Importance of early snowfall for Swedish ski resorts: Evidence based on monthly data

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Abstract

Since the early 1970s, Sweden has experienced an almost uninterrupted surge in demand for downhill skiing. However, from the 2009/2010 season, lift ticket sales have stagnated. With the use of monthly data, this study investigates the role of snow depth and economic factors in the demand for downhill skiing in Sweden. The empirical approach is based on a seemingly unrelated regression model, allowing snow conditions, but not economic factors to differ during the season. The estimates show that an early season increase in natural snow depth by 10 centimetres raises the growth rate of lift ticket sales by 9 percentage points in the same period. Further, the results indicate that downhill skiing is characterised by low income and price elasticities, implying weak impacts on demand for such changes. The price increase of lift tickets exceeds that of the inflation rate. The recent decline in demand might indicate changed leisure preferences.

Keywords: Swedish ski resorts, snow depth, snow in early and late season, winter tourism, demand for downhill skiing, income and price elasticities.

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1. Introduction

The major ski markets of the world are reaching a point of stagnation or decline (Vanat, 2014). After a long period of increased demand and expansion (Nilsson, 2001; Heberlein et al., 2002; Bodén, 2010) this trend also holds true for Swedish ski resorts. These resorts are small players in the worldwide downhill market, mainly serving the domestic demand with only approximately 10% of skiers coming from abroad (Fredman, 2008; SLAO –Swedish Association of Ski Lift Companies). Following the historical winter seasons of 2008/2009 and 2009/2010, the number of skier visits declined according to the SLAO (see Figure 1 in the Appendix). A similar picture is obtained when the output of ski lift companies is measured as the volume of lift ticket sales (constant prices). Overall, this may indicate that the Swedish alpine industry has followed the international pattern and entered the stagnation stage of the tourism life cycle as described by Butler (1980).

Although stagnation is apparent, the main factors influencing the demand for skiing in Sweden are not fully disentangled. One hypothetical explanation is the cost of skiing. In the last 20 years the increase in lift ticket prices has exceeded the inflation rate (see Figure 2 in the Appendix). Another explanation is that skiing is no longer a growth activity, with lift ticket sales rising less than proportionally with economic growth. This may imply low income elasticity. Tourism demand is generally characterised by high income elasticities, indicating that tourism is a luxury good (Peng et al., 2014). In particular, this is valid for international rather than domestic tourism demand. Climate change with increasing occurrence of snow poor winters, especially in the early season, may contribute to the stagnation of lift ticket sales. Snow depth observations for the two largest downhill areas in Sweden, Sälen and Åre reveal a clear downward trend during the last three decades (Figure 3 in Appendix).[1] Besides economic factors and weather conditions, a general shift in leisure preferences towards other activities over time may also have an impact on lift ticket sales.

In this study we examine the relationship between the inter-annual variation of lift ticket sales and snow depth using monthly data for the 24 largest ski lift operators in Sweden, covering 80% of the market (SLAO Skiddata). This data is combined with detailed information on snow depth from a group of mountain weather stations. The model is estimated using

[1] Pre-season snow depth in Sälen (Särna) and Åre (Storlien) decreased by about 15 cm on average between the early 1980s and 2014. For January the downward trend is even more pronounced, although the snow coverage for this month still has a more comfortable distance to 0. The average snow-depth in Sälen, the southernmost of the large resorts, is much lower than that of the Åre (Storlien) area.

seemingly unrelated regressions (SUR), applied to a first difference specification. This approach makes it possible to account for the correlation of the error terms across the different winter months. In the empirical model the change in lift ticket sales relative to the same period the previous winter season is related to the corresponding changes in snow conditions, real GDP, relative prices and control variables (e.g., early Easter holidays). An important feature of the model is that the economic factors are restricted to be identical across the winter months in a given year while the snow conditions and calendar effects are allowed to differ.

Currently, there are 370 downhill ski areas or facilities in operation in Sweden, many of them small. These ski areas are concentrated to the West and to the North (see Figure 4 in Appendix for a map of the larger resorts). With about 6.6 million skier visits in the winter season of 2013/2014 (based on the 50 most-visited ski establishments, SLAO), Sweden is much below the leading countries in Alpine skiing - the United States, France, Austria, Japan, Italy and Switzerland (Vanat, 2014). The five most frequented areas - Åre, Sälen, Vemdalen, Idre Fjäll and Funäsdalen - account for 72% of lift ticket sales during the 2013/2014 season.

The Swedish ski industry has followed international trends of increased concentration with fewer, but larger operators. Skistar is the largest. Unique features of Swedish mountains and ski resorts are the small vertical drop (Moen & Fredman, 2007; Fredman et al., 2014) - making skiing not overly demanding - and the climate, defined as Köppen zone D (moist mid-latitude climate with cold winters), implying that elevation is less an issue for the availability of snow than latitude.[2]

Numerous studies have examined the determinants of snow based winter tourism (for Australia Pickering, 2011; for Austria Steiger, 2011 and Damm, Köberl & Prettenthaler, 2014; for France Falk, 2015; for Japan Fukushima et al., 2002; for Switzerland Gonseth, 2013; for the United States Hamilton, Brown & Keim, 2007, Shih, Nicholls & Holecek, 2009, Dawson, Scott & McBoyle, 2009 and Holmgren & McCracken, 2014). Lift ticket sales, skier visits or number of passengers transported uphill are commonly employed as measures of winter tourism demand.[3] Income, relative prices, temperatures and snow depth are found to be significant determinants of winter tourism demand.

[2] See SMHI (Jordens huvudklimattyper).

[3] Other studies use overnight stays in ski resorts as a proxy of winter tourism demand (see, e.g., Töglhofer, Eigner & Prettenthaler, 2011, Falk, 2013b). However, day-trippers are not captured by overnight stays and there might be underreporting in the official accommodation statistics. In addition to lift ticket sales, performance measures such as cash flow are also used (Tang & Jang, 2011, 2012).

Unfortunately, available studies are not fully comparable because of the use of different time scales (daily, monthly or annual data), various definitions of the dependent variable (skier visits, lift ticket sales or number of passengers), inclusion or exclusion of prices and real income, and different methods (regression models, descriptive statistics). The majority of studies focus on the relationship between weather conditions (e.g., temperatures and snow conditions) and skier visits or lift ticket sales, neglecting the role of lift ticket prices and real income (for exceptions see Falk, 2015; Holmgren & McCracken, 2014). It should be emphasised that relative prices and real income are the central determinants of tourism demand (see Song & Li, 2008 for a survey; see Peng et al., 2014 for a meta-analysis). Currently, there is no consensus about the role of weather conditions for skiing demand, specifically when it comes to the impact of natural snowfall in the early winter season. This is the first study investigating the impact of snow conditions on lift tickets sales for the economically important Christmas and New Year holiday season.

The main contribution of this study is the investigation of the impact of snow conditions on skiing demand for the early, mid and late winter seasons, based on a new and unique dataset. We argue that the use of monthly data gives a more detailed picture of the relationship between weather and snow based winter tourism demand. Another contribution of the paper is that we use the price of lift tickets as a measure of the price variable rather than proxy variables such as the consumer price index. Previous tourism demand studies for Sweden do not distinguish between different seasons or tourism activities (Coenen & van Eekeren, 2003), or focus on international tourism demand (Khalik Salman, 2003; Nordström, 2004; Khalik Salman et al., 2010). For domestic tourism demand in Sweden, Khalik Salman et al., (2007) find high price elasticities in absolute terms and insignificant income elasticities.

