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The demand for winter sports: empirical evidence for the largest French ski-lift operator

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This paper investigates the determinants of long-run winter tourism demand for French ski resorts. The data are based on skier visits to the largest ski-lift operator in the world (Compagnie des Alpes) for the winter seasons 1993/1994 to 2011/2012. Using dynamic panel data models for six ski resorts, the study finds relatively low income and price elasticities in absolute terms, with long-run elasticities of 0.64 and –0.40, respectively. Furthermore, the study finds that snow depth measured at the weather station Col de Porte – located at the medium elevation of 1,325 metres above sea level – is a significant predictor of skier days in the high-elevation ski areas. However, the magnitude of the effect of poor snow years is very small: on average, low-snow winter seasons (such as 1989/1990 or 2006/2007) will lead to a reduction in skier visits of about 2.5%. The results are not sensitive with respect to the measurement and timing of snow depth.

Keywords: winter tourism demand; weather; snow depth; skier visits; dynamic panel data methods; French Alps

Since the beginning of the 1990s, ski resorts in France have been facing a slowing-down and stagnation of market demand (Tuppen, 2000; Paget *et al*, 2010). This is evident for the ski resorts belonging to Compagnie des Alpes (CDA), which is the largest ski-lift operator in the world. For instance, the number of skier visits to the ski areas Paradiski (La Plagne, Les Arcs, Peisey-Vallandry) and Les Menuires-Méribel each grew by 0.7% per year on average between 1993/1994 and 2011/2012 (see Table 1). Other ski areas that belong to the CDA group, namely Espace Killy (Tignes, Val d'Isère), Les Deux Alpes and Serre-Chevallier, have experienced a decline in the number of skier visits during the same period.[1]

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Table 1. Evolution of the number of skier visits.

Winter season	Paradiski (La Plagne, Les Arcs, Peisey-Vallandry)	Espace Killy (Tignes, Val d'Isère)	Les Trois Vallées (Les Menuires, Méribel)	Grand Massif (Flaine, Giffre)	Les Deux Alpes	Serre-Chevallier
1993–94	4,095,427	3,236,031	2,162,226	NA	NA	NA
1994–95	3,947,774	3,120,077	2,084,482	NA	NA	NA
1995–96	3,938,515	3,018,222	2,070,077	NA	NA	NA
1996–97	4,118,602	2,867,443	2,085,677	NA	NA	NA
1997–98	4,298,616	3,225,000	2,285,626	1,088,417	1,372,000	1,028,000
1998–99	4,463,000	3,238,800	2,385,000	1,052,000	n.a.	n.a.
1999–00	4,386,000	3,121,639	2,424,000	1,131,000	n.a.	n.a.
2000–01	4,593,000	3,277,423	2,494,000	1,151,000	1,386,785	1,470,271
2001–02	4,483,000	3,259,512	2,519,000	1,124,000	1,353,306	1,284,447
2002–03	4,574,000	3,256,000	2,532,000	1,285,000	1,358,894	1,289,751
2003–04	4,659,000	3,208,308	2,588,000	1,266,000	1,441,000	1,560,072
2004–05	4,566,000	3,142,216	2,503,000	1,201,000	1,258,819	1,340,471
2005–06	4,610,000	3,022,943	2,553,000	1,268,000	1,325,768	1,344,600
2006–07	4,519,000	3,006,586	2,428,000	1,142,000	1,310,000	1,312,301
2007–08	4,823,000	3,071,503	2,644,000	1,281,000	1,362,390	1,392,411
2008–09	4,768,000	2,770,000	2,599,000	1,309,000	1,319,716	1,438,496
2009–10	4,683,000	2,765,727	2,491,000	1,276,000	1,267,916	1,378,898
2010–11	4,501,000	2,742,000	2,364,000	1,285,000	1,214,000	1,331,000
2011–12	4,687,000	2,746,000	2,456,000	1,316,000	1,224,000	1,306,000

Source: CDA annual report, Montagne Leaders various issues.
Note: Data for the winter seasons 1993–1994 to 1996–1997 are calculated based on sales revenues in constant prices drawn from the annual reports.

The ski resorts belonging to CDA also seem to have been significantly affected by the economic and financial crises. In particular, for the three largest ski areas of the CDA group (Paradeski, Espace Killy and Les Menuires-Méribel) one can observe a decline in the number of skier visits from the winter season 2008/2009 onwards (see Table 1). Another striking finding is that, even with the appreciation of the Swiss franc, the CDA group's skier visits have not increased since 2009, which has led to an improvement in price competitiveness of French ski resorts compared to Swiss ski resorts – their main competitors. This may indicate a low price elasticity of tourism demand.

In this paper, we investigate the determinants of long-run winter tourism demand using error-correction models applied to six large ski resorts in France. We place special emphasis on the effects of weather factors measured as snow depth and temperatures. Another important aspect involves our consideration of a bundle of factors that influence the demand for downhill skiing and snowboarding rather than the bivariate relationship between tourism demand and weather patterns. These factors include prices relative to competitors, domestic and foreign GDP and dynamic adjustment processes.

Our novel contribution to the previous literature is twofold. First, we use new and unique data on the number of skier visits of the ski areas belonging to the CDA group. Only recently have studies started to use skier visits as a measure of winter tourism demand. We believe that the number of skier visits is perfectly suited for studying winter tourism demand because it does not suffer from underreporting, such as other measures (for example, arrivals and visitor nights) (Guizzardi and Bernini, 2012). Furthermore, skier visits can be regarded as a true measure of the demand for winter sports, unlike the sales revenues of ski-lift operators, which often include sales from non-ski business (such as renting and restaurant sales). Second, we use dynamic panel data methods to investigate the determinants of the number of skier visits. In particular, we carefully investigate the role of prices and GDP besides the impacts of snow depth and temperatures. To the best of our knowledge, this is the first study to estimate a dynamic tourism demand model using skier visits as the measure of tourism demand in the winter season.

The data consist of six French resorts under the control of the CDA group. As mentioned, the CDA group is the largest ski-lift operator in the world, having recorded about 13.7 million skier visits for the winter season 2011/2012.[2] Its resorts include Paradiski (La Plagne, Les Arcs, Peisey-Vallandry), Espace Killy (Tignes, Val d'Isère), Les Trois Vallées (Les Menuires, Méribel), Grand Massif (Flaine, Giffre), Les Deux Alpes and Serre-Chevallier. All of these ski areas are characterized by high slope elevations (up to more than 3,000 metres), modern lift systems and expansive skiable terrain.

