Return on Investments in New Ski Lifts: The Importance of Weather Conditions and Elevation

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Abstract

This paper investigates the factors that influence the change in passenger ski-lift transports between a normal winter and an anomalously mild winter based on individual lift and aggregate ski-area data. Special focus is placed on the return on investments in new ski lifts. Using endogenous treatment effects models, we find large average treatment effects for ski lifts at the individual level (including a difference of about 90 percentage points in growth rate). At the aggregate ski-area level, however, no significant output effects can be detected. This indicates that the indirect business-stealing effect outweighs the direct expansion effect. Furthermore, the change in ski-lift output between anomalously warm and normal winter seasons depends positively and non-linearly on the average elevation of the ski lift at hand. Growth in passenger numbers is independent from an elevation of 2,365 metres or higher for existing lifts and 1685 metres for new ski lifts. A large number of guest beds and a high share of slopes covered by snowmaking equipment also have positive effects on changes in ski-lift transports. The probit model shows that ski lifts with a high number of passengers in the beginning of the period, as well as older and smaller lifts, are more likely to be replaced.

Keywords: firm growth, investment, endogenous treatment effects model, climate change, ski lift companies.

JEL classification: D22, D24, O33, L25, L92.

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1 Introduction

Under pressure from global warming, aging populations, and changes in leisure preferences, the output of ski lift companies is stagnating around the world. This also holds true for Austrian ski lift companies.[1] Despite the moderate growth of the ski business, Austrian ski lift companies continue to invest heavily in new ski lifts (where investments amount to €200-250 million per year on average).[2] Little is known about the output growth effects of newly installed ski lifts, particularly during or after anomalously mild winter seasons.

In the related literature, there has been an extensive discussion about the sensitivity of ski lift companies' output in winter periods with low snowfall. The managers of these companies often argue that large investments in snowmaking have significantly reduced the snow sensitivity of the ski business. However, between the two normal winter seasons of 2002-03 and 2003-04 and the anomalously warm winter of 2006-07, the number of passengers transported uphill dropped by 20 and 24 per cent, respectively (based on unweighted averages for about 730 ski lifts in Austria). This indicates that ski lift transports react strongly to anomalously warm winter temperatures such as those recorded in 2006-07. However, there are still important gaps in our understanding of the complex relationship between anomalously mild weather conditions and the output growth of ski lift companies. In particular, there is still no consensus regarding the types of ski lifts and ski-area sections that are affected most during anomalously mild winter seasons.

The aim of this paper is to provide an initial empirical investigation of the determinants of the output growth of ski lift companies between normal and extraordinarily warm winter seasons. The availability of detailed data at the ski-lift level makes it possible to account for lift-specific (e.g. number of passengers transported in the past, number of seats, and age), ski-area-specific (e.g. share of slopes covered by snowmaking equipment), and location-specific factors (e.g. distance to nearest neighbouring ski area). Special emphasis is placed on how new ski lifts are linked to subsequent output growth, where output is measured as the number of passengers transported uphill in the winter season. In order to ensure that our results are not affected by the potential endogeneity of new ski lift installations, a selection equation explaining decisions to invest in new ski lifts is added to the output growth equation. It is

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[1] The sales revenue growth rate for the largest ski lift companies is about 2 per cent per year in nominal prices (unweighted average based on annual accounts).

[2] Source: Austrian cable car association.

important to note that only a minority of ski lifts was replaced over the sample period (about 10 per cent). The phenomenon of zero investment is common among firms in the business sector (Nilsen and Schiantarelli, 2003).

The ski business is an interesting industry in which to study the link between investments in new ski lifts and output growth. A new chairlift or gondola that replaces a two-seat chairlift or t-bar lift is usually associated with a capacity expansion. Since a new chairlift is typically more comfortable, it attracts more skiers and leads to more repeat lift rides. This is the direct demand effect. The costs of a new chairlift range between €8 and €10 million on average. However, such investments include a significant amount of sunk costs and are often irreversible, which is similar to the petroleum refining industry (Dunne and Mu, 2010). At the same time, a new lift system can lead to a decline in demand for neighbouring ski lifts. This can be referred to as the displacement effect. This is especially likely in winter seasons characterised by very warm temperatures and excess capacities.

In addition to investment, another key variable is ski lift elevation. In particular, we investigate whether low- and high-elevation ski areas are affected differently in anomalously warm winter seasons. A recent study by the OECD suggests that low-elevation ski stations are the most vulnerable to global warming and future climate change (Agrawala, 2007). For the Austrian province of Tyrol, Steiger (2011) finds that the anomalously warm winter season of 2006-2007 had a strong negative impact on the average number of passenger transports, with larger effects for low-elevation ski resorts. Furthermore, many studies have emphasised the influence elevation has on the performance of ski lift companies (Pickering, 2011; Steiger, 2011). For Australia, Pickering (2011) finds that low natural snow cover leads to a strong decline in visitors – ranging between 52 and 86 per cent – for the three lowest-altitude ski resorts compared to the average number of visitors for the previous nine years. For Austrian ski areas in the province of Tyrol, lower-elevation resorts experienced the largest reductions in the number of passengers transported uphill during the extraordinarily warm winter season of 2006-2007 (Steiger, 2011). For New Hampshire, Hamilton et al. (2003) find that many low-elevation ski areas in the southern part of the state have been abandoned in favour of those at higher elevations in more northerly locations. Overall, one can expect output growth to be lower for low-elevation ski areas in warm winter seasons marked by low snowfall. However, the question remains as to which other factors may have an impact on output growth.