The paper is structured as follows. Section two introduces the empirical model. Section three provides the data and descriptive statistics. Section four presents the empirical results, and section five concludes.

2. Empirical model

Snow based winter tourism is weather sensitive. Despite large investments in snowmaking facilities in the last decades, the recent literature shows that skier visits strongly depend on natural snow depth. However, the strength of the relationship is not conclusive. For Swiss ski resorts, Gonseth (2013) reports that snow depth is particularly important for ski areas with poor snowmaking facilities. In a study of high elevation ski resorts in the French Alps, Falk (2015) shows that variations in natural snow depth only explain a small proportion of the change in skier visits over time. A limitation of these studies is that they explore skier visits for the total winter season and thus are not able to account for the timing of snowfall.

Rather than the average snow depth for a total season, the distribution of snow during the winter is of high importance (Burroughs, 2000). A poor start to the winter season with a lack of snow during the Christmas and New Year holiday period may have a disproportionately negative impact on the output and profits of the industry (Elsasser & Bürki, 2002). Therefore, an open question is whether and to what extent the number of visitors to ski areas is affected by snow conditions in the economically important Christmas and New Year holiday season.

The choice of the time scale of the weather data (e.g., monthly, daily or total season) is crucial when modelling the relationship between weather factors and tourism demand. Gómez Martín (2005) suggests that weather conditions can cause major variations in visitor flows on the same day or on successive days but over a longer period these effects are likely to be small. In fact, studies based on daily data confirm that variations in weather conditions can have large impacts on skier visits (Hamilton et al., 2007 for ski areas in New Hampshire; Shih et al., 2009 for two Michigan ski areas and Damm et al., 2014 for the ski resort "Schladming" in Austria). For instance, Hamilton et al. (2007) find that snowfall explains more than 50% of the variation in the number of daily visitors. However, studies based on daily data have not accounted for price and income effects which do not vary within a given winter season. Therefore, we argue that a monthly basis is the most suitable frequency for studies of the determinants of lift ticket sales or skier visits.

The theory of recreational demand predicts that the number of visitors depends positively on real income and negatively on (relative) prices (Larson, 1993). Cost factors are also commonly regarded as a significant determinant of skiing demand (Tuppen, 2000). Morey (1984) distinguishes between costs of lift tickets, transportation costs and ski equipment rental fee. Similarly, Gilbert and Hudson (2000) discover that economic factors such as high expenses and high costs are the major constraints for skiing participation. More recently, Priporas et al. (2014) find that financial costs and interpersonal constraints are the main factors determining skiing participation. In contrast, winter sport related limitations such as lack of snow and congestion on the slopes play a minor role.

Ski lift ticket prices often increase faster than the inflation rate and thus may have contributed to the stagnation of skiing demand. Skiing demand is expected to increase with real income. Many tourism destinations exhibit income elasticities exceeding one, indicating that tourism is a luxury good (Peng et al., 2014). However, for winter sport destinations in the mature phase characterised by stagnation or decline in output, income elasticities can be expected to be low, particularly when there is a high share of domestic tourists. For instance, Falk (2013b) finds that the income elasticities of domestic overnight stays are significantly lower than those (of about 0.2) for Austrian winter sport destinations.

Following the literature, the number of visitors to ski areas or lift ticket sales may be modelled as a function of relative lift ticket prices, GDP in constant prices, average snow depth in the ski area and the time trend. Given the availability of monthly data, the model can be specified for each month separately. This makes it possible to separate out sub-seasonal factors. It is well known that tourism demand is strongly influenced by seasonal factors where the intra-annual variation in tourism demand is considerably higher than the inter-annual variation (see for instance Becken, 2013). In Sweden, the largest number of visitors to ski resorts can be observed in February (SLAO), which is also the month when most schools close one week for winter holidays. Specifying a separate model of each month makes it possible to focus on the relationship between the inter-annual variation in winter tourism demand and snow conditions. Based on the monthly data, the empirical model consists of *m* regression equations:

$$\ln YCP_{mt} = \alpha_m + \beta_{1m} \ln PS / CPI_t + \beta_{2m} \ln GDPcp_t + \beta_{3m} \ln SNOW_{mt} + \beta_{4m} trend_t + \varepsilon_{mt} \qquad (1)$$

where m=1,..,5 months (sum for November-December, January, February, March and sum for April-May) and time period *t*=seasons 1992/1993 to 2013/2014. The prefix ln denotes the natural logarithm and *trend* represents the time trend. *YCP* reflects lift ticket sales (net of value added tax) deflated by the price index of ski lift tickets. It would be preferable to use weighted GDP of the main visitor countries. However, the visitors to Swedish ski resorts are predominantly domestic tourists.[4] *PS* is the price index of ski lift tickets measured as the deflator of lift ticket sales. *CPI* denotes the consumer prices index with a fixed base year, and *GDPcp* represents Swedish GDP in constant prices. Note that prices and GDP refer to the year when the season starts (e.g., season 2013/14 uses 2013 values). The reason for this is that

[4] The number of foreign overnight stays in hotels in the four largest ski resorts is about 78% in 2010 (based on Statistics Sweden data). However, the share of foreign skier visits is much lower because of the large number of second homes in Swedish mountains.

lift ticket prices are set in the summer and do not change during the upcoming winter season. *SNOW* stands for average monthly snow depth based on information from several mountain weather stations in the winter months. The error term ε_{mt} is assumed to be identically and independently distributed with a zero mean and constant variance (i.e., $\varepsilon_{mt} \sim IID(0, \sigma^2)$). In the model the coefficients are allowed to vary across months.

The static model can be separately estimated by OLS for each sub-period. In case the variables are characterized by a unit root, the OLS model produces downward biased standard errors. Unit root tests show that the dependent variable is stationary in the majority of cases and the independent variables consist of both stationary and non-stationary variables.[5] Therefore an error correction model is not appropriate in this case and the tourism demand model is instead specified in first differences (as compared to the same period the previous year). Further unit root tests show that the time series integrated of order one becomes stationary after taking first differences.

Since the OLS model specified in first differences cannot account for the correlation across the different winter months, we use Zellner's (1962) seemingly unrelated regression (SUR). This model is appropriate when the disturbances of different equations are correlated and the explanatory variables are assumed to be exogenous. By running the set of regression equations simultaneously instead of one by one, the parameter estimates become more efficient. Zellner (1962) suggests that the approach is suitable in the analysis of data provided by a single cross-section budget study, for instance, when regressions for several commodities are to be estimated or in time-series analyses of the demand for a variety of consumption goods. In this case downhill skiing for each specific time period is considered a separate consumption good for which demand is investigated. Another advantage of the SUR model is that it permits to constrain price and income elasticities to be identical across the different winter months. This is a reasonable assumption given relative prices and the fact that income generally does not fluctuate heavily over shorter periods of time. Additionally, the restrictions increase the precision of the price and income elasticity estimates. The resulting specification in first differences can be written as follows:

[5] Augmented Dickey Fuller tests show that the null hypothesis of a unit root is rejected for the logarithm of lift ticket sales at the 5% level in three out of five cases. Similarly, for snow depth the null hypothesis of a unit root is rejected in three out of five winter months, indicating that average snow depth can be partly regarded as stationary. For the remaining explanatory variables, unit root tests show that the logarithm of relative prices is stationary while log GDP in constant prices is integrated of order one. The results are available upon request. Note that unit-root tests are known to be biased in small samples as is the case here (with T=20).

