A Survival Analysis of Ski Lift Companies

MARTIN FALK

Austrian Institute of Economic Research WIFO
Arsenal Objekt 20
A-1030 Vienna
Austria

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Phone: + 43-1-798 26 01 – 226
Fax: + 43-1-798 93 86
E-mail: Martin.Falk@wifo.ac.at

Abstract:

This paper investigates the factors influencing the survival of ski lift companies over the period 1996-2011. Using a new and unique data set for about 242 ski lift operators in Austria, we are able to analyse the role of timing of adoption of snowmaking facilities and fast lifts, maximum elevation of the ski area, year of entry, size and location. We use both Cox proportional hazard and competing risk models distinguishing between temporary closures and permanent exits (both with time-varying covariates). The results show that early adaption of snowmaking leads to a significantly lower hazard rate (i.e. longer survival). However, introducing snowmaking at later periods does not have a significant impact. Surprisingly, we find that the probability of permanent exits and temporary closures is independent of the (maximum) elevation of the ski area. Furthermore, snow poor winter seasons and economic downturns lead to a higher risk of being closed down permanently but the magnitude of the effects is rather modest. However, early adoption of snowmaking cannot reduce the risk of being closed on a temporary basis.

Keywords: exits, closures, failures, survival analysis, ski lift companies, ski areas, winter tourism, introduction of technological innovations.

1. Introduction

Under pressure of climate change, changing demographics, increasing competition and saturated markets, the number of ski resorts significantly decreased in the last decade (Hudson, 2004; Taylor et al., 2007). According to the NSAA, in the US the number of operating ski resorts decreased from 735 in the winter season 1982-1983 to 471 in 2009-2010.[1] For New Hampshire, Hamilton et al. (2003) suggest that not only the number of small ski areas but also the number of larger and chair lift served ski areas decreased over time. Kureha (2008) show that in Japan in 2007, there were 147 close ski areas. However, the decline in the number of ski areas seems to be uneven across world regions. In Austria and (also in other European Alpine countries), the number of shutdowns of ski areas is much lower. For instance, in Austria between the period 1996-2011, about 20 percent of about 240 ski lift companies with three or more ski lifts went formally bankrupt or voluntarily closed their operations permanently for different reasons. Currently, little is known about the factors influencing the survival of ski lift companies. Possible determinants include firm characteristics, technology use and location specific variables (e.g. distance and elevation of the ski area).

The aim of the paper is to provide a first investigation of the determinants of survival of ski lift companies. In particular, we investigate the impact of firm specific (e.g. year of entry, size and technology use), location specific (e.g. maximum elevation of the ski area, distance to nearest city or to the next neighbouring ski area) and macroeconomic variables (e.g. occurrence of snow poor winter seasons and the business cycle). A special emphasis is put on the impact of timing of adoption of snowmaking facilities on the probability of firm survival. The database consists of a new and unique data set covering data for 242 ski lift companies with at least three or more ski lifts and four kilometres of slopes or more. Another key variable is elevation of the ski area. In particular, we investigate whether low elevation and high elevation ski areas have different chances of survival. We

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[1] See www.nsaa.org/ retrieved September 2011.

do this because 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). Since the analysis time is already influenced by global warming with higher temperatures, less snow and reductions in glaciers we expect that the failure risk is significantly higher for low elevation ski areas. In addition, we investigate whether the probability of failure increased during or after the extraordinarily warm temperature anomalies such as the winter 2006-2007, with record warm temperatures in large parts of northern Europe and the European Alps. This winter can be regarded as a temperature analogue for normal winter conditions in the 2050 under a medium emission scenario and therefore can be used as a representative of a projected future average winter climate. Another innovation of the paper is that we investigate whether the probability of failures of ski lift operators increases during snow poor winter periods and during economic downturns.

The empirical model is based on a Cox proportional hazard survival model. This model describes both the occurrence of exits and the timing of exits. In the first step, we analyze the determinants of survival, irrespective of whether the ski areas are closed either permanently or temporarily where the latter is a subgroup. In the second step we investigate the determinants of permanent exits. In addition, we use the competing risk survival model developed by Fine & Gray (1999) where temporary and permanent exits are treated as competing hazards.