Our work is related to Beaudin and Huang (2014) who investigate the impact of the investment decision in snowmaking on survival of ski lift companies where investment is assumed to be endogenous. In this study, the decision to invest in new ski lifts is modelled. The empirical model is the endogenous treatment effects model introduced by Heckman (1976) and Barnow, Cain, and Goldberger (1980) in which investments in new ski lifts are allowed to be endogenous. This model makes it possible to estimate the average treatment effects of investments in new ski lifts. The two-equation system consists of a probit equation modelling the introduction of a new ski lift and an outcome equation, which is measured as the change in the number of passengers. Since ski lift age and initial number of passengers transported uphill do not affect demand directly, they are used as identifying variables. Note that the treatment indicator is allowed to vary with the average elevation of the ski lift. To account for the business stealing effect within ski areas, we also estimate a treatment effects model at the ski area level instead of for individual ski lifts.

The empirical analysis is based on new and unique data that includes the total population of ski lifts in Austria (gondola, chairlifts and ropeways), which covers 730 ski lifts and 117 ski areas. We compare the extraordinarily warm winter of 2006-2007 with two normal winter seasons, 2002-2003 and 2003-2004. The winter of 2006-2007 was characterised by record-high temperatures in large parts of the Alps. This winter can be regarded as a temperature analogue of the normal winter conditions projected for the year 2050 in a medium-emission scenario, and can thus be used to represent an average winter climate in the future.

The structure of this paper is as follows. Section 2 outlines the theoretical background, and section 3 introduces the treatment effects model. Descriptive statistics and the data used for the study are discussed in section 4. Section 5 presents the empirical results, and section 6 presents our conclusions.

2 Theoretical background

Firm growth depends on a combination of factors. In the literature on industrial organisation, firm age and size are central variables. Jovanovic (1982) presents a theoretical model of firm growth and suggests that such growth depends negatively on firm age for a given size. According to Klepper (1996), earlier entrants exhibit higher performance and also generate higher profits in the early stages of the industry’s lift cycle. Firm growth is also expected to be higher for small firms. However, in the mature stage of the industry life cycle, initial size is likely to be less relevant.

The literature confirms that innovative firms exhibit a higher output growth rate. In the skiing industry, the major new technologies include detachable chairlifts and gondolas (which are replacing older and smaller ski lifts), as well as snowmaking facilities. The replacement of an older ski lift (e.g. a t-bar lift) by a new chairlift or a gondola can be regarded as a product or process innovation. New ski lifts can also be perceived as a service innovation, as they often offer greater capacity, speed, and comfort (heated seats, bubbles, loading carpets, etc). It is important to note that replacements of ski lifts are often accompanied by investments in snowmaking facilities. For instance, according to the ski lift company Kitzbuehel Bergbahnen, new ski lifts are usually only installed when the corresponding slopes are covered by powerful snowmaking facilities.[3] The vintage capital theory also presents important implications for the relationship between technology use and firm growth: It predicts that plants with older equipment have lower growth rates than those with a more recent vintage of equipment (Salvanes and Tveterås, 2004).

Although the direct effects of new lift installations on output growth are insightful, they do not provide evidence on the growth effects witnessed for the remaining ski lifts in the same ski area. It is likely that new lift installations draw demand away from neighbouring ski lifts. This is known as the business stealing effect or the substitution/displacement effect. However, new ski lifts could also have positive spillover effects on the remaining ski lifts in the same ski area due to overall demand growing at the expense of other ski areas. In order to account for the business stealing or substitution effect, the output growth equation is also estimated at the ski area level.

Elevation is commonly regarded as a factor critical to performance in anomalously warm winter seasons (Pickering, 2011; Steiger, 2011). Lower sections of ski areas are typically more vulnerable to warm winter temperatures – and the dearth of snow and skiable days they often entail – than are higher-elevation slopes. Low-elevation sections also receive more precipitation in the form of rain. The related literature confirms that low-lying ski areas have been considerably more affected by warm winter seasons than high-elevation areas (Bark, Colby, and Dominguez, 2010; Gonseth, 2013; Hamilton et al., 2003; Pickering, 2011; Steiger, 2011; Tuppen, 2000). Similarly, related studies predict that climate change will have negative consequences for low-elevation ski resorts (Abegg et al., 2007; Dawson and Scott, 2013).

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[3] "*Keine neue Anlage ohne schlagkräftige Schneeanlage*" ("No New Ski Lift Without Powerful Snowmaking System"). Kitzbuehel Bergbahnen annual report, 2006-2007.