$$\Delta \ln YCP_{mt} = \alpha_m + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{3m} \Delta SNOW_{mt} + \beta_4 D_t + \beta_{5e} EARLYEASTER_t + \varepsilon_{mt} \quad (2)$$

where $\Delta \ln YCP_{mt}$ is a vector of the dependent variables measured as the change in log lift ticket sales in a given month and $\Delta SNOW_{mt}$ is a vector of explanatory variables in a given month *m*. D_t is a dummy variable equal to one for a given time period. The *m* system of equations can be written separately for each month:

$$\Delta \ln YCP_{1t} = \alpha_1 + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{31} \Delta SNOW_{1t} + \beta_4 D_t + \varepsilon_{1t}$$

$$\Delta \ln YCP_{2t} = \alpha_2 + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{32} \Delta SNOW_{2t} + \beta_4 D_t + \varepsilon_{2t}$$

$$\Delta \ln YCP_{3t} = \alpha_3 + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{33} \Delta SNOW_{3t} + \beta_4 D_t + \varepsilon_{3t}$$

$$\Delta \ln YCP_{4t} = \alpha_4 + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{34} \Delta SNOW_{4t} + \beta_4 D_t + \beta_{54} EARLYEASTER_t + \varepsilon_{4t}$$

$$\Delta \ln YCP_{5t} = \alpha_5 + \beta_1 \Delta \ln PS/CPI_t + \beta_2 \Delta \ln GDPcp_t + \beta_{35} \Delta SNOW_{5t} + \beta_4 D_t + \beta_{55} EARLYEASTER_t + \varepsilon_{5t}$$

where $\operatorname{var} \varepsilon_{mt} = \sigma_m^2$, $\operatorname{cov}(\varepsilon_{mt}\varepsilon_{jt}) = E(\varepsilon_{mt}\varepsilon_{jt}) = \sigma_{mj}$, for all $t = 1,2..T$ and $m \neq j$ and

$\operatorname{cov}(\varepsilon_{mt}\varepsilon_{js}) = E(\varepsilon_{mt}\varepsilon_{ms}) = 0$ for $t \neq s$.

The assumption of the model is that the error terms ε_{mt} are independent across time, but may have significant contemporaneous correlations across the equations: σ_{mj}. In addition to economic factors and snow depth, we include a dummy variable equal to one when Easter Sunday is early (March or first week of April) and zero otherwise. Early Easter holidays are usually associated with an increase in skier visits. The parameters β_1 and β_2 can be interpreted as the short-run price and income elasticities. The β_{3m} measures the short-run elasticity of lift ticket sales with respect to snow depth, and β_{54} and β_{55} represent the effect of the Easter dummy.

When all regressors appear the same in each period, OLS produces results identical to the SUR model. In this model snow depth varies across the winter months. The SUR model can be estimated by Feasible Generalized Least Squares (FGLS) as a two-step approach or by the

Maximum Likelihood estimator. Both estimators are asymptotically equivalent. We use the FGLS method to estimate the equation.

3. Data and descriptive statistics

Data used for this analysis are drawn from publicly available sources. Information on lift ticket sales (net of value added tax) in constant prices is provided by the Association of Swedish ski lift companies.[6] Information refers to the 24 largest ski lift operators for the five periods of the winter season from 1993/1994 onwards (November-December, January, February, March and April-May, where the first period refers to the end of November and the last period includes the beginning of May). These major establishments cover 80% of the downhill market. GDP in constant prices and the components of consumer price index (CPI) are derived from Statistics Sweden national accounts and price statistics, respectively.[7] Both variables refer to the calendar year when the season starts. The deflator for lift ticket sales is calculated by dividing lift ticket sales in nominal prices by lift ticket sales in constant prices provided by the SLAO (both net of value added tax). Exchange rates originate from OECD statistics and are calculated for the five sub-periods. Information on snow depth is based on daily reports for three weather stations from the Swedish Meteorological and Hydrological Institute (SMHI): Storlien-Visjövalen in Jämtland, and Särna and Nornäs in Dalarna.[8] These particular weather stations are chosen because they are close to the largest downhill areas and also provide the longest time series. Daily data is aggregated to the monthly level (see Figure 3 in Appendix for the evolution of snow depth for November-December and January). Table 1 shows descriptive statistics for real growth rate of GDP, relative prices defined as the deflator of lift ticket sales divided by the CPI, and change in snow depth.

In order to check the reliability of the data, lift ticket sales in constant prices are compared with skier visits to the largest ski resorts. Skier visits can be regarded as an alternative output measure. Figure 1 in the Appendix shows that the evolution of lift ticket sales closely follows that of skier visits. Overall, for the total sample period, lift tickets sales (in constant prices) in the early winter season and in the high season increased by between 1.6% and 2.4% on average (Table 1). Results for March and April-May are heavily influenced by the timing of the Easter holidays. In the 1980s downhill skiing boomed with growth rates of lift ticket sales

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[6] See SLAO, Various issues.

[7] See Statistics Sweden, National Accounts and Price Statistics.

[8] See SMHI (Snödjupsobservationer).

in constant prices of 8% per year on average. This followed from increased wealth of households and a new taste for alpine skiing (Bodén, 2010) which was possibly influenced by Ingemar Stenmark's spectacular 15 years of success in downhill competition races between 1974 and 1989. From the season 2009/2010 onwards, lift ticket sales (and skier visits) declined. This is particularly pronounced for the late season (April-May). Similar stagnation tendencies as in the Swedish ski business can be observed for ski lift companies in the European Alps and in North America (Vanat, 2014; Falk, 2015).

Table 1
Descriptive statistics

	mean	standard deviation	min.	max.
monthly data	percentage change in lift ticket sales in constant prices to the same month in the previous year			
November-December (sum)	2.4	22.1	-37.6	62.3
January	1.5	10.5	-16.1	25.9
February	1.6	7.6	-14.6	18.3
March	0.4	17.0	-25.6	28.8
April-May (sum)	-1.4	34.5	-57.4	73.5
		Change in log snow depth in % to the same month in the previous year		
November-December (sum)	-3.5	71.4	-147.1	155.5
January	-1.8	37.1	-61.9	73.2
February	-1.3	30.0	-50.7	42.1
March	-4.0	37.2	-90.4	62.2
April-May (sum)	-7.0	68.9	-111.5	111.1
annual data:		other determinants (percentage change to previous year)		
change in real GDP in %	2.2	2.7	-5.2	6.4
change in relative prices in %	2.2	2.1	-2.6	5.5
early Easter dummy multiplied by 100	38.1			

Notes: The sample period refers to the seasons 1993/1994 to 2013/2014. Source: SLAO, Statistics Sweden and SMHI.

Figure 2 in the Appendix presents the evolution of the deflator of lift ticket sales, prices of ski lift tickets and the consumer price index component calculated by Statistics Sweden. A comparison with the price index of ski lift tickets shows that the lift ticket deflator (adjusted for changes in the value added tax) is a good approximation of the price of lift tickets. Additionally, the growth of lift ticket prices exceeds that of the inflation rate. The strong increase in relative prices is striking given the decrease in the value added tax over the period, but is partly explained by massive investments in snowmaking facilities and new ski lifts.