In tourism research, few empirical studies are available on the factors influencing the survival of firms. Examples include the accommodation, hotel and restaurant sector (e.g. Gu, 2002; Gu & Gao, 2000; Kim & Gu, 2010 all for restaurants; Kaniovsky, Peneder & Smeral, 2008 for the accommodation sector and Santarelli, 1998 for new tourism service firms in Italy). The studies show that firm survival is significantly positively related to firm size. However, most studies using survival models so far have used the tourists' length of stay at a destination as the dependent variable (see e.g. Barros & Machado, 2010; Gokovali, Bahar & Kozak, 2007).

To our knowledge, this is the first study investigating the determinants of exits and survival among ski lift companies. Knowledge of the determinants of business failures is relevant for policy makers, managers and stakeholders for a number of reasons. On one hand, failures involve large costs to private agents such as investors and creditors. On the other hand, insights into the determinants of failures are important for local government authorities since some ski lift companies are partially in public ownership or supported by public funds, particularly in Eastern Austria. The study will make a number of significant contributions to the literature. First, it provides an indication of the relative importance of technology adoption, location factors, business cycle and weather factors to the failure risk of ski lift companies. Second, this paper contributes to the literature on the effects of innovation on performance of tourism firms. Hjalager (2010) and Hall & Williams (2008) suggest that there is still limited empirical evidence on the effects of innovation activities and technology adoption for tourism enterprises. Third, the findings might be helpful for formulating a guideline on how to reduce the rate of failure in the future period.

The present paper is structured as follows. Section 2 introduces the empirical model, while section 3 presents the data and descriptive statistics. Section 4 presents the empirical results, and section 5 concludes.

2. Theoretical background and empirical model

Theoretical background

Firm survival depends on a number of factors (see Manjón-Antolín & Arauzo-Carod, 2008 for a recent survey of the literature). Firm age and size are central variables in the theoretical industrial organization literature on firm exits. Theoretical models show that firm exits are expected to decline with firm age due to firm-level learning. According to Klepper (2002), earlier entrants are more likely to be long-term survivors because they make higher profits in the early stages of the industry's lift cycle and also show higher performance. Furthermore, the probability of failure is expected to be higher for small firms (see e. g. Jovanovic, 1982). There are a number of reasons why large ski lift companies are less likely to fail. One reason is that large companies are closer to the minimum efficient scale. Small firms (and also young firms) often have limited access to external funds.

Use of modern technologies is also an important determinant of survival. Technology use and innovations can be measured in various ways. One can distinguish between product and process innovations (that are new to the market), organizational innovations, management innovations and adoption of products, services or production processes that are already introduced onto the market but new to the firm (see Camisón & Monfort-Mir, 2011; Hjalager, 2010). In the skiing business, the major new technologies are the introduction of snowmaking facilities, detachable chairlifts and gondolas which can be both regarded as a process innovation or a new and improved service.

Previous theoretical and empirical literature has shown that the implementation of new products will lead to higher sales, lower exit risk and declining sales for non-adopters (Klepper, 1996; Klepper & Simons, 2000). In this connection, it is useful to consider the theory of diffusion introduced by Rogers (1995) that classifies organizations and firms on the basis of timing of technology adoption: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. Recently, Sinha and Noble (2008) has emphasized the importance of the timing of adoption in determining firm survival. The authors propose three testable hypotheses concerning the relationship between timing of technology adoption and firm survival: H1: Early technology adoption will increase the likelihood of firm survival. H2: Adoption prior to the maximum penetration will increase the likelihood of survival. H3: Adoption of a greater number of technologies will increase the likelihood of survival.