Another factor that is likely to affect ski lift output is the geographical concentration of ski areas. The co-location of firms can, for example, have positive effects due to geographically localised spillovers or agglomeration advantages. Fischer and Harrington (1996) suggest that service firms can benefit from agglomeration by attracting more customers even when there are no explicit regional spillovers. This is because geographically concentrated firms are able to attract more customers as a group relative to what they could attract individually (Kalnins and Chung, 2004). Customers who minimise their search costs by visiting a location served by many firms also increase demand (Kalnins and Chung, 2004). This holds particularly true when the products the firms offer are heterogeneous (Fischer and Harrington, 1996). However, co-location can also have negative effects. Chung and Kalnins (2001) suggest that it may lead to more intensive competition, which can have a negative impact on the performance of weaker firms. In the case of ski resorts, ski areas with nearby neighbours may have an advantage, as their lift tickets are often also valid on these adjacent slopes. The related benefits comprise not only more slope kilometres, but more diversity and variety, as well. Other factors that may have an influence on output growth include the percentage of slopes covered by snowmaking equipment and the number of guest beds. Snowmaking is an effective means of compensating for low natural snowfall, such as that which was recorded in the winter of 2006-2007. The supply of accommodation beds is also likely to be positively related to output growth between normal and mild winters.

3 Empirical model

We assume that the relationship between input and output can be approximated by a constant-returns Cobb-Douglas production function (where the subscript *i* is suppressed for firms):

$$Y = A^t K^\alpha L^\beta ,$$

where *Y* is output in constant prices, *K* is the capital stock in constant prices, *L* is labour, *A* is the technology level, and *t* is the time trend. Taking the natural logarithm, applying first-difference transformation, and adding an error term results in the following regression equation:

$$\Delta \ln Y = c + \alpha \Delta \ln K + \beta \Delta \ln L + \varepsilon .$$

In the following section, the labour input can be neglected because the ski business is a capital-intensive industry with an average share of labour costs in total added value of about

25 per cent.[4] Adding a vector of time-invariant firm characteristics (Z) produces the following regression equation:

$$\Delta \ln Y = c + \tilde{\alpha} DINV + Z\theta + \tilde{\varepsilon} \,,$$

where growth of the capital stock is replaced by a dummy variable ($DINV$) that is equal to one for the installation of a new ski lift (chairlift or gondola) and zero otherwise. The coefficient on the investment dummy provides an approximation of the return on investments in new ski lifts. Assuming that the investment variable is exogenous, OLS with fixed ski-area effects can be used to estimate the output growth equation.

The binary investment indicator, however, cannot be regarded as exogenous due to the self-selection of ski lifts with solid performance. Specifically, older ski lifts and those that have performed successfully in the past are more likely to be replaced. Table 1 shows that the characteristics of replaced ski lifts differ systematically from those of existing ski lifts. In addition, the investment variable may be correlated with the error term. If the treatment indicator is endogenous, the OLS estimator leads to biased estimates and possible overestimation of the return on investments in new ski lifts.

To account for the endogeneity of investments in new ski lifts, we use an instrumental variable approach. In particular, the treatment effects model is used to estimate the effects of new ski lifts (Barnow, Cain, and Goldberger, 1980; Maddala, 1983; and Clougherty and Duso, 2015 for an overview of treatment effects models). The treatment effects model makes it possible to estimate the effect of an endogenous binary treatment (t) on a continuous, fully observed variable, $\Delta \ln Y_{ij}$, in a manner conditional on the independent variables. Here, the outcome variable is the change in the number of passenger transports, with X and Z representing ski-lift-specific and ski-area-specific factors, respectively. The endogenous treatment effects model consists of two parts. To examine whether the treatment dummy depends on elevation, interaction terms with elevation and its squared term are introduced. This makes it possible to investigate whether the returns on new ski lifts differ between low and high ski-lift elevations. The outcome equation is specified as follows:

$$\Delta \ln Y_{ij} = c + \theta_1 t_{ij} + \theta_2 \ln Elev_{ij} + \theta_3 \ln Elev_{ij}^2 + \theta_4 \ln Elev_{ij} \times t_{ij} + \theta_5 \ln Elev_{ij}^2 \times t_{ij} + X_{ij}^{'}\alpha + Z_{j}^{'}\beta + \varepsilon_{ij} \,,$$

where i denotes the ski lift and j the ski area. The endogenous binary variable t_{ij} indicates whether a new ski lift was installed in the three years prior to the record-warm winter of

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[4] Evidence based on annual reports of the 0 largest ski lift operators.

2006-2007. It is measured as a dummy variable equal to one if the ski lift company has installed a new ski lift during the past four winter seasons (2003-2004, 2004-2005, 2005-2006, and 2006-2007) and zero otherwise. The dependent variable is the percentage change in number of passengers, calculated for a three- and four-year period. $\ln Y_{ijt-r}$ is the initial number of transports for a given past year, and the growth rate is defined as $\Delta \ln Y_{ij} = \ln Y_{ijt} - \ln Y_{ijt-r}$. In order to investigate the impact of an extraordinarily warm winter period, the change in lift performance between the winter season of 2006-2007 and two (climatically) relatively normal winter seasons (r=2003-2004 or 2002-2003) is calculated. This approach is often used in literature on climate change. The basic idea is to compare output between an anomalously warm and climatically normal winter (Dawson, Scott, and McBoyle, 2009).