The sample period starts with the 1993/1994 season, directly after the severe domestic financial crisis in Sweden. In connection with this crisis, tourism in general and the demand for skiing fell drastically (Nyberg, 1995; Bodén, 2010). Another motivation for the chosen time period is that snow depth data are often not available for earlier years. Including earlier years may also distort the regression results because of the 1991 tax reform, where the value added tax base was widened to include most services and goods.

In order to get an initial idea of the relationship between snow depth and lift ticket sales, two scatter plots are provided. Figure 5 in the Appendix illustrates that lift ticket sales are significantly positively related to changes in snow depth in the early season. The correlations are fairly large at about 0.44 given that the variables are measured in first differences.

4. Empirical results

Table 2 shows the estimates of the seemingly unrelated regression (SUR) model. The dependent variable is the change in the logarithm of lift ticket sales relative to the same month in the previous winter season. Separate results are reported for the five periods of the winter season: November-December, January, February, March, April-May. Real GDP and relative lift ticket prices (both measures as percentage changes to the previous year) and the dummy variable for the seasons 2010/2011 to 2013/2014 are constrained to be identical for all winter months whereas the snow depth variable and the dummy variable for early Easter holidays are allowed to vary. The Breusch–Pagan test of independence of the residuals shows that the null hypothesis of independence of residuals is rejected at the 1% significance level. This indicates that SUR estimates are more efficient than OLS estimates.[9]

Table 2

Seemingly unrelated regression estimates of the determinants of growth of lift ticket sales for Swedish ski areas

	dep. var.: Change in lift ticket sales relative to same period previous year								
	November-December			January			February		
	coeff.		t	coeff.		t	coeff.		t
change in log average snow depth in mountain destinations	0.14	**	2.50	0.11	***	2.95	0.05		1.07
change in log GDP in constant prices	0.88	***	3.37	0.88	***	3.37	0.88	***	3.37
change in (deflator lift ticket sales/CPI)	-0.68	**	-2.03	-0.68	**	-2.03	-0.68	**	-2.03
dummy time period 2010-11 to 2013-14	-0.08	***	-4.28	-0.08	***	-4.28	-0.08	***	-4.28
constant	0.04		0.90	0.03		1.22	0.03		1.29
	March			April-May					
	coeff.		t	coeff.		t			
change in log average snow depth in mountain destinations	-0.03		-0.76	-0.04		-0.69			
change in log GDP in constant prices	0.88	***	3.37	0.88	***	3.37			
change in (deflator lift ticket sales/CPI)	-0.68	**	-2.03	-0.68	**	-2.03			
dummy time period 2010-11 to 2013-14	-0.08	***	-4.28	-0.08	***	-4.28			
early Easter	0.33	***	12.10	-0.49	***	-5.80			
constant	-0.11	***	-4.60	0.18	***	2.67			

Notes: ***, ** and * denote significance at the 1, 5 and 10% levels. The average R^2 across the five equations is 0.35. Estimates rely on small sample statistics.

The results of the SUR model estimations show that a percentage change in lift ticket sales depends significantly positively on the percentage change in natural snow depth and real GDP

[9] Table 6 in the Appendix shows the correlation of residuals. The highest correlation can be observed between lift ticket sales for the March and the April-May equations.

growth, and significantly negatively on the change in relative prices of ski lift tickets. The R-squared of the equations is 0.35 measured as the average for the five equations. Average snow depth is significant at the 5% level for the change in lift ticket sales in the early winter months of November-December and January. In contrast, snow depth is not significant for the mid-season months of February and March or for the late season. The results clearly show that snow conditions are particularly important in the early season but not relevant in the high season (February) and late winter season (March, April-May). Snow coverage in the early season is also expected to be particularly vulnerable in a scenario of global warming, as discussed by Moen and Fredman (2007) and Berghammer and Schmude (2014). The importance of good snow conditions in the early season for lift ticket sales is a new result in the literature. The findings suggest that the frequency of weather data is important. Using data for the total winter season is clearly inappropriate when studying the relationship between tourism demand and weather.

The short-run elasticities of lift ticket sales with respect to snow depth are 0.14 for the November-December period and 0.11 for January. This indicates that a rise in snow depth by 10% leads to an increase in lift ticket sales in constant prices by 1.4% and 1.1%, respectively.

Table 3
Effects of a change in one standard deviation of the main explanatory variables on the percentage change in lift ticket sales

explanatory variables	one standard deviation change X 100	elasticity	effect of a one standard deviation increase, percentage points
change in log snow depth Nov-Dec	68.6	0.14	9.3
change in log snow depth Jan	40.3	0.11	4.6
change in log GDP constant prices	2.7	0.88	2.3
change in log relative prices	2.3	-0.68	-1.5

Notes: Elasticities are based on the SUR regression results provided in Table 2. The effects measure the predicted response of lift ticket sales in % to a one standard deviation change of the explanatory variables and are calculated by multiplying the elasticities with the one standard deviation change of the explanatory variables.

Given that the main explanatory variables appear in different scales or dimensions (change in log snow depth versus growth rates of GDP and relative prices), a proper comparison of magnitudes requires that the effects be calculated in standard deviation units of the parameters. Table 3 shows the effects of a one standard deviation change in snow depth and economic factors. The sample standard deviation of change in log GDP is 2.7%. For changes in the average November-December snow depth, the sample standard deviation of changes is 68.6% (or equal to 10 centimetres). Given the elasticity estimates for real GDP and the

November-December snow depth of 0.88 and 0.14, respectively, an increase of one standard deviation in the change over time leads to a rise in the growth of lift ticket sales by 2.3 and 9.3 percentage points. The corresponding effect of a one standard deviation change in the year-to-year changes in snow depth in January is 4.6 percentage points. The price effect of a one standard deviation change is relatively low at -1.5 percentage points. This indicates that year-to-year variations in natural snow depth in the early winter season are much more important than economic factors in determining the output of ski lift companies. The significant relationship between early snow depth and skiing demand has important implications since it emphasises that the output of ski lift operators is not independent of variations in natural snow depth despite large investments in snowmaking facilities. Given that the early season snow depth trends reported here are representative for all skiing areas, global warming could put the economically important Christmas/New Year's holiday season at risk, especially in the southern parts (Sälen).

A natural question is why demand is snow sensitive in pre-season but not in the mid- or late season. A tentative explanation is that there are larger numbers of alternative activities competing with the Swedish mountains during the Christmas and New Year holiday period, which normally means at least two weeks off for schools. For instance, potential skiers might switch to alternative ski destinations in the Alps, decide to visit cities or fly to a sun destination. An explanation for the insignificance of snow conditions in the high season is that snow supply is normally stable and the winter holidays from school are shorter, reducing the competitiveness of faraway destinations.

It is interesting to compare the results of the relationship between real lift ticket sales and snow depth with those for other countries. Falk (2015) finds that the magnitude of the relationship between snow depth and skier visits is rather small for French ski areas belonging to the Compagnie des Alpes group. A reduction of one standard deviation in snow depth – that is, 32 cm compared to the long-run average over a 40-year period – caused the number of skier days to fall by about 2% on average over the last 20 years. However, this study has not accounted for the sub-seasonal distribution of snowfall.

Another important finding of this study is that the growth rate of ski lift ticket sales declines from the winter season 2010/2011 onwards, given the impact of changes in real income, lift ticket prices and snow depth. These results contradict Bodén (2010) – who reports that Swedish mountain destinations themselves expect that demand will continue to accelerate –

and are more in line with anecdotal evidence from manufacturers of winter sport equipment that sales of downhill skis have fallen in recent years while interest in alternative snow activities such as cross-country skiing has grown (Skidspår, 2015).