Ski resorts have been the major focus of articles on tourism and climate change in recent years (Becken, 2013; Dawson and Scott, 2013; Kaján and Saarinen, 2013; Pang *et al*, 2013). It is generally accepted that winter tourism is rather sensitive to variations in weather factors, such as changes in natural snowfall, temperatures and precipitation patterns. However, ski-lift managers often argue that skier demand is largely independent of variations in natural snowfall because of extensive snowmaking facilities. For instance, CDA's annual report states the following: 'Because of the high elevation CDA are less affected by snowfall than lower altitude resorts' (CDA, 2007). Traditional factors, such as the income of source countries and prices relative to those of the main competitors, also play a significant role. While a broad range of literature has investigated the determinants of winter tourism demand using econometric methods, few studies have used skier visit data at the resort level in order to study long-run winter tourism demand.

French ski resorts are an interesting case study for several reasons. First, France is the largest ski destination in the world and is commonly regarded as the leader in Alpine skiing, comprising the largest ski areas in the world (Paget *et al*, 2010; Vanat, 2015). Second, CDA ski resorts, meanwhile, are particularly intriguing because they are all characterized by high elevations; the attendant low temperatures make these resorts less vulnerable to a changing climate. While it is generally accepted that low-altitude resorts are particularly affected by low-snow winter periods (Pickering, 2011; Steiger, 2011), the extent to which high-elevation resorts equipped with extensive snowmaking machines are affected by variations in snowfall in lower elevations is unclear.

The results show that skier visits depend significantly and positively on the snow depth measured at the weather station Col de Porte, which is located at medium elevation outside the ski area, close to Grenoble – the largest urban agglomeration in the European Alps with about 650,000 inhabitants. The weighted GDP of visitor countries and relative prices are also significant. The elasticities of real income and prices, however, are rather low in absolute terms. The latter indicates that an improvement in relative prices compared to France's primary competitor – Switzerland – will only lead to a moderate increase in skier visits.

The structure of this paper is as follows. The next section presents the literature review. We then present the empirical results before providing the summary statistics and the description of the data. The penultimate section presents the empirical results and the final section concludes.

Literature review

The ski business in Europe and North America has been generally plagued by a number of challenging problems, including climate change and environmental issues, changing demographics, increasing competition, and the intensified concentration and saturation of markets (Tuppen, 2000; Flagestad and Hope, 2001; Hamilton *et al*, 2003; Hudson, 2003; Vanat, 2015). In the related literature, there has been considerable discussion in recent years on the performance and growth prospects of ski areas in low-snow winter periods (Tuppen, 2000; Steiger, 2011; Gonseth, 2013).

There are two main strands of literature. One strand investigates the impact of snow depth and other factors in a tourism demand model while accounting for price and income effects (for Austria, see, Falk, 2010, 2013; Töglhofer *et al*, 2011). These studies find that the sensitivity of winter tourism demand (measured as the number of overnight stays) with respect to snow depth is relatively low. This finding can be mainly attributed to the large-scale production of technical snow (Fischer *et al*, 2009). The literature on tourism demand also shows that income and relative prices are the most important determinants of tourism demand (Song and Li, 2008). However, previous tourism demand studies on winter sport destinations find mixed evidence on the magnitude of income elasticities. For instance, using 28 ski resorts for Austria, Falk (2010) finds income elasticities of unity (that is, one). Using a broader data set from ski resorts in Austria, Töglhofer *et al* (2011) find insignificant income elasticities. Using data for 28 winter sport destinations in Austria, Falk (2013) more recently calculates an elasticity of 0.19 for domestic overnight stays with respect to domestic GDP, indicating that domestic winter tourism only marginally increases when there is an improvement in general economic conditions in a given country. That said, income elasticity likely depends on ski resort characteristics. For the sample of high-elevation ski resorts in Austria, Falk (2010) finds income elasticities of about 1.6. Studies on other Alpine destinations also find high income elasticities. For South Tyrol, for instance, Brida and Risso (2009) find income elasticities of 1.9. For Switzerland, Luzzi and Fluckiger (2003) calculate an income elasticity of 1.75 with overnight stays as the measure of tourism demand. However, the last two studies focus on all seasons rather than on the winter season.

The other strand of literature – dealing mainly with climatology and tourism geography – investigates the bivariate relationship between skier demand and snowfall, neglecting income and price effects. Examples include Bark *et al* (2010) for Arizona; Fukushima *et al* (2002) for Japan; Gonseth (2013) for Switzerland; Hamilton *et al* (2003) for New Hampshire; Hamilton *et al* (2007) for New England; Pickering and Buckley (2010) for Australia; Scott, (2005) for the USA; Shih *et al* (2009) for Michigan; and Steiger (2011) for Austria. These studies mainly examine the impact of low-snow winter periods on skier visits by comparing snow poor winter seasons with average winter seasons. The general findings of these studies are that snow depth strongly affects winter tourism demand. In particular, for the Austrian province of Tyrol, Steiger (2011) finds that extreme seasons – such as the 2006/2007 winter season – have a strong negative impact on the number of lift transports on average with larger effects for low elevations ski resorts. Using data for 65 Swiss ski resorts, Gonseth (2013) finds that skier visits strongly depend on natural snow depth, with higher effects for resorts with poor snowmaking facilities. Pickering (2011), meanwhile, demonstrates that snow cover explains 72% of the annual variation in visitor days based on resort-level data for Australia.

The previous empirical research presents a wide range of conflicting evidence across two strands of literature. However, these studies are difficult to compare because they are situated in different geographical locations (in terms of latitude, longitude and altitude); they also involve different measures of winter tourism demand (such as lift ticket sales, skier visits, number of days of ski-lift operations, number of lift transports and overnight stays), different levels of aggregation (individual- or resort-level data), different data frequencies (annual, monthly or daily intervals), different model specifications (static and dynamic) and large differences in sample size. Few studies include a broader set of economic variables that affect winter tourism demand, such as the real income of visitor countries and relative prices. However, in the tourism economics literature it is generally agreed that meteorological variables and economic variables should be included simultaneously in the regression model (Taylor and Ortiz, 2009; Álvarez-Díaz and Rosselló-Nadal, 2010; Otero-Giráldez *et al*, 2012). In addition, very few studies have been carried out at the level of individual ski-lift companies (for some rare examples, see Fukushima *et al*, 2002; Bark *et al*, 2010; Pickering, 2011; Steiger 2011). Despite the growing literature on the determinants of winter tourism demand and the role of weather factors, there is still no general consensus on the extent to which weather, snow conditions and extreme events influence winter tourism demand.