Elev represents average ski-lift elevation, measured as the average of the valley and uphill lift stations. The positive coefficient of θ_2 and a negative coefficient for θ_3 would indicate an inverted u shaped relationship between change in passengers and elevation. The turning point for elevation expressed in metres can be calculated as: $EXP(\theta_2 /(\theta_3 \cdot 2) \cdot (-1))$. For new ski lift the turning point can be calculated as $EXP((\theta_2 + \theta_4)/((\theta_3 + \theta_5) \cdot 2) \cdot (-1))$.

X is a vector of lift-specific control variables, such as past level of passenger transports, vertical distance between the valley and uphill ski-lift stations, age, and type of ski lift; and *Z* represents ski-resort-specific factors, such as number of guest beds, percentage of slopes covered by snowmaking facilities, and the agglomeration variable (measured as the geographical distance in kilometres to the next ski resort). In addition, a set of regional dummy variables is included to account for common factors across regions.

The second part of the model consists of a probit model specified as follows:

$$t_{ij}^* = X_{ij}\alpha + Z_j\beta + W_{ij}\gamma + u_{ij}$$

The observed decision *t* is expressed as:

$$t_{ij}^* = \begin{Bmatrix} 1, & if & t_{ij} > 0 \\ 0, & \text{otherwise} & \end{Bmatrix},$$

where ε and u are bivariate normal with mean zero and with the following covariance matrix:

$$\begin{bmatrix} \sigma^2 \rho\sigma \\ \sigma \quad 1 \end{bmatrix}.$$

ρ is the correlation coefficient of the error terms of the outcome equation and the investment decision equation. If the correlation coefficient between the error terms (ρ) is zero, then the two equations are independent and the outcome equation can be estimated by OLS. If the correlation is positive, then OLS will overestimate the treatment effect. The opposite is true when the correlation is negative. The vector W consists of the three instruments: log number of passengers, age of ski lifts, and percentage of slopes covered by snowmaking equipment. Preliminary estimates show that these three variables do not have a direct impact on the outcome, measured as the change in the logarithm of the number of passengers.

The treatment effects model can be estimated by maximum likelihood. To account for ski-resort-specific effects, we include the mean of explanatory variables across ski areas (Mundlak, 1978; Wooldridge, 2002). Note that the treatment variable, namely ski lift replacements, is interacted with the log of ski lift elevation. Therefore, the estimated coefficient of the treatment level cannot be interpreted as an estimate of the average treatment effect. The Stata command "margin" is used to calculate the treatment effect.

Given the theoretical background, we investigate how and to what extent slope elevation affects the performance of ski lifts during extraordinarily mild winter season when controlling for other ski lift characteristics (size, age of equipment). Furthermore, we investigate the importance of resort-specific factors, such as number of beds, distance to other ski areas, distance to large population centres, and amount of snowmaking facilities. The key question concerns the direct return on investments in new ski lifts.

We expect a negative relationship between output growth and elevation in warm winter seasons because lower-elevation ski areas receive more precipitation in the form of rainfall and need more energy for snow production due to higher temperatures. High-altitude ski areas, meanwhile, have a general advantage due to the economies of scale afforded by the possibility of more and longer skiable days.

The estimates of the average treatment effect of new ski lifts only describe the direct effect of new investments. As mentioned above, however, new ski lifts often draw demand away from other ski lifts in the same ski area. Chen, Hi, and Ik (2005) find that a large portion of innovative firms' gains in market share is due to their "stealing business" from industry rivals. In order to account for indirect effects on other ski lifts at the same ski resort, estimates of the treatment effects at the aggregate ski-area level are provided. These estimates give an indication of the total effect of new ski lifts on output growth.

4 Data and descriptive statistics

The data at hand has been obtained from several sources. The main basis of data is provided by lift statistics from the Austrian Federal Ministry for Transport, Innovation, and Technology (BMVIT), which are available from the early 1950s to 2006-2007. This database contains information on number of passengers, hours of operation, operation days, elevation of valley and uphill stations, type of ski lift (t-bar, chairlift, gondola), and the capacity of individual lifts. The information on t-bar lifts is limited such that this type of lift can only be included when it has been replaced by a new ski lift. Furthermore, new ski lifts ("new entries") that lead to an extension of a ski area cannot be accounted for because there is no information on output at the beginning of the sample period.

The percentage of slopes covered by snowmaking facilities is collected from several sources and refers to the year 2002.[5] The data on number of guest beds is drawn from Statistics Austria. The sample consists of 730 ski lifts at approximately 117 ski areas. Table 1 presents descriptive statistics for the total sample and the two subsamples of the treated and non-treated group. The change in log number of passengers transported uphill between the two normal winter seasons and the anomalously warm winter season of 2006-07 is negative, with reductions of 24 and 20 per cent, respectively. One can clearly see that the characteristics of replaced ski lifts differ from existing ski lifts. Replaced ski lifts exhibit an average high number of passengers before replacement given its size. They are also older and smaller on average. The ski-area-specific factors also differ: Those with new ski lifts, for example, exhibit a higher share of slopes covered by snowmaking facilities. Compared to existing ski lifts, newly installed lifts correlate with a significantly higher growth rate in number of passengers (0.29 vs. -0.29 for the period 2003-04 to 2006-07, and 0.36 vs. -0.26 for period 2002-03 to 2006-07).