The dummy variable for the seasons 2010/2011 to 2013/2014, accounting for a break in the growth trend, is negative and significant with a coefficient of -0.08. This indicates that the growth rate of lift ticket sales (in constant prices) is eight percentage points lower for these most recent years than for the total period of time studied, given economic factors, snow depth and occurrence of early Easter holidays. Possible reasons for the decline in the growth of lift ticket sales are changes in preferences towards other (or less) snow based winter sport activities including snowshoeing, alpine skiing/ ski-mountaineering, off-piste skiing, and free-ride skiing, all of which are increasingly popular among mountain tourists (Bourdeau, Corneloup, & Mao, 2002). This change in preferences towards other leisure activities is not new. For the French Alps, Tuppen (2000) suggests that classic downhill skiing is no longer the sole fashionable winter sport activity but only one of many. However, unlike in France, skier participation among Swedish residents increased between the mid-1980s and the end of the 1990s whereas participation in cross-country skiing remained stable over the same period (Fredman & Heberlein, 2003). This indicates that the saturation of the market for downhill skiing and snowboarding arrived later in Sweden than in other countries.

An alternative reason behind the stagnation in demand for downhill skiing is the shift in leisure tourism towards city tourism. A recent study based on Swedish hotels shows that growth of overnight stays in city hotels is significantly higher than that of other hotel types (Falk & Hagsten, 2015). Additionally, there is a significantly negative impact of relative lift ticket prices on lift ticket sales with an elasticity of -0.68. This means that an increase in the relative lift tickets price by 1% leads to a decrease in sales by 0.7%. As outlined above, the rise in lift ticket prices exceeds that of the inflation rate (see Figure 2 in the appendix for the evolution of ski lift tickets). Therefore, the increase in relative prices combined with moderate price elasticity (in absolute terms) is one reason for the stagnation of lift ticket sales.

The elasticity of lift ticket sales with respect to GDP is 0.88 and significant at the 1% level. The finding of an income elasticity of about one shows that skiing in Sweden cannot be regarded as a luxury product. Similar findings are obtained for the largest French ski resorts with skier visits as the dependent variable (Falk, 2015). Using data for a sample of Austrian ski resorts, Falk (2013b) finds income elasticities of domestic and foreign overnight stays of

0.26 and 1.9, respectively. Using individual data for 28,000 Swedish persons, Coenen and van Eekeren (2003) discover an income elasticity of around one. However, the results are difficult to compare because not only skiing but also other activities are included (e.g., sunbathing, city trips).

The finding of low income elasticity stands in contrast to that of city tourism which disproportionally increases from the rise in real income (see Smeral, 2014 for tourism demand for Vienna). Given that the growth prospects of the Swedish economy (like other West and North European countries) are quite modest with a GDP growth rate of about 2% per year, ski lift operators cannot expect a strong increase in the number of visitors in the near future.

The dummy variable for early Easter is significant and shows the expected signs. Early Easter holidays lead to higher lift ticket sales in March while late Easter Holidays lead to a decline in lift ticket sales in the late winter season. These results are highly plausible and consistent with the anecdotal evidence that inhabitants of Sweden prefer summer destinations when Easter holidays are late in the season. The strength of the effects is quite large: Easter Holidays early in the season lead to an increase in the growth rate of lift tickets sales by more than 30 percentage points, and consequently also lead to a decrease in lift ticket sales in April-May. This indicates that there is a calendar effect, shifting the ski business from April-May to March.

Several robustness checks have been conducted. First, the SUR model is re-estimated with the level of average snow depth instead of its logarithm. Again, snow depth is positive and significant for the early season and for January (unreported results are available upon request). Second, the "backyard hypothesis" introduced by Hamilton et al. (2007) is tested by including data on snow depth for Stockholm. This hypothesis states that snow conditions in the home areas of skiers may influence the demand for skiing elsewhere. However, unreported results show that snow depth in the capital city never appears significant at conventional levels. Third, possible lagged effects are examined by introducing snow depth for the previous month or for the same month the year before. Neither of these lagged variables turns out to be significant, meaning there is no time delay in the reaction of skier demand to changes in snow depth.[10] Fourth, it is reasonable to assume that there is a non-linear relationship between the number of lift ticket sales and snow depth. Thus, we allow for

[10] Results available upon request.

a non-linear relationship by the inclusion of the squared snow depth term. Unreported results show that adding the squared term does not improve the fit of the model. Fifth, in order to determine whether price elasticity has undergone changes over time, we re-estimate the specification for various subsamples by extending the sample by one year at a time. Unreported results show that elasticities are stable over time.

Sixth, it could be argued that variations in exchange rates have an impact on the demand for winter tourism (Falk, 2013b). Because of this, two hypotheses were tested: i) whether demand is affected by a strengthening of the Swedish currency (SEK) to the Euro (EUR), shifting part of the interest for downhill skiing from the Swedish mountains to the European Alps, and ii) whether a strengthening of the Norwegian currency (NOK) to the SEK increases the Norwegian interest for downhill skiing in Sweden. Indeed, the null hypotheses of no exchange rate effects can be rejected. When added to the estimations, both the monthly EUR/SEK and SEK/NOK exchange rates turn out significant at the 1 and 5% levels, respectively (relative to the same period the previous year). The positive sign for the EUR/SEK exchange rate implies that the demand for downhill skiing in Sweden increases when the EUR appreciates against the Swedish Krona (Table 4). The negative sign of the NOK/SEK rate indicates that an appreciation of the Norwegian Krona leads to a surge in demand for downhill skiing across the border in the Swedish mountains (Tables 5, Appendix). The main result that snow depth is particularly important in the early season is not affected by the addition of the exchange rate variables.

5. Conclusions

Numerous studies have investigated the determinants of the demand for snow based winter tourism. However, the majority of studies do not consider sub-seasonal snow depth. This paper provides first insights into the determinants of lift ticket sales for Swedish ski areas based on monthly data for the winter seasons 1993/1994 to 2013/2014, with an emphasis on availability of snow. We use data for the 24 largest ski areas, covering 80% of the market, and an empirical model that allows the impact of snow conditions to differ across the winter months while the income and price elasticities are constrained to be the same. Using seemingly unrelated regression models estimated for five sub-periods, we show, as expected, that lift ticket sales depend significantly negatively on lift ticket prices and significantly positively on real GDP. Both income and price elasticities are quite low in absolute terms. A new empirical result is that a decline in snow depth in the early season has a strong negative impact on lift ticket sales. The snow effect is also much more pronounced than the impact of economic factors and the results are robust to the inclusion of other determinants of tourism demand, such as exchange rates. In particular, a reduction in snow depth by one standard deviation leads to a drop in the growth of lift ticket sales by 9 and 5 percentage points for the November-December and January periods, respectively. However, there is also a strong decline in lift ticket sales starting in the 2010/2011 season when controlled for relative prices, real income and snow depth. A tentative explanation is that the fall of lift ticket sales is caused by an exogenous shift in leisure preferences towards other (or less) snow based winter sport activities. Another reason for the stagnation of lift ticket sales is that the price increase of lift tickets exceeds the inflation rate over a longer period of time.