Empirical model

The relationship between the weather/climate and skier demand is rather complex. It is well known that winter tourism also generally depends on a amalgamation of factors, such as the real income of visitor countries and relative prices. Income, prices relative to those of the origin countries in question and to those of the main competitor, travel costs and changes in exchange rates are indeed commonly regarded as the main explanatory variables of tourism demand (Li *et al*, 2005). In particular, real income has the largest impact, with elasticities between one and two (Crouch, 1994a, 1994b). Witt and Witt (1995) suggest that the median of income elasticities is about 2.4. Using a meta-analysis, Crouch (1995) finds real income elasticities of 1.7 and 2.3 for northern and southern Europe, respectively. A more recent meta-analysis indicates that holiday tourism is highly income-elastic in general, evincing an elasticity of about 2.5 (Peng *et al,* 2014). Income elasticities for holiday tourism in sun, sand and sea destinations, for example, also exhibit income elasticities exceeding one. While prices and income are the explanatory variables most commonly used to explain tourism demand in general, there are a number of other factors that may affect winter tourism demand. Snow conditions and temperatures in ski areas are important factors, for example. Knowledge of the relationship between snow depth and tourism demand is essential because all Intergovernmental Panel on Climate Change (IPCC) scenarios predict a decrease in snow cover due to increases in temperatures. Furthermore, in the western European Alps, there has been a significant decrease of snow depth for both low and high elevation stations (Terzago *et al*, 2013). Riddington *et al* (2000) find that snow cover in ski areas is one of the most important factors influencing day-trippers' choices of ski areas, but does not play a role in overnight stays. Due to the large size of the local consumer base, day-trippers are also a key target market for CDA resorts.

Snow depth in ski areas cannot be included in the model due to the lack of reliable weather data for the French Alps. In France, all of the high elevation weather stations are located in the Pyrénées. Durand *et al* (2009) suggest that there is a lack of mountain meteorological observations in the French Alps with reliable data for snow depth. Even when data based on unofficial sources is available, the extent to which the high-elevation ski areas of the CDA group are affected by high winter temperatures and/or low snow cover is unclear; all of these areas were early adopters of snowmaking machines and thus increased their snowmaking capacity rapidly during the time period under review (see Table 2). The previous literature reveals that skier demand is influenced not only by the weather and snow conditions at the ski resorts themselves, but also by the weather conditions outside the ski areas in lower elevation areas (Hamilton *et al*, 2007). The reason being that people in larger cities prefer other leisure activities during mild winter seasons. This is referred to as the 'backyard hypothesis'. Since there are no official weather stations at high elevations in the French Alpes, we use weather data at the medium-elevation station Col de Porte. We believe that the Col de Porte weather station is appropriate for investigating the 'backyard hypothesis' since it is located in the Chartreuse Mountains that spreads from the outskirts of Grenoble.

Besides weather factors, there are a number of other factors that could affect the number of skier visits. Gonseth (2013) finds that snowmaking capacity is an important determinant of skier visits based on 65 Swiss ski resorts. For French ski resorts, Goncalves (2013) suggests that the number of ski lifts and their transport capacity are the main factors of performance for ski lift companies. Other studies find that gondola queues and the quality and size of skiable terrain are important determinants of skier visits (Ormiston *et al*, 1998; Riddington *et al*, 2000). According to the CDA's (2007) annual report, visitor numbers depend on elevation of the slopes, variety of trails, snow-making capacity and links with other ski areas. Echelberger and Schafer (1970) suggest that driving time from metropolitan areas are important factors in determining skier demand. Some of these factors, such as terrain, slope elevation and distance

Table 2. Snowmaking capacity of CDA ski areas (%).

	1999/2000	2004/2005	2012/2013
La Plagne	4	18	22
Les Arcs	3	11	11
Peisey-Vallandry	19	32	
Les Menuires	23	28	41
Méribel	24	44	50
Tignes	13	13	17
Val d'Isère	NA	NA	20
Grand Massif (Flaine et Giffre)	4	18	NA
Serre Chevallier	NA	NA	33

Source: CDA annual reports various issues, 2012–2013 based on websites.

to larger cities, are time-invariant and thus automatically taken into account by the fixed-effects estimator or dynamic panel data methods. The adoption of new lifts, changes in transport capacity and snowmaking capacity and other factors can be measured, but are difficult to calculate for longer time periods.

The empirical model is based on a tourism demand model augmented by weather variables. The standard demand factors are relative prices (relative to the destination country's competitors) and the income of visitor countries (Crouch, 1994a, 1994b; Lim, 1997). Previous studies find that winter tourism demand in high elevation ski resorts is highly income elastic, indicating that tourism demand increases disproportionately with increases in income (Falk, 2010). Given the literature and the availability of data, the number of skier days is modelled as a function of real GDP of the visitor countries, relative prices and weather factors:

$$X_{it} = f(Y_{ikt}, RP_{jt}, SD_t, TEMP_t). \tag{1}$$

The expected relationships are as follows:

$$\frac{X_{it}}{Y_{ikt}} > 0, \frac{X_{it}}{RP_{jt}} < 0 \ \frac{X_{it}}{SD_t} > 0, \frac{X_{it}}{TEMP_t} < 0, \tag{2}$$

where X_{it} denotes the number of skier visits (including snowboarders) in ski resort i; Y_{ikt} national income of origin countries k, weighted by the visitor share; RP_{jt} relative prices, ratio of prices at destination i to prices of the main competitor j where competitor prices are converted in euro; SD_t average natural snow depth for the period December to February; and $TEMP_t$ average temperatures for the period December to February.