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[5] For Tyrol Department for Sports of the Tyrolean Government. For remaining countries Ski guides.

Table 1: Descriptive statistics

	mean	std. dev	min	max
	total sample (N=731)			
change in log number of passengers 2003-04 to 2006-07 in %	-0.24	0.65	-4.41	2.34
change in log number of passengers 2002-03 to 2006-07 in %	-0.20	0.61	-4.15	2.64
elevation of lift (average) in metres	1694	455	721	3155
elevation of valley lift station in metres	1480	482	419	3100
elevation of uphill lift station in metres	1909	452	814	3440
replacements of ski lifts 2003-04 to 2006-07 (0/1)	0.09		0	1
replacements of ski lifts 2002-03 to 2006-07 (0/1)	0.13		0	1
mean elevation in metres	1694	361	721	2665
number of seats two or less (0/1)	0.28		0.00	1.00
vertical rise in metres	430	213	19	1750
age of lift in years	18	12	3	80
distance to the nearest neighbour in km	12	8	1	57
# of guest beds	8310	6582	241	24913
# of passengers in 2004	471497	299369	2726	1556304
% of slopes covered by snowmaking	0.51	0.29	0.00	1.00
	treated sample (new ski lifts) (N=65)			
change in log number of passengers 2003-04 to 2006-07 in %	0.29	0.68	-2.19	2.07
change in log number of passengers 2002-03 to 2006-07 in %	0.36	0.67	-1.68	2.64
elevation of lift (average) in metres	1596	464	838	2981
elevation of valley lift station in metres	1390	479	629	2795
elevation of uphill lift station in metres	1803	473	925	3273
mean elevation in metres	1592	341	861	2665
number of seats two or less (0/1)	0.66		0	1
vertical rise in metres	412	206	106	1298
age of lift in years	31	10	3	69
distance to the nearest neighbour in km	13	9	3	45
# of guest beds	8726	7165	529	24913
# of passengers in 2004	316000	202948	45408	1134274
% of slopes covered by snowmaking	0.58	0	0	1
	Untreated sample (existing ski lifts) (N=666)			
change in log number of passengers 2003-04 to 2006-07 in %	-0.29	0.63	-4.41	2.34
change in log number of passengers 2002-03 to 2006-07 in %	-0.26	0.58	-4.15	1.37
elevation of lift (average) in metres	1704	453	721	3155
elevation of valley lift station	1488	481	419	3100
elevation of uphill lift station	1919	449	814	3440
mean elevation in metres	1704	362	721	2665
number of seats two or less (0/1)	0.25		0	1
vertical rise in metres	431	213	19	1750
age of lift in years	17	12	3	80
distance to the nearest neighbour in km	11	7	1	57
# of guest beds	8269	6527	241	24913
# of passengers in 2004	486673	303025	2726	1556304
% of slopes covered by snowmaking	0.50	0.29	0.00	1.00

Source: Austrian Railway statistics, various sources.

5 Empirical results

The maximum likelihood estimates for the treatment effects model of the determinants of investment decisions and changes in number of passengers are presented in Table 2.[6] This table contains the average treatment effect (ATE). The t-values are based on standard errors

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[6] We use the STATA command "etregress" to estimate the treatment effects model (see www.stata.com/manuals13/te.pdf).

that are cluster-adjusted across ski areas. The three excluded instrumental variables – the logarithm of number of passengers before replacement, the logarithm of lift age, and share of slopes covered by snowmaking equipment at the ski-area level – are each significant at the five per cent level. Furthermore, these instruments are not significant in the outcome equation, indicating that the instruments are valid. The results show that the correlation between the outcome equation and the probit model is negative and significant at the five per cent level. The Wald test shows that the null hypothesis (of no correlation between the errors terms of the two equations) can be rejected at the one per cent level. This clearly shows that the treatment effects model is more appropriate than the OLS model, assuming that new ski lifts are exogenous. In particular, the negative correlation indicates that OLS estimates underestimate the average treatment effect.