Capital vintage theory also gives some implications for the relationship between technology use and survival. The theory predicts that plants with older equipment have higher exit rates than those with a more recent vintage of equipment (Salvanes & Tveterås, 2004). There are already some studies investigating the relationship between technology use and firm survival. Sinha & Noble (2008) is one of the few studies investigating the relationship between timing of technology adoption and firm survival. Using firm level data for the UK manufacturing sector, the authors find that early adoption increases the likelihood of survival. Evidence based on the industrial organization literature reveals that adoption of new technologies directly increases firm productivity and hence the survival duration of firms (Dunne, 1994; Doms et al., 1995). Using firm level data for manufacturing and service sectors in the Netherlands (Cefis & Marsili, 2005), find that innovating firms (measured as introduction of product and/or process innovations) have 11 percent higher chances of survival than non-innovating firms. Other studies also find that innovation activities and inventions are important for firm survival (see Chen, 2002 for the impact of technology use on survival of US petroleum refining plants, Helmers & Rogers 2010 for new UK firms in all industries). In tourism research, few studies are available. Notable exceptions include Hall & Williams (2008) that find that tourism innovation plays an important role for the probability of survival using data for tourism firms in New Zealand. For Switzerland based on data for 147 Valaisan hotels, Scaglione, Schegg & Murphy (2009) find that website adoption is positively related to revenue growth.

Firm survival does not only depend on firm characteristics but also on location specific factors (such as elevation and distance to large population areas) and on external factors (business cycle and weather factors). Other factors that affect the survival probability consist of location specific variables such as geographical proximity to other ski areas or distance to populated areas. Several studies have highlighted the importance of location and geographical concentration for firm performance (Porter 1998, 2000). Whether the presence of ski areas in close proximity leads to a lower or higher shut down probability is an empirical question. On the one hand co-location can have positive effects for neighbouring firms because of geographically localized spillovers. On the other hand, colocation of firms may lead to more intensive competition and thereby may increase the exit rate of weaker firms (Chung & Kalnins, 2001).

Firm survival may also depend on the business cycle. In summarizing the literature on firm exits, Caves (1998) find that the survival probability is rather insensitive to variations in macroeconomic performance variables. However, recent studies on the impact of macroeconomic conditions on firm exits show that bankruptcies are higher during economic downturns (Bhattacharjee et al., 2009; Salvanes & Tveterås, 2004).

Since ski business is a weather dependent industry current and past weather and snow conditions may also affect survival of ski lift companies. In particular, the failure risk is expected to increase during winter seasons with high temperature anomalies or anomalies in snow cover. Indeed, climate change has been referred to as the greatest challenge to the sustainability of winter tourism and the snow business in the 21st century (Agrawala et al., 2007; Becken, 2010; Becken & Hay, 2007). Based on a survey of 61 ski lift companies for Austria, Bank & Wiesner (2011) find that in the warm winter season 2006-2007, 42 percent of ski lift operators suffered severe losses, whereas 32 percent of the companies experienced small losses. Only 27 percent are not affected.

Recent studies show that climate change will lower the reliability of snow cover, reduce the length of the ski season and increase snowmaking costs (Abegg et al., 2007; Steiger & Mayer, 2008). In fact, in Austria mean winter temperature increased significantly in the last 50 years. Snow depth and snowfall shows a downward trend. Much of that change has occurred from the end of 1980s onwards. Agrawala et al. (2007) predicts that with a +2°C temperature increase scenario by 2050 the number of snow reliable ski areas would drop between 8 percent (Eastern Austria) and 62 percent (Western Austria).