Assuming a log-linear form, the static relationship between skier visits, real income, relative prices and weather factors can be specified as follows:

$$\ln X_{it} = \alpha_i + \beta_1 \ln Y_{ikt} + \beta_2 \ln RP_{jt} + \beta_3 \ln SD_t + \beta_4 TEMP_t + \varepsilon_{it}, \tag{3}$$

where ln denotes the natural logarithm and ε is the error term and α_i is the ski resort effect. Since all variables except temperatures are transformed into logs, β_1 and β_2 can be interpreted as income and price elasticities. Economic theory suggests positive income elasticities and negative price elasticities. β_3 is the elasticity of skier visits with respect to snow depth. β_4 is the semi-elasticity of skier visits with respect to temperatures.

We use a dynamic panel data model to address habit persistence and/or partial adjustment (Lim, 1997; see Seetaram, 2010, for recent applications). To account for dynamic relationships, we use error-correction models that can be derived from an autoregressive distributed lag (ARDL) model. Given the panel data nature of the study, we employ the pooled mean group (PMG) method that allows the short-term impacts of income, relative prices, and snow depth to vary across ski areas, but keeps the long-term impacts equal. This approach also addresses the problem of non-stationarity, which may result in spurious relationships between the dependent variable and the independent variables. The pooled mean group estimator can be applied to either stationary or non-stationary regressors. Given the short time dimension, our main specification for the number of skier visits takes the following form:

$$\begin{aligned}\Delta \ln X_{it} &= -\gamma(\ln X_{it-1} - \tilde{\beta}_1 \ln Y_{ikt} - \tilde{\beta}_2 \ln RP_{jt} - \tilde{\beta}_3 \ln SD_t - \tilde{\beta}_4 TEMP_t - \alpha_i) \\ &+ \delta_1 \Delta \ln Y_{ikt-1} + \delta_2 \Delta \ln RP_{jt-1} + \delta_3 \Delta \ln SD_t + \delta_4 \Delta TEMP_t + \tilde{\varepsilon}_{it}. \end{aligned} \tag{4}$$

The long-run elasticities of skier visits with respect to real GDP, real prices and snow depth are $\tilde{\beta}_1$, $\tilde{\beta}_2$ and $\tilde{\beta}_3$. Our main research question deals with the extent to which the number of skier days is influenced by current weather trends (that is, primarily temperature and snow depth but also precipitation). The pooled mean group estimator is estimated using the maximum likelihood method, where the long-run parameters are directly estimated (Pesaran *et al*, 1999). To check the sensitivity of the results, we also use simpler estimation approaches, such as the fixed effects estimator and OLS, based on first differences.

Data

The empirical analysis covers six ski areas of the CDA group for the winter seasons 1993/1994 to 2011/2012. Skier visits are defined as the number of people who obtain a lift ticket or a lift pass and use the ski area for all or any part of one day and/or night. The data is drawn from various annual reports of the CDA group, which is a listed company. The group was founded in 1989 during a period of warm, low-snow winter seasons (1987–1988, 1988–1989 and 1989–1990). In the following years, CDA acquired a number of ski resorts that all share some common characteristics: extensive skiable terrain, high elevation and a high attractiveness for international visitors. As of winter season 2011/2012, the CDA group comprised Paradeski (La Plagne, Les Arcs, Peisey-Vallandry), Espace Killy (Tignes, Val d'Isère), parts of the Les Trois Vallées ski areas (Les Menuires, Méribel), Grand Massif (Flaine, Giffre), Les Deux-Alpes and Serre-Chevallier (see Figure 1). All of the group's ski areas have slopes at up to 3,000 metres and higher. According to the CDA's annual report, 23%

Figure 1. Location of the ski resorts.
Note: Ski resorts: 1 – Tignes, 2 – Val D'Isère, 3 – Les Arcs, 4 – Peisey-Vallandry, 5 – La Plagne, 6 – Méribel, 7 – Les Menuires, 8 – Serre-Chevalier, 9 – Les 2 Alpes, 10 – Flaine.
Source: CDA website.

of the trails are equipped with snowmaking facilities and the total ski area covers 1,700 kilometres of linear ski runs (CDA, 2007/2008). Owing to a lack of data on skier visits, Grand Massif (Flaine, Giffre) can only be analysed from 1997/1998 onwards. Data for Les Deux-Alpes and Serre-Chevallier, meanwhile, are available from 2000/2001 onwards.

Data on snow depth, temperatures and precipitation can be downloaded from the National Centre for Meteorological Research.[3] Mean snow depth refers to 10-day averages. As mentioned, the weather station in question is located at Col de Porte (Massif de la Chartreuse-Isère) at an elevation of 1,325 metres above sea level (Lesaffre *et al*, 2012). The geographical distances between the weather station and the nearest CDA ski resorts are 50 km for Les deux Alpes and about 60 km for Méribel.

The data on GDP in constant euro prices are taken from OECD stats. To construct weighted GDP, we use the visitor share from 2006 (based on overnight stays) and information drawn from the annual accounts. Foreign skiers account for between 30 and 60% of the CDA visitors according to the group's annual reports, with half of foreign visitors coming from the United Kingdom. Other foreign customers hail mainly from continental Europe: Belgium, Germany, Italy, Switzerland, the Netherlands and, more recently, Russia. Visitors from the USA account for a small share.

The price variable is defined as relative prices to the main competitor – Switzerland. Time series data on lift ticket prices can be obtained from the Blue Book of European Ski Resorts. However, lift ticket prices are likely to be endogenous to output because increases in lift ticket prices often reflect quality improvements (such as installations of new ski lifts and snowmaking facilities), which lead to an increase in output (Falk, 2011). Therefore, we use aggregate prices to construct the relative price variable. Consumer price data exist for railway passenger transport in France, but for Switzerland, data are available only from 2005 onwards. Given the difficulties associated with accessing and measuring tourist prices, this paper uses service prices less prices of the housing sector as a proxy. The price index for services less housing in France and Switzerland and the EUR–CHF exchange rate are all taken from OECD statistics. The price index for Switzerland is converted into Euro using the EUR-CHF exchange rate. A comparison of the evolution of lift ticket prices and the service price index shows little differences in the two price measures. For instance, based on the Blue Book, the average annual change in lift ticket prices of the Trois Vallées ski area is 2.6% per year, whereas the change in price index is 2.2%.