Table 2: Results of the endogenous treatment effects model at the ski lift level

	Linear part: change in log passengers 2003-2004 to 2006-07			probit model introduction of new ski lift 2003-2004 to 2006-07				
lift specific factors:	coeff		t	coeff		t	marg eff.	
log elevation of ski lift	10.27	**	2.37					
log elevation of ski lift squared	-0.66	**	-2.23					
new ski lift 2003-04 to 06-07	-69.2	*	-1.95					
new ski lift x log elevation	19.3	**	2.01					
new ski lift x log elevation squared	-1.33	**	-2.04					
log # of passengers 2004	-0.01		-0.20	7.28	***	3.01	0.52	***
log # of passengers 2004 squared				-0.29	***	-3.00	-0.02	***
log age of ski lift	0.05		1.16	1.09	***	3.96	0.08	***
dummy variables number of seats <=2	-0.23	***	-3.75	0.46	***	3.10	0.04	***
vertical rise of lift in metres	-0.17	***	-3.92					
ski area specific factors (averages):								
mean elevation of lifts	0.93	***	3.53					
mean number of seats <=2	-0.40	**	-2.08					
ski resort specific factors:								
log distance to the nearest neighbour	-0.12	**	-2.23					
log number of accommodation beds	0.08	***	2.82					
snowmaking in 2002 in percent				0.74	***	3.92	0.05	***
regional dummies	yes							
constant	-46.4	***	-2.77	-50.3	***	-3.28		
ρ	-0.17	**	-2.22					
ATE of new ski lifts	0.89	***	8.31					
# of observations	713							

Notes: ***, ** and * denotes significance at the 1, 5 and 10 per cent significance levels. In the ML model standard errors are cluster adjusted across ski areas (across 117 ski areas).

The key result of the estimates is that new ski lift installations have a large and significant impact on the number of passengers transported uphill when measured at the individual-lift level. The average treatment effect of new ski lifts is about 0.90, revealing an increase of 90 percentage points in the growth rate of number of passengers between the climatically normal winter of 2003-2004 and the anomalously warm winter of 2006-2007. Unreported OLS estimates produce a coefficient of 0.60, indicating that taking the endogeneity of the decision to invest in ski lifts into account increases the output growth effect of such investments (results are available upon request).

Wald tests show that the treatment variable for new ski lifts and the interaction terms between new ski lifts and elevation (along with its squared term) are jointly significant at the one per cent level. Graph 1 shows the average treatment effect of the introduction of new ski lifts in connection with their average elevation. The average treatment effect rises with elevation up to a threshold of 1,400 metres before falling again for higher locations. Note, however, that the average treatment effect of new ski lift investments only measures their direct effect; it does not account for the negative substitution effect these lifts could have by drawing demand away from neighbouring ski lifts. Meanwhile, small ski lifts (those with one or two seats) and lifts with a low vertical incline exhibit lower performance. Among the resort-specific factors, number of tourist beds and geographical proximity to neighbouring ski areas are significant and show the expected sign. The closer a ski lift is to the next ski area, the higher the growth rate of number of passengers was between the two winter seasons. Furthermore, having a large number of guest beds in the ski area is an advantage.

Average ski-lift elevation and its quadratic term are highly significant. The significantly positive coefficient of log elevation indicates that ski lifts at higher elevations perform better in terms of number of passengers transported uphill between the climatically normal winter of 2003-2004 and the anomalously mild winter of 2006-2007. The negative coefficient of its quadratic term shows that the importance of elevation decreases at higher altitudes (see Graph 2 for the marginal effect of elevation). The turning point is 2365 metres for existing ski lifts and 1685 metres for new ski lifts. Above the turning points the marginal effect of average lift elevation becomes insignificant. This means that lifts with the higher elevation than those of the turning points do have a higher output growth rate between the normal winter and the during the anomalously warm winter season of 2006-2007. Overall, the turning points are quite high since the average lift elevation is about 1694 metres (unweighted mean across 730 ski lifts). The importance of lift elevation for growth and survival is consistent previous studies. For instance, Falk (2013) finds that the exit probability of ski areas is significantly higher for areas at an average elevation of 1,700 metres or lower.

The probit estimates reveal a positive and significant relationship between number of passengers and the probability of replacement, indicating that successful ski lifts (those with a high share of passengers) are more likely to be replaced. Older ski lifts are more likely to be replaced, as well. The percentage of ski areas equipped with snowmaking facilities has a positive impact on decisions to invest in new ski lifts. Furthermore, small ski lifts are more likely to be replaced. A number of determinants are not significant at the 10 per cent level and have therefore not been included in the final specification of the probit model. These include ski lift elevation and ski-area-specific factors, such number of guest beds and distance to the next ski area.

Table 3 shows the results of the treatment effects model at the aggregate ski-area level. This makes it possible to account for both the direct and indirect effects of investments in new ski lifts. The correlation between the two error terms is once again statistically significant, indicating that investment decisions are statistically dependent on output growth.

The probit model indicates that the probability of introducing new ski lifts depends on the past level of passengers, the age of existing ski lifts, and the share of slopes covered by snowmaking equipment. The key finding is that new ski lift replacements no longer have a positive and significant impact. Indeed, the investment variable now shows a negative sign and is only slightly significant, which implies that the negative indirect effects on neighbouring ski lifts in the same ski area outweigh the positive direct effects. Ski area elevation remains positive in a linear form, indicating that elevation and performance go hand in hand. The share of slopes covered by snowmaking facilities is now positive and highly significant, in contrast to the treatment effects model estimated at the ski-lift level. The number of guest beds remains highly significant, which means that a low supply of accommodation units is a disadvantage in anomalously warm winters marked by a lack of snowfall. However, geographical distance is no longer significant and is therefore excluded from the model.

