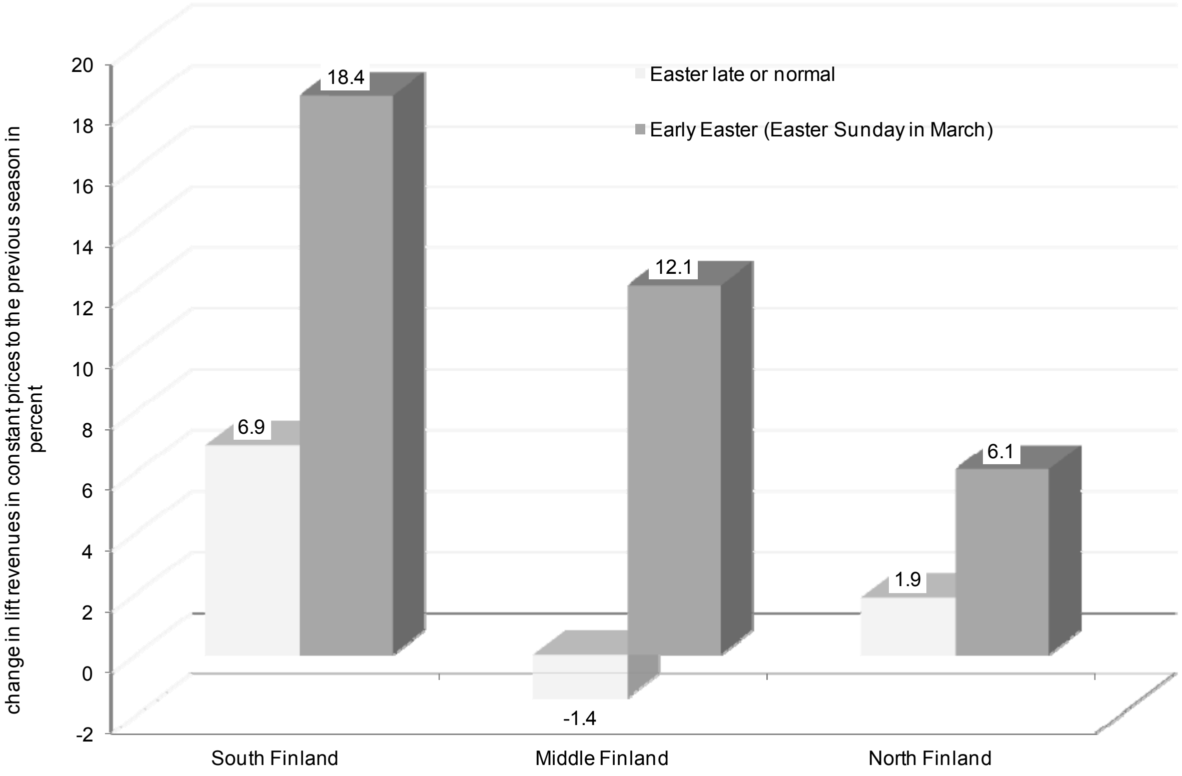
Source: SHKY and Finnish Meteorological Institute.

Figure 1: Lift ticket revenues and snow depth



Source: SHKY and Finnish Meteorological Institute.

Figure 2: Change in lift ticket revenues and early Easter



Source: SHKY.

Table 4. Results of panel unit root tests and ADF tests

Im-Pesaran-Shin unit-root test				
W t-bar	p	# N	av. # T	Lag structure
Log ski lift revenues in constant prices				
-2.03 **	0.02	20	16.3	AIC 1
-0.47	0.32	20	16.3	lag 1
log snow depth December - January				
-8.11 ***	0.00	20	16.3	AIC 1
-2.45 ***	0.01	20	16.3	lag 1
log snow depth December				
-9.55 ***	0.00	20	16.3	AIC 1
-3.70 ***	0.00	20	16.3	lag 1
Augmented Dickey Fuller test				
z(t)	MacKinnon p-value			T
Log GDP in constant price Q4+Q1				
-1.29	0.25		17	Lag 1
Log relative prices				
-2.66	0.89		17	Lag 1

Notes ***, ** and * denote significance at the 1 %, 5 % and 10 % level.