Table 1 shows the evolution of the number of skier visits between 1993/1994 and 2011/2012. The number of skier visits to the ski areas Paradiski (La Plagne, Les Arcs, Peisey-Vallandry) and Les Menuires-Méribel grew only slightly over this period. The remaining ski resorts – Espace Killy (Tignes, Val d'Isère), Les Deux-Alpes and Serre-Chevallier – experienced a decline in the number of skier visits. The ski resorts belonging to the CDA group have also been greatly affected by the economic and financial crisis. From 2008/2009 to 2010/2011, the group recorded 711,000 fewer skier visits. The number of skier visits for the 2011/2012 season is still below pre-recession levels. This figure also fell by 404,000 from the previous season during the extreme winter season of 2006/2007. (see Figures 2 to 4 for the evolution of skier visits, relative prices, real

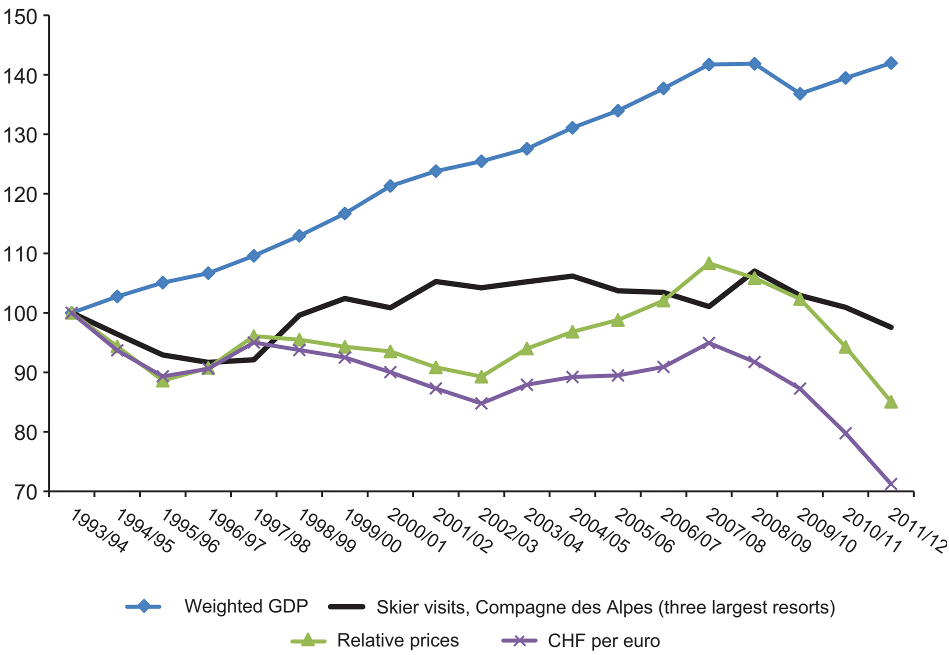

Figure 2. Evolution of skier visits, weighted GDP of the visitor countries and prices.
Source: CDA annual reports various issues, Montagne Leaders various issues, OECD Statistics.

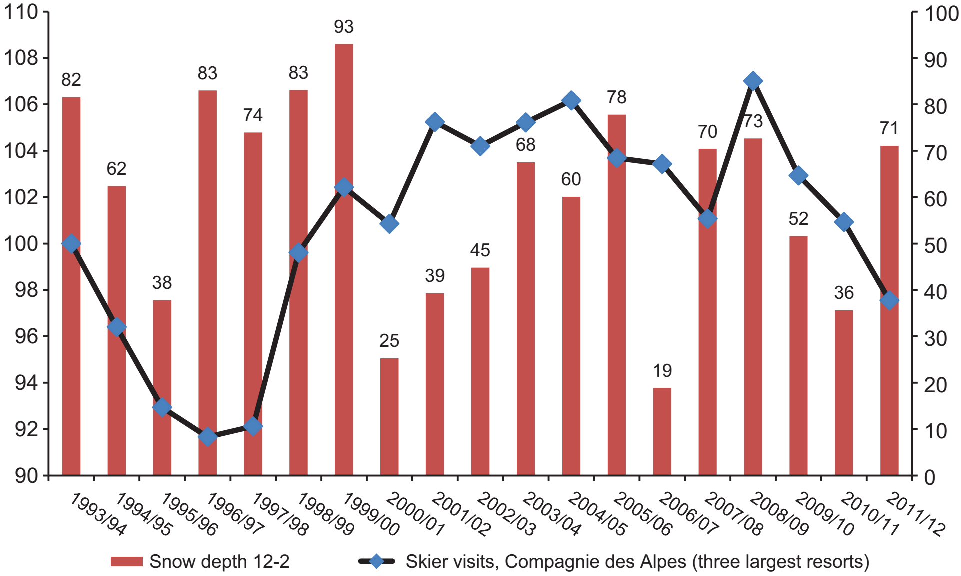

Figure 3. Evolution of skier visits and snow depth of the weather station Col de Porte.
Note: Snow depth is measured in centimetres and refers to the average for December to February.
Source: National Centre for Meteorological Research.