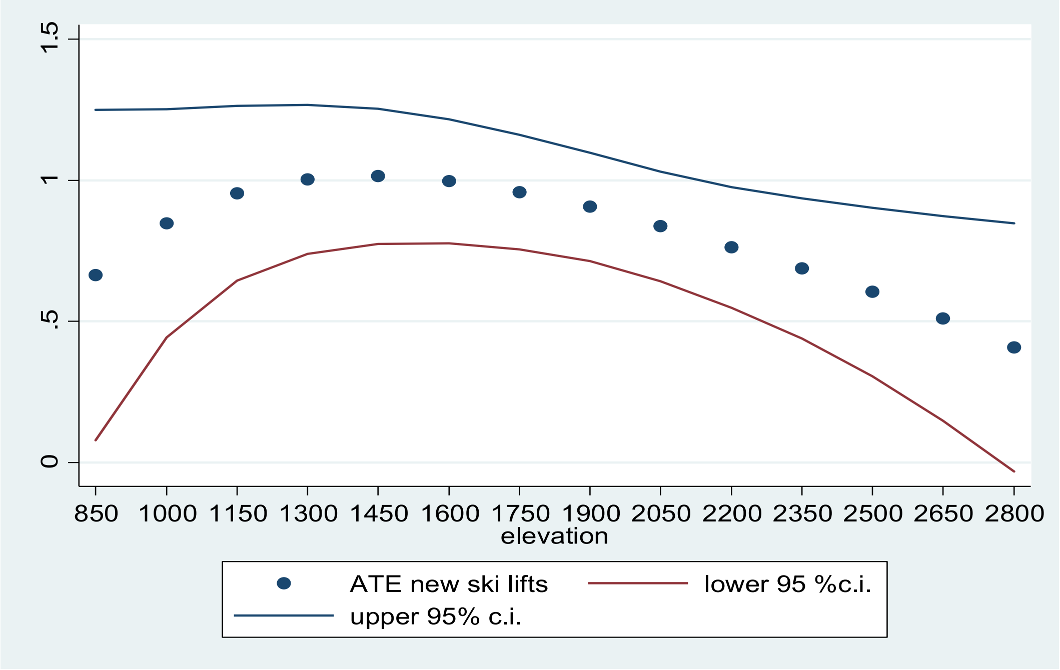
We have conducted several robustness checks. First, we have estimated separate regressions for the group of feeder ski lifts and the remaining ski lifts, as their respective effects are likely to differ. However, the sample of newly installed feeder lifts is too small to draw strong conclusions about their effects. Second, we have re-estimated the treatment effects model, excluding ski areas south of the Alpine divide based on the fact that the ski areas south of the divide received more snowfall than those north of it. In spite of this, the relationship does not differ much from the total sample.

Table 3: Results of the endogenous treatment effects model at the aggregate ski area level

	output growth equation dep. var: change in log passengers 2003-04 to 2006-07					
			(i)			(ii)
	coeff.		t	coeff.		t
log average elevation	1.55	***	6.63	1.50	***	3.78
dummy new ski lift 2003-04 to 2006-07	-0.35	*	-1.91	-1.71		-0.32
log average elevation X new ski lift				0.18		0.26
snowmaking in 2002 in percent	0.67	***	3.18	0.68	***	2.63
log number of accommodation beds	0.15	**	2.34	0.15	**	2.45
constant	-13.20	***	-7.80	-12.78	***	-4.03
regional dummies	yes			yes		
	probit equation dep. var: installation of a new ski lift between 2003-04 to 2006-07					
	coeff.		t	coeff.		t
log # of passengers 2004	0.61	***	4.81	0.60	***	4.13
log age of ski lift	1.14	***	3.02	1.13	***	2.83
snowmaking in 2002	1.24	**	2.36	1.24	**	2.56
constant	-12.61	***	-4.72	-12.53	***	-4.01
regional dummies	yes			yes		
ρ	0.74	***	3.30	0.76	***	2.71
ln sigma	-0.50	***	-6.34	-0.49	***	-3.44
# of observations	117			117		