When the mid-winter season is considered the results indicate that the underlying key causes of the stagnation of lift ticket sales are as follows: low income elasticity, the exogenous shift in leisure activities from the season 2010/11 onwards, and the significant price sensitivity of skiing demand. Future prospects for Swedish ski lift operators are poor given moderate growth in real domestic income and possible price increases in lift tickets following huge investments in snowmaking and new lifts. In addition, the results indicate that further investments in snowmaking in order to extend the season (or to combat increase in green early winter seasons following global warming) may be insufficient to attract new clients. Nevertheless, due to latitude and climate zone characteristics, the prospects of snowy winters may still be far better than for certain areas in the European Alps. While the latent demand for alpine skiing is calculated to be low in Sweden (Fredman et al., 2012), attracting a larger group of international skiers might be one way to break the phase of stagnation for ski resorts (Heberlein et al., 2002). An important requirement though for this is the availability of transportation, such as direct flights to Östersund or nearby Norwegian cities from Central Europe (Heberlein et al., 2002).

This study is bound by several limitations. First, it was conducted for aggregate data. It is likely that the determinants of lift ticket sales differ across ski resorts due to elevation, latitude, size and distance to urban areas. For instance, early snowfall might be less critical for Idre and Funäsfjällen since they are located in a colder climate zone (Bodén, 2010). Accessibility also differs widely across ski resorts. Bodén (2010) suggests that there seems to be an increased demand for downhill skiing closer to larger cities. Åre is far away from the most densely populated areas, but has reasonably good train and flight connections. Sälen has no airport nearby, but is instead less distant, although peak season traffic can be jammed. Funäsdalen has disadvantages both in distance and accessibility, e.g., no trains.

Future work can apply the same methodology to other countries. It is important to acknowledge other factors that may affect lift ticket sales such as coverage of slopes by snowmaking and investment in new ski lifts. Another research idea is to investigate the determinants of the length of visits. Bodén (2010) suggests that the number of overnight stays per trip have decreased from 4.25 to 3.2 in Dalarna in the last decade. This is considered an indication of increased demand for several shorter trips rather than fewer and longer stays. Also, vital pensioners have become a large target group for ski resorts.

Although this study does not attempt to analyse whether climate change has occurred or not, there is no doubt that understanding the relationship between demand for downhill skiing and natural snow depth based on historical data is beneficial for future work on global warming and winter tourism.

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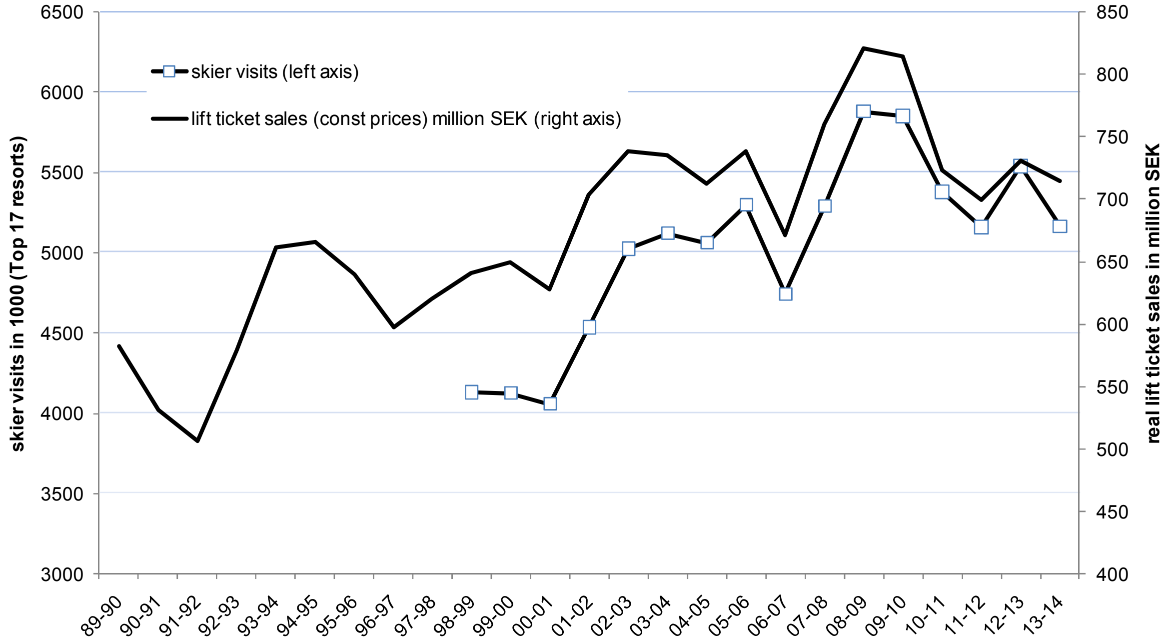
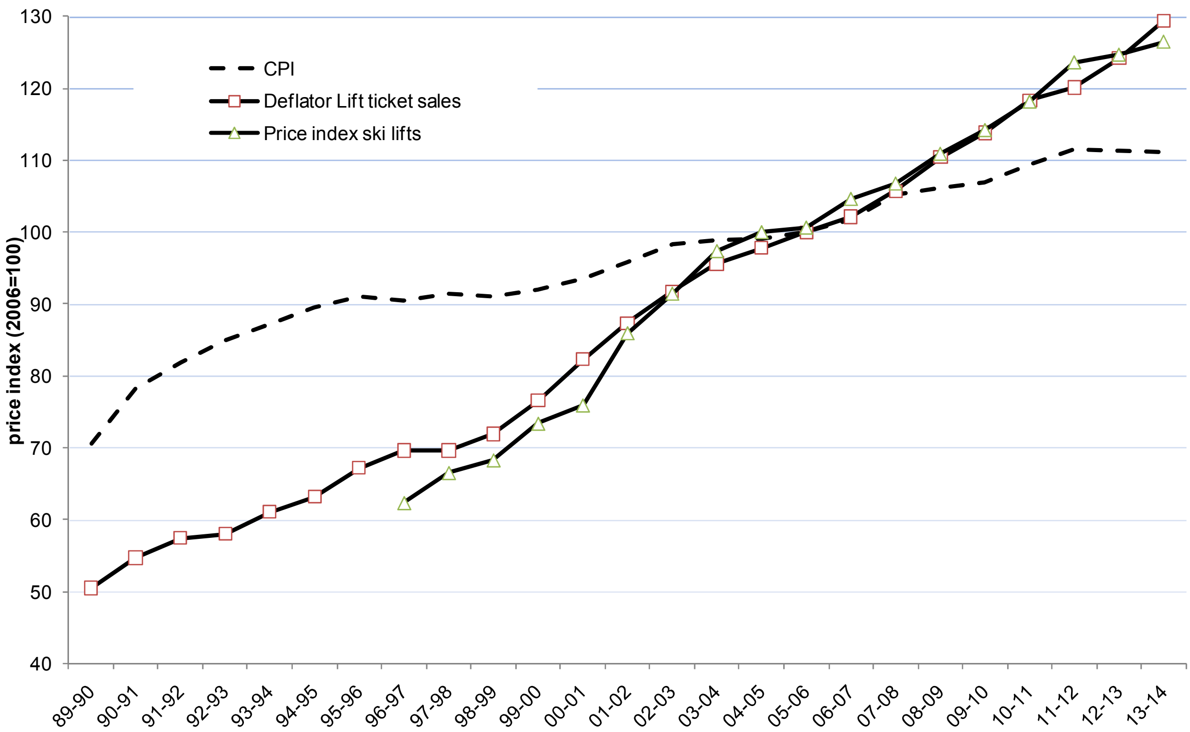
Appendix