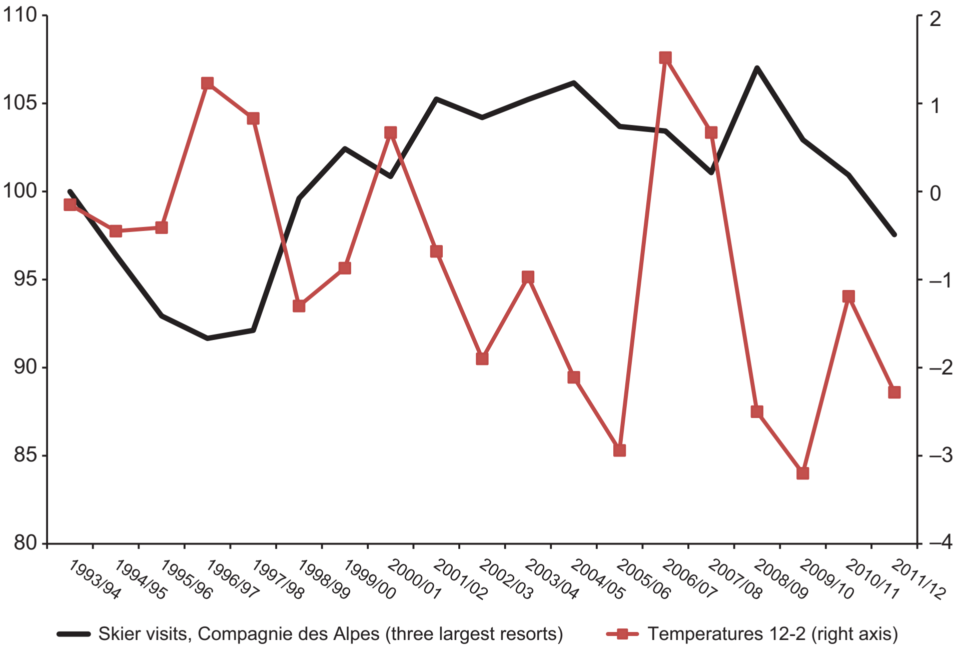

Figure 4. Evolution of skier visits and average temperatures of the Col de Porte station.
Note: Temperatures refer to the average for December to February.
Source: National Centre for Meteorological Research.

GDP, snow depth and temperatures for the period 1993/1994 to 2011/2012). Note that, due to missing data, the descriptive statistics for ski visits from 1993/1994 onwards refer to the three largest ski resorts of the CDA group.

Results

As a first step, we examine the stationarity and cointegration of the time series under review. Panel unit root tests show that weighted GDP per capita and skier visits are I(1). The second-generation panel unit root tests introduced by Pesaran (2007), which accounts for cross-sectional dependence, lead to similar results. Furthermore, simple ADF tests show that snow depth and temperature are I(0). Panel unit root tests with a small time span should, however, be generally interpreted with caution because the tests have no power. Therefore, we also report simpler specifications using static fixed effects models (see Table 4) and OLS based on first differences of the data as well as results obtained from the robust regression method, which gives less weight to potential outliers (see Table 3).

Table 5 reports the results of the pooled mean group estimator. A panel cointegration test based on the significance of the error correction term introduced by Westerlund (2007) shows that the null hypothesis of no cointegration can be rejected at the 1% level. This indicates a long-run relationship between skier visits, real income, relative prices and snow depth. Overall, the R^2 indicates that our model explains 35% of the variation in skier demand.[4] This indicates that a large proportion of the variation in skier demand cannot be explained by the evolution of income, relative prices and snow depth. Further-

Table 3. OLS and robust regression estimates of the demand for skier visits.

	OLS		Robust regression method	
	coeff	***t***	**coeff**	***t***
Δln relative price index	0.215**	2.55	0.190**	2.06
Δln weighted real GDP	0.377**	2.03	0.470*	1.82
Δln snow depth Dec-Feb	0.023**	2.52	0.021***	3.37
Constant	–0.005	–1.25	–0.005	–0.82
Number of observations	90			
R^2	0.150			
	coeff	***t***	**coeff**	***t***
Δln price index of railways	0.145	0.32	0.657	1.30
Δln weighted real GDP	0.509**	2.99	0.473**	1.82
Δln snow depth Dec–Feb	0.025***	2.85	0.022***	3.61
Constant	–0.012	–2.42	–0.020**	–1.99
Number of observations	90		90	
R^2	0.12			

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The dependent variable is the log change in the number of skier visits. The estimation method is OLS with clustered standard errors across ski resorts.

Table 4. Fixed effects model of the demand for skier visits.

	(i)		(ii)	
	Coeff	z	Coeff	z
ln weighted real GDP	0.958***	4.20	0.962***	4.24
ln price index of railways	–0.683***	–3.37	–0.673***	–3.20
ln snow depth Dec–Feb	0.016**	2.15	0.021***	3.29
Average temperature depth Dec–Feb	–0.004	–1.13		
Constant	17.42***	19.53	17.32***	18.76
R^2 (within)	0.31		0.31	
Number of observations	98		98	
Number of ski resorts	6		6	

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The dependent variable is the log number of skier visits. Z-values are based on standard errors adjusted for six clusters.

Table 5. Dynamic panel data estimates (pooled mean group estimator).

	(i)		(ii)	
	Coeff	z	Coeff	z
Long-run elasticities:				
ln weighted real GDP	0.66***	7.64	0.64***	8.73
ln relative prices	–0.44***	–3.20	–0.40***	–3.39
ln snow depth Dec to Feb	0.042**	2.16	0.034***	2.71
Average temperatures Dec to Feb	0.004	0.58		
Short-run coefficients:				
Error correction term	–0.62***	–4.05	–0.64***	–4.08
Dln relative prices	0.55***	4.16	0.56***	4.28
Dln weighted real GDP	–0.43	–0.94	–0.33	–0.78
Constant	8.72***	4.20	9.00***	4.23
Log likelihood	185.07		184.89	
Number of observations	90		90	
Number of ski resorts	6		6	
R-squared	0.35		0.35	

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. This table presents pooled mean group estimates for a panel of six French ski resorts between 1993/1994 and 2011/2012. The dependent variable is the log change of the number of skier visits. The R^2 is based on the one-step error correction model estimated with resort-specific fixed effects.

more, unreported results reveal that serial correlation and heteroscedasticity do not exist in the residuals.

The long-run coefficients of real GDP, relative prices and snow depth show the expected sign. In the long run, skier visits are significantly and positively related to the real income of the visitor countries (measured as weighted GDP in constant prices) and snow depth at the Col de Porte weather station. Meanwhile, there is a negative long-run relationship between skier visits and relative prices. This means that an appreciation of the Swiss franc, which would result in a decrease in the relative service prices of France versus Switzerland, will stimulate the number of skier visits to the six French ski resorts. A 1% decrease in relative prices implies a 0.4% increase in skier visits.