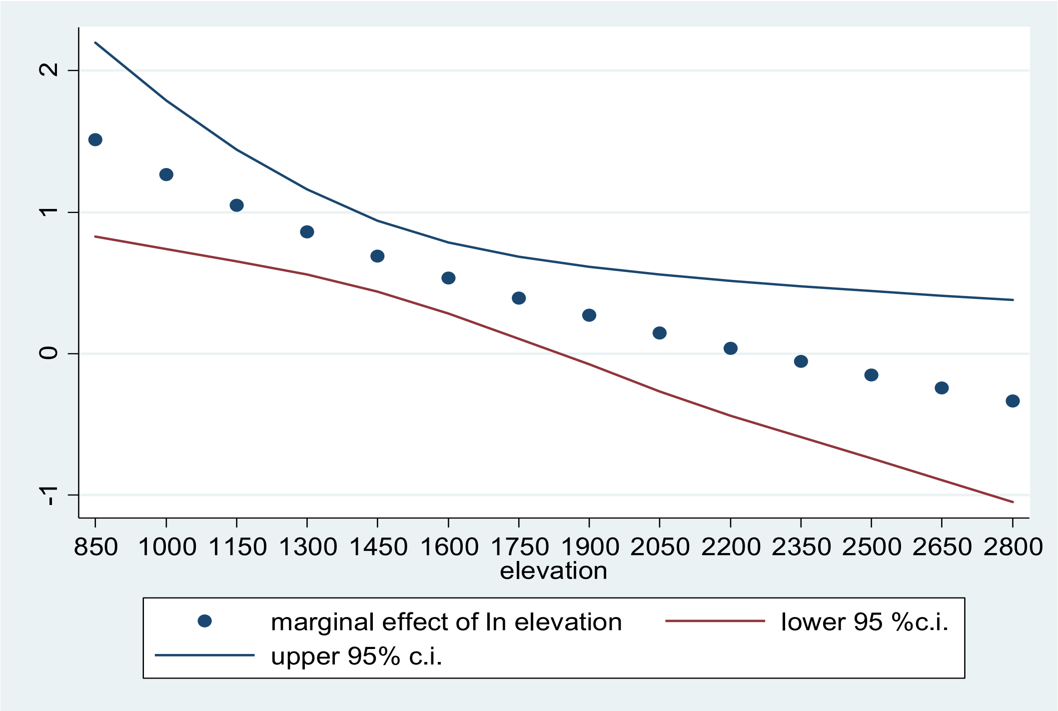
Notes: ***, ** and * denotes significance at the 1, 5 and 10 per cent significance levels.

Graph 1: Average treatment effect of new ski lifts (2003-04 to 2006-07)



Notes: The average treatment effect is based on the regression results displayed in Table 1.

Graph 2: Marginal effect of elevation on growth of passengers (2003-04 to 2006-07)



Notes: The average treatment effect is based on the regression results displayed in Table 1.

6 Conclusions

In this paper, we investigate the determinants of ski lift performance between the winter of 2006-2007 (which featured anomalously high temperatures and low snowfall) and the climatically normal winter of 2003-2004. The statistics used were drawn from a new and unique database on 713 ski lifts in 117 ski areas in Austria. One particular aspect of our analysis involves an examination of the role of ski lift elevation and the introduction of new ski lifts. The empirical model consists of an endogenous treatment effects model in which the treatment variable is interacted with covariates (in this case, elevation and its squared term). For existing ski lifts we find a positive and significant relationship between output growth and ski lift elevation up to an average elevation of 2365 metres, at which point the strength of the relationship decreases as elevation rises. Above this threshold output growth is thus independent from ski lift elevation. For new ski lifts the corresponding threshold is 1685 metres.

Furthermore, we find a significant average treatment effect for the replacement of old ski lifts with new lifts. The average treatment effect (ATE) of new ski lifts is very large, as indicated by the difference of about 90 percentage points in the growth rates of passenger numbers. The ATE increases with ski lift elevation up to a threshold of 1,450 metres before declining again at higher altitudes. This indicates that the individual returns on investments in ski lifts are large, even during anomalously warm winter seasons.

At the aggregate ski-area level, however, no significant effects can be detected for new ski lifts. This implies that the negative indirect effects on neighbouring ski lifts (read: the business stealing effect) outweigh the positive direct expansion effect of the new ski lifts. Furthermore, having plenty of accommodation beds and snowmaking coverage has a significant impact on output growth at this level.

Several policy implications can be drawn from these findings. In general, knowledge of the relationship between ski lift output and ski area elevation is relevant for policy makers, managers, and stakeholders (e.g. investors and banks) for a number of reasons. For instance, the connection between output growth and elevation is important to banks and investors because the latter is used as a criterion in risk assessment methodologies and credit ratings (Trawöger, 2014). In terms of policy, planned investments in new ski lifts in times of global warming should be carefully evaluated, given that the returns on new ski lifts amount to more or less nothing at the aggregate ski-area level. The insignificance of such lifts is likely related to the fact that capacity outstrips demand in warm winter seasons. Another implication involves the strong dependence of ski lift performance on ski lift elevation at elevations of 1,800 metres and below. Therefore, given that the winter of 2006-2007 may represent a typical winter in 2050, investment plans at elevations below 1,700 metres (in terms of the average elevation of valley and uphill lift stations) should be thoroughly reconsidered.

Furthermore, high-elevation ski lifts (those at an average elevation of 1700 metres or above) will benefit from greater demand. This in turn will lead to a rise in concentration, with a small number of large ski-lift companies at higher elevations dominating the ski industry. For Switzerland, Mueller and Weber (2008) also suggest that high-altitude ski areas may be able to benefit from concentration processes (see Hamilton et al., 2003 for New Hampshire). One possible measure would be to close sections at lower elevations and expand development at higher locations. Due to the realities of local topography and environmental concerns, however, this option is not always available (Hopkins, 2014).

Several ideas present themselves for future work. Given that the data consists of two aggregation levels, one could estimate multi-level models. Another idea would be to estimate the output effects of newly linked ski areas. In Austria, several closely related ski areas have installed connection lifts over the last 20 years. Finally, constructing a longer time series starting from the 1950s would make it possible to investigate the link between weather factors and numbers of ski lift passengers.

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