Fig. 1: Evolution of skier visits and lift ticket sales in constant prices



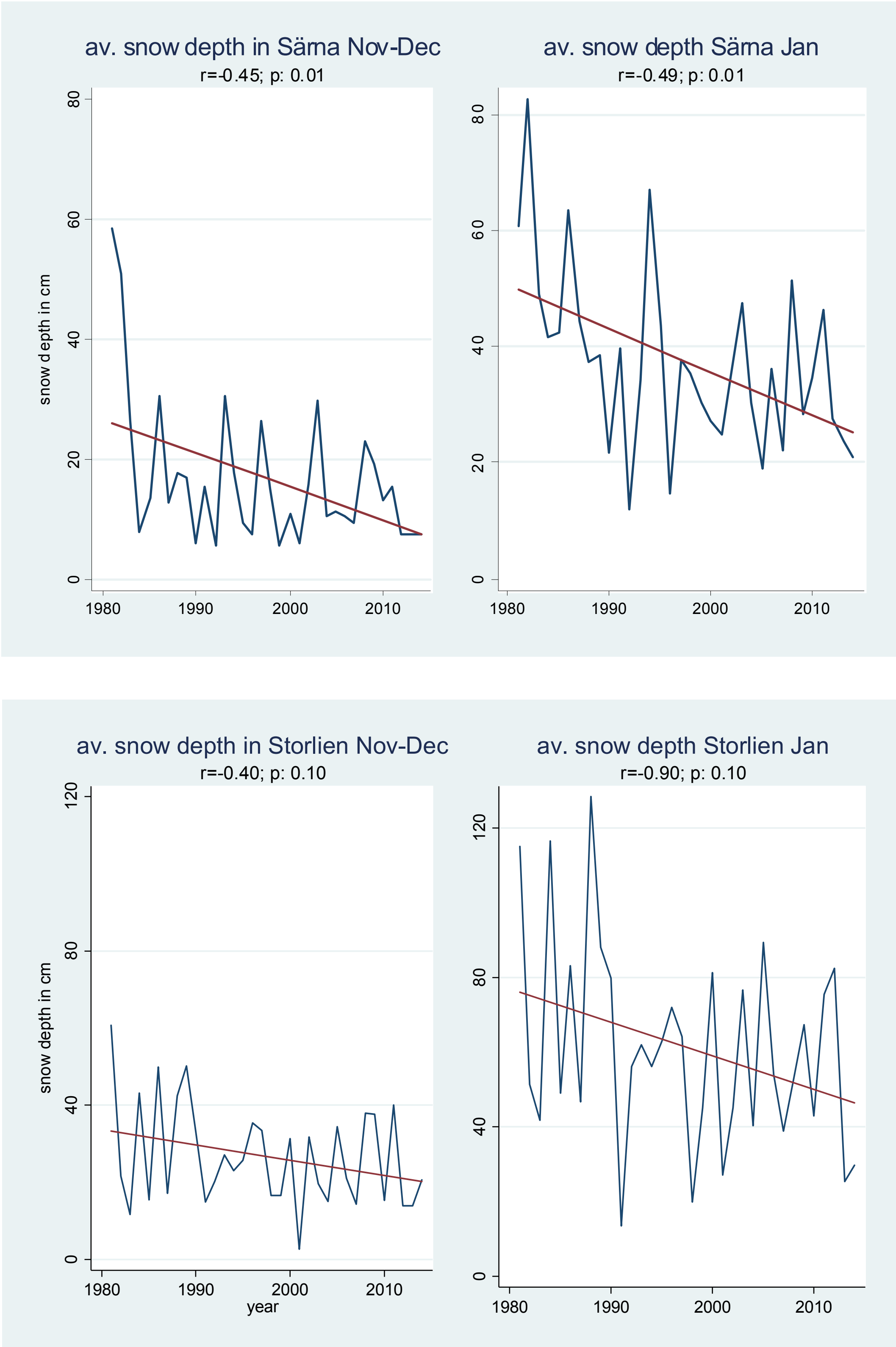
Source: SLAO various issues.

Fig. 2: Evolution of the price index for ski lifts and total CPI



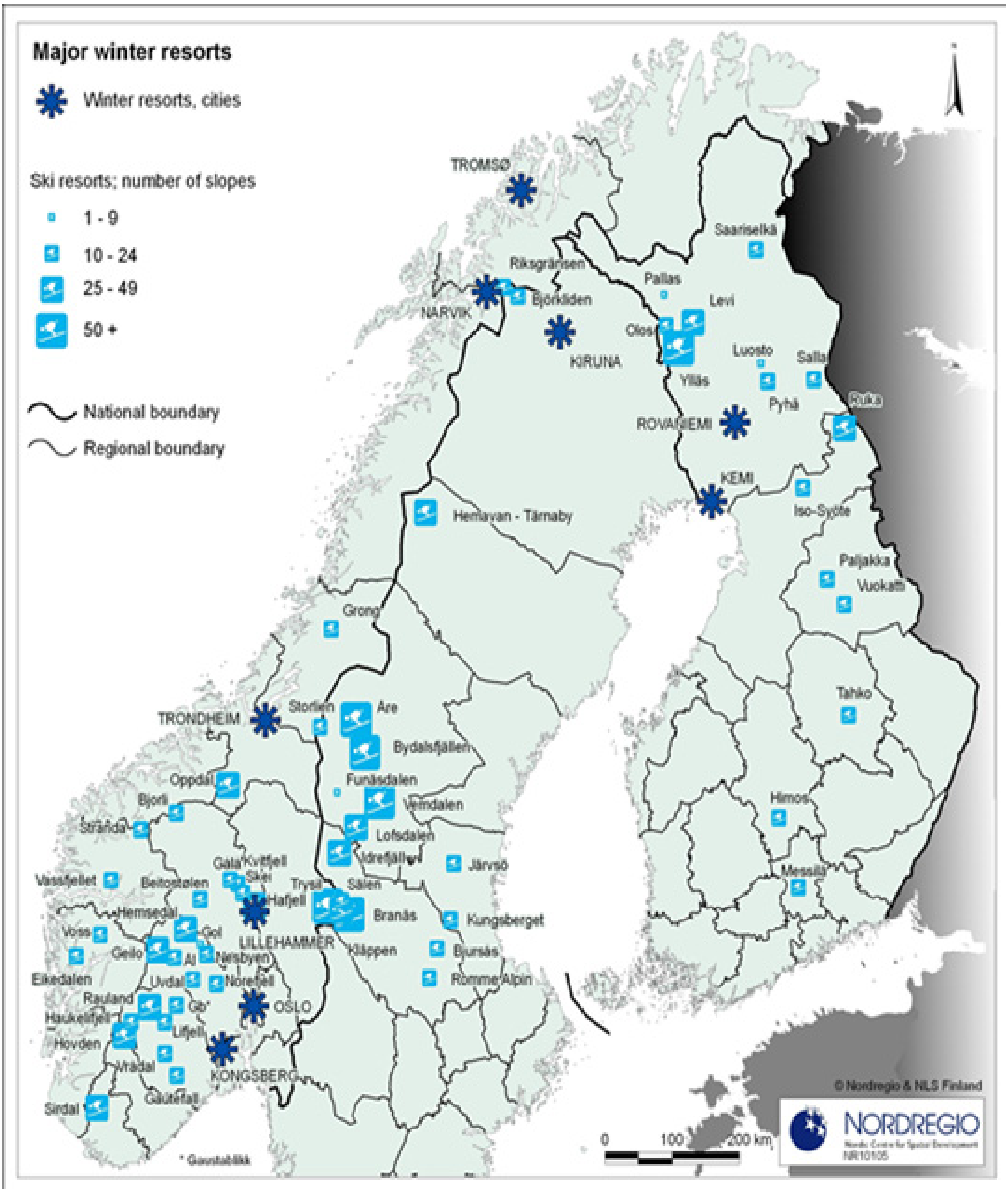
Source: SLAO various issues and Statistics Sweden.