The long-run real income elasticity is about 0.64 (see specification (ii)). This means that a 1% increase in real income will lead to a 0.64% increase in the number of skier visits on average given the impact of relative prices and snow depth. A *t*-test shows that the income elasticity is significantly below unity. Thus, winter tourism activities in France – such as skiing and snowboarding – are income inelastic or a necessity good rather than a luxury good. The findings that winter sport activities are a necessity good stands in contrast to the previous literature. For instance, using data on visitor nights for high elevation ski resorts in Austria, Falk (2010) finds income elasticities ranging between 1.6 and 2.5. This low income elasticity might be explained by the large domestic consumer base, which accounts for 60% of skier visits on average (CDA, various years). A low income elasticity also means the number of skier visits in recession periods will not fall as much as they would with an income elastic coefficient. However, the low income elasticitiy also means that the ski business in France is not a 'growth' industry. When real incomes are growing significantly in the visitor countries, the number of ski visits grows only very slowly. We conclude that the low real GDP growth of the visitor countries combined with a low income elasticity are main factors for the stagnation of the winter tourism demand in CDA ski resorts for the total sample period. However, there are reasons to be cautious in interpreting the results of the income elasticity given the low model fit. A larger sample is probably needed in order to empirically examine the exact value of the income elasticity of French winter tourism demand.

The long-run elasticity of skier visits with respect to snow depth at the Col de Porte weather station is 0.034. This indicates that snow conditions outside the main ski area located close to large urban agglomerations are a strong predictor of the number of skier visits in high-elevation ski areas. The findings are related to the backyard hypothesis introduced by Hamilton *et al* (2007), which finds that snowfall in urban backyards has a larger impact on skier demand in the mountains than snow depth in the mountains. For Austria, however, Töglhofer *et al* (2011) do not find evidence supporting the backyard hypothesis.

Although highly significant, the effect of snow depth on skier visits is rather small. A reduction of one standard deviation in snow depth – that is, 32 cm or 53% compared to the long-run average over a 40-year period – will cause the number of skier days to fall by 1.8%. During the sample period there have been only two winter seasons with reductions of 50% or more (namely 2006/2007 and 1989/1990). The results stand in contrast to results for Australia that find a much higher sensitivity of skier visits with respect to natural snow fall (for example, Pickering, 2011). However, the results are in line with findings for Austrian ski resorts, including Falk (2010) and Töglhofer *et al* (2011). The latter authors find that the number of overnight stays will decrease between 0.6 and 1.9% due to a one-standard-deviation change in snow conditions based on data for 185 Austrian ski resorts for the period 1972/1973 to 2006/2007. However, the results of these studies are not directly comparable: in the current study, winter tourism demand is measured as the number of skier visits, and the weather station in question is located outside the adjacent ski area at a medium elevation site. Nevertheless, we conclude that the sensitivity of skier visits to snow depth is relatively large when compared to findings based on Austrian ski resorts, given that CDA ski resorts are characterized by high-elevation skiable terrain and early adoption of snowmaking facilities. Therefore, it is surprising that the snow depth at a weather station located outside of a ski area should have an impact on the number of skier days at much higher elevations. One tentative explanation is that French ski resorts have less snowmaking capacity than Austrian ski resorts. Another involves potential day-trippers from large urban agglomerations, such as Grenoble (or Lyon), preferring other leisure activities, such as walking, cycling and golf, during low-snow winter seasons.

The remaining weather variables, including average temperatures (Table 5, see specification (i)), are not significantly different from zero. Unreported results also show that average precipitation for the months December to February has no impact on the number of skier visits. Furthermore, the time trend is not significant and therefore not included in the final specification.

To shed further light on the implications of the estimates, we conduct some calculations in which different scenarios of real GDP growth, changes in snow depth, and changes in relative prices are considered. First, we calculate the extent to which the number of skier visits decreased during the economic and financial crises of 2008–2009. Second, we calculate the impact of a reduction in snow depth of 75% (equivalent to the drop witnessed between December 2006 and February 2007 compared to the 40-year average). Third, we calculate the impact of the decrease in relative prices due to the Swiss franc's appreciation since 2009. The results show that the recession of 2008–2009 has decreased the number of skier visits by 2.2% (Table 6). A reduction in snow depth of 75% from the 40-year average leads to a decrease of 2.5%, indicating that the effect of low-snow winter periods is similar in magnitude to that of a deep recession. Furthermore, the calculated scenarios suggest that the 20% improvement in French prices relative to those of Switzerland from 2009 onwards has had the largest effect on skier days: an 8% increase in ski visits (Table 6). In other words, the fall in the number of skier days would be much greater in the absence of the strong improvement in prices relative to the main competitor.

However, the findings of the scenarios need to be interpreted with caution since the predictions should be generally interpreted with the corresponding

Table 6. Impact of extreme scenarios on the number of skier visits.

	Change in number of skier visits (%)
Decrease in snow depth by 75% (equivalent to the reduction in the winter season 2006–2007)	–2.5
Decrease of weighted GDP in constant prices by 3.6% (equivalent to the recession 2008–2009)	–2.2
Decrease in relative prices between 2007–2008 to 2010–2011 relative to Switzerland by 19.4%	+8.0

Note: Scenarios are calculated based on the long-run elasticities displayed in Table 5.

confidence interval. Song *et al* (2010) introduced a new statistical method to construct confidence for demand elasticities based on a bias corrected bootstrap method.

The larger contribution of relative prices to changes in skier visits than that of real income is not surprising given that fluctuations in prices are much larger than that in income. However, changes in relative prices are unable to explain the stagnation of the number of ski visits from 2008 onwards given that relative prices declined. Similarly, the stagnation of skier visits from 2008 onwards cannot be attributed to weather factors since both temperatures and snow depth were close to the long term average. Therefore, we conclude that low economic growth of the domestic market since 2009 are the main reasons for the stagnation of the performance of French ski resorts.