Fig. 3: Evolution of average snow depth in the early season



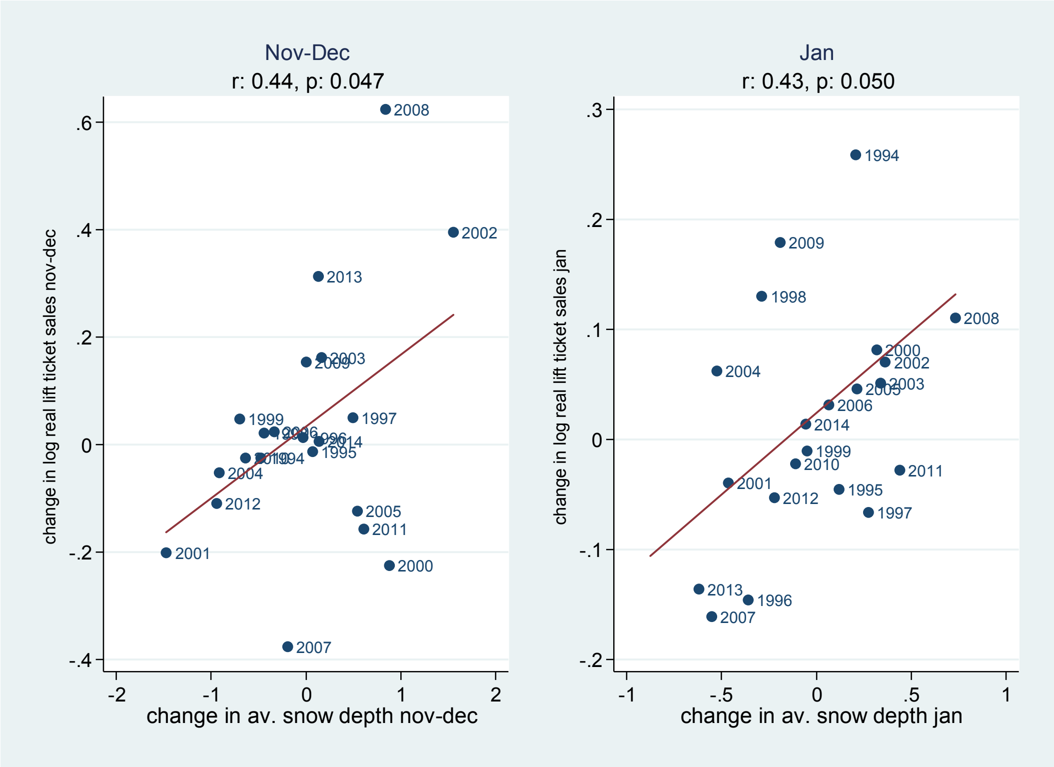
Source: SMHI weather stations Storlien-Visjövalen in Jämtland and Särna in Dalarna.

Fig. 4: Map of ski areas in Sweden and neighbouring countries



Source: http://www.nordregio.se/en/Maps--Graphs/09-Other/Major-winter-resorts-in-Scandinavia.

Fig. 5: Correlation between change in lift ticket sales and snow depth



Source: SLAO various issues and SMHI.

Table 4

Seemingly unrelated regression estimates of the determinants of growth of lift ticket sales for Swedish ski areas with the EUR/SEK exchange rate

	November-December			January			February		
	coeff.		t	coeff.		t	coeff.		t
change in log average snow depth in mountain destinations	0.12	**	2.46	0.13	***	3.57	0.09	*	1.69
change in log GDP in constant prices	0.77	***	3.26	0.77	***	3.26	0.77	***	3.26
change in (deflator lift ticket sales/CPI)	-0.56	**	-1.87	-0.56	*	-1.87	-0.56	*	-1.87
dummy time period 2010-11 to 2013-14	-0.07	***	-4.70	-0.07	***	-4.70	-0.07	***	-4.70
change in log EUR/SEK rate	0.35	***	3.24	0.35	***	3.24	0.35	***	3.24
constant	0.04		0.90	0.03		1.32	0.03		1.26
	March			April-May					
	coeff.		t	coeff.		t			
change in log average snow depth in mountain destinations	-0.03		-0.97	-0.04		-0.83			
change in log GDP in constant prices	0.77	***	3.26	0.77	***	3.26			
change in (deflator lift ticket sales/CPI)	-0.56	*	-1.87	-0.56	*	-1.87			
dummy time period 2010-11 to 2013-14	-0.07	***	-4.70	-0.07	***	-4.70			
change in log EUR/SEK rate	0.35	***	3.24	0.35	***	3.24			
early Easter	0.35	***	13.48	-0.52	***	-6.14			
constant	-0.12	***	-4.71	0.19	***	2.90			

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

Table 5
Seemingly unrelated regression estimates of the determinants of growth of lift ticket sales for Swedish ski areas with the SEK/NOK exchange rate

	November-December			January			February		
	coeff.		t	coeff.		t	coeff.		t
change in log average snow depth in mountain destinations	0.12	**	2.46	0.09	**	2.17	0.05		0.94
change in log GDP in constant prices	0.83	***	3.64	0.83	***	3.64	0.83	***	3.64
change in (deflator lift ticket sales/CPI)	-0.84	***	-2.85	-0.84	***	-2.85	-0.84	***	-2.85
dummy time period 2010-11 to 2013-14	-0.08	***	-4.96	-0.08	***	-4.96	-0.08	***	-4.96
change in log SEK/NOK rate	-0.32	**	-2.56	-0.32	**	-2.56	-0.32	**	-2.56
constant	0.04		1.03	0.03		1.40	0.03		1.49
	March			April-May					
	coeff.		t	coeff.		t			
change in log average snow depth in mountain destinations	-0.03		-0.99	-0.09	*	-1.80			
change in log GDP in constant prices	0.83	***	3.64	0.83	***	3.64			
change in (deflator lift ticket sales/CPI)	-0.84	***	-2.85	-0.84	***	-2.85			
dummy time period 2010-11 to 2013-14	-0.08	***	-4.96	-0.08	***	-4.96			
change in log SEK/NOK rate	-0.32	**	-2.56	-0.32	**	-2.56			
early Easter	0.32	***	11.85	-0.49	***	-5.53			
constant	-0.11	***	-4.27	0.18	***	2.71			

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

Table 6
Correlation matrix of residuals based on the seemingly unrelated regression estimates

	equation 11t12	equation 1	equation 2	equation 3	equation 4t5
equation 11t12	1				
equation 1	0.17	1			
equation 2	0.13	0.57	1		
equation 3	-0.36	-0.53	0.14	1	
equation 4t5	0.28	0.62	0.08	-0.82	1

Notes: The correlation matrix is based on the SUR estimates displayed in Table 2.