We performed a number of sensitivity analyses to check the robustness of our results. First, we re-estimated the error-correction model with different definitions of the timing of snow depth (for example, snow depth averages for the end of November to the end of December, and for the end of November to the end of January). The results are generally found to be robust with respect to the definition of snow depth. Second, there are good reasons to suspect that the relationship between snow depth and skier visits may be non-linear. For instance, at high levels of snow depth, there may be a negative relationship between snow depth and skier visits because day-trippers are less likely to go skiing. To account for a non-linear relationship, we re-estimate our model with snow depth and snow depth squared. However, the quadratic specification does not lead to an improvement of the model fit. Third, in order to check for influential observations, the model was re-estimated excluding one of the ski areas. Unreported results show that the long-run coefficients are not sensitive to the inclusion or exclusion of one of the six resorts. Fourth, given the short time period and the number of ski resorts, we have also estimated simpler models. Results based on the fixed-effects model, ignoring the non-stationarity of the variables, show that both real income and snow depth are significantly and positively related (see Table 4). The coefficient of snow depth is 0.021 – somewhat lower than the long-run elasticity based on the error correction model. However, relative prices are not significantly different from zero and therefore have been replaced by the price index of railways. The insignificance of relative prices clearly shows that the panel error-correction model is more appropriate than the static fixed-effects model in describing the data, even when the sample is relatively small. We have also estimated a long difference model using OLS (see Table 3). OLS estimates produce a coefficient of snow depth of 0.023, which is very close to the static fixed-effects model. Robust regression methods lead to similar results. Prices, however, are again insignificant, and the overall fit is much lower than that of the error correction model. Fifth, we also examined the potential contribution of additional variables that could have an impact on the number of skier visits. In particular, we have included a dummy variable measuring early Easter holidays. However, the dummy is never significant at conventional significance levels. In addition, we have included a dummy variable as another robustness check for the ski resort Paradeski; it is equal to one for the period 2003/2004 to 2011/2012 and zero otherwise. The reason is that a new gondola connecting Les Arcs to La Plagne was installed in 2003, resulting in one of the largest ski areas in the world. The hypothesis is that the number of ski days increased following the installation of this new lift. However, unreported results show that the dummy variable is not significantly different from zero and therefore not included in the final specification.

Conclusion

This article has investigated the long-run determinants of winter tourism demand for six ski areas in France that belong to the largest ski-lift operator in the world, the Compagnie des Alpes group. In particular, we have investigated the role of weather factors (temperatures, snow depth, precipitation) as a determinant of winter tourism demand. The empirical results of a panel error-correction model show that relative prices, real income, and snow depth are significant long-run determinants of the number of skier visits. Furthermore, we found that changes in relative prices have the largest effect on winter tourism demand, followed by real income and snow depth. Income elasticity, however, is about 0.64 and significantly lower than unity, indicating that ski tourism in France is not a luxury good, but rather a necessity good. Meanwhile, snow depth at the medium-elevation ski station Col de Porte is a significant predictor of skier days in high-elevation ski areas. Although the reduction of skier visits due to natural snow depth pulling is statistically significant, the effect is relatively small: On average, low-snow winter seasons, similar to 1989/1990 or 2006/2007, will lead to a reduction in skier visits of about 2.5%. The results are robust with respect to the timing of definition and snowfall. Our key finding is that snow conditions at medium elevations outside of ski areas have a strong positive impact on the number of ski visits to CDA ski areas, which are all characterized by high slope elevations and extensive snow making facilities. The magnitude of the results show that a one-standard-deviation reduction in snow depth from the long-run average over a 40-year period will lead to a 1.8% decrease in skier days. Calculations of different scenarios based on the long-run parameters show that deep recessions and winters with extraordinarily little snowfall have similarly negative impacts on the number of skier visits. That said, improvements in relative prices (due to changes in exchange rates, for instance) have much larger effects. Overall, the occurrence of low-snow winter periods may be only one explanation for the stagnation of skier visits in France. The other factor is the low income elasticity at hand, which indicates that French ski resorts benefit only disproportionally from the economic growth of visitor countries.

There are several policy implications for ski lift operators that can be drawn based on the empirical results. First, the sensitivity of winter tourism demand to changes is low in real income and prices. Therefore, lowering tourism prices is not an effective tourism policy. Note that French ski resorts are already more price competitive than Swiss ski resorts when quality differences are accounted for (Falk, 2011). Second, low growth of GDP in origin countries combined with a low real-income elasticity are the reasons for the stagnant skier demand witnessed at CDA ski resorts in the last 20 years. The growth prospects of the CDA's main visitor countries (France, the UK and the Benelux countries) are also relatively modest for the coming years. Therefore, it is important that marketing activities are expanded in highly promising markets, such as Russia.

The low-income elasticity found for French ski resorts may also indicate that downhill skiing and other winter sport activities have reached the end of their life cycle (Weiermair and Fuchs, 1999; Tuppen, 2000; Hudson, 2003). This means that these ski resorts are in the stagnation phase. Buhalis (2000) suggests that different stages of the destination life cycle require different marketing strategies. New and different marketing strategies are thus required to attract more winter sport tourists and achieve greater product diversification. In addition, the ski industry is still vulnerable to variations in natural snow depth in high-elevation areas despite extensive investments in snowmaking facilities. It is well known that there is a trend decline in the amount of snow and duration of snow and number of days with snowfall, which is likely to continue in the future. Therefore, winters with less snow will lead to a decrease in the number of skier visits on average. However, the magnitude of the effects tends to be very small. Even increased occurrences of extreme weather events, such the mild winter of 2006/2007, will lead to very small decreases in the number of skier visits to the ski areas belonging to the CDA group.

This study is subject to three limitations. First, the ski resorts in the sample all belong to the CDA group, which are not representative of the total population of French ski resorts. CDA resorts are larger, equipped with modern ski lifts, and located at high elevations. The results can thus not be generalized for all French ski areas. Second, the fit of the model is rather low with a R squared for the dynamic and static models of 0.35 and 0.31, respectively. This indicates that a large proportion of winter tourism demand cannot be explained by the evolution of the classical demand factors, such as relative prices and income, and natural snow depth. Third, the study only considers income and relative prices (in addition to weather factors) as determinants of skier visits. New lift linkages and improvements in ski lift systems, such as replacement of older lifts, are not considered due to the lack of data. These variables could also affect the number of skier days.

There are several opportunities for future work. One suggestion would be to include other factors of winter tourism demand. These could include ski lifts replacements and increases in lift capacity, investment in new ski lifts, and the timing of snowmaking facility adoption as well as complementary services (such as ski schools, accommodation) and cooperative arrangements regarding pricing decisions and marketing initiatives. We would also propose a re-estimation of the model using a larger sample of French ski resorts, which would make it possible to compare low- and high-elevation ski resorts.

Endnotes

1. Note that Val d'Isère, Les Deux-Alpes and Serre-Chevallier have been acquired since 2004, but are included in the analysis of the total time span.
2. See the CDA (various) annual reports.
3. http://www.cnrm-game.fr/spip.php?article289andlang=en.
4. The R^2 is based on the one step error-correction model estimated including resort specific fixed effects.

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