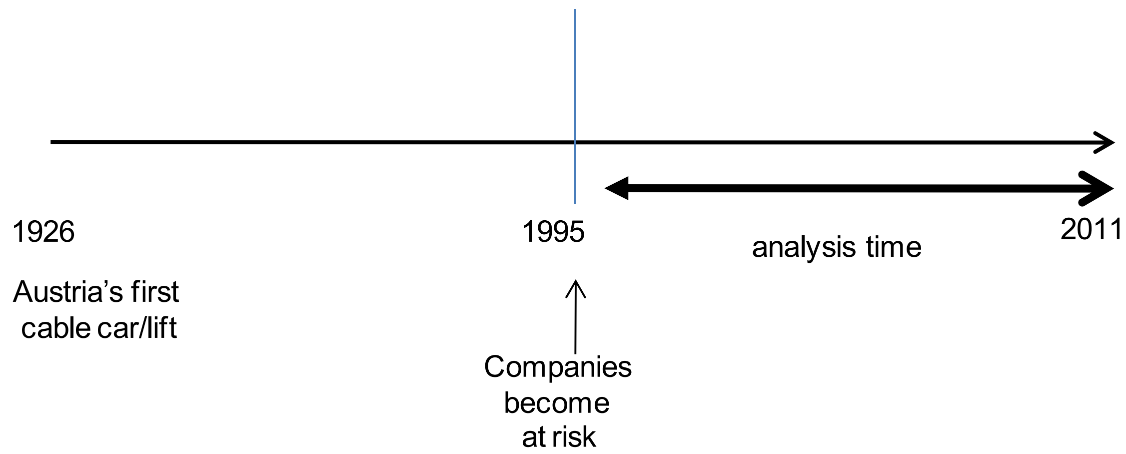
Overall this indicates that in times of global warming low lying ski areas in Eastern Austria will be considerably more affected than the high elevation ski areas in Western Austria. Studies investigating climate change impacts on ski resorts predict that climate change will have negative effects on ski businesses in low elevations (Agarwala, 2007). Previous empirical evidence suggests that lower elevation resorts experienced the largest reductions in skier visits and lift transports during snow poor winter periods (see Pickering, 2011 for Australia and Steiger, 2011 for Austria). Therefore, average or maximum slope height may play an important role for the performance and survival of ski lift companies. One can expect that low and high elevation ski resorts are differently affected by global warming since the snow lasts longer in high elevation areas.

Empirical model

Given the theoretical and empirical literature on the determinants of firm failures, we model failures as a function of firm size, age, timing of technology adoption, location specific factors and macroeconomic factors. The empirical model is based on a survival model. Most studies investigating firm exits use survival models. Few studies use logit or probit models. The advantage of survival models is that they account not only for the exit event but also for the timing of exits. In the survival model, the hazard rate describes the probability that the ski area shuts down at a point in time t, conditional on having survived until t. We define exit as exit by failure, i.e. the company is formally bankrupt or voluntarily liquidated. Voluntary liquidation includes discontinuance of a ski lift company for any reason. Exit can be either temporary or permanent. Exit by mergers is not considered.

Survival models account for right censoring and left truncation and also for the inclusion of time varying covariates. Right censoring occurs because the majority of ski lift companies are still in operation at the end of the sample period. Left truncation is present because information on exit is only available after 1995 due to data availability. The dependent variable is the years a ski resort stayed in business calculated at survival time at exit minus year of incorporation of the ski area. The first year of exit is 1996 (equal to the survival time of one year) (see Figure 1 for the definition of the analysis time).

Figure 1: Definition of the analysis time



For the survival model, we choose the Cox proportional hazard model that is widely used in survival analysis. Here the hazard rate, h(t), depends on a vector of time-invariant explanatory variables X and vector of time-varying covariates Z:

$$h(t, X_i, Z_{tt}) = h_0(t)\exp(X_i\beta + Z_{ti}\gamma),$$

where $h_0(t)$ is the baseline hazard; β and γ are vectors of coefficients to be estimated. The list of time invariant explanatory variables X and the time varying variables Z is as follows:

$$X = [\text{snowmaking}, \text{liftquality}, \ln(\text{size}), \ln(\text{entryr}), \ln(\text{alt}), \ln(\text{distcity}), \ln(\text{distneigh})],$$

$$Z = [\text{snowpoor}, \text{GDP growth}, \text{timing of adoption}],$$

where ln is the natural log.

The specific variables are defined as follows:

liftquality: adoption of at least one fast lift installed in 1996 or earlier (e.g. detachable chairlifts, modern gondola ropeways or MGDs, and funitel systems),

snowmaking: adoption of snowmaking facilities installed in 1996 or earlier,

size: total length of slopes, in kilometres,

entryr: year of installation of first lift,

alt: maximum elevation of the ski area measured as a set of three dummy variables (i) max. elevation 1500m or below, (ii) max. elevation between 1500-1800m, (iii) max. elevation between 1800-2000 metres with elevation of 2000m or higher as the reference group, alternative the logarithm of elevation,

distcity: road distance to the nearest largest town in kilometres (with population of 50,000 or more),

distneigh: road distance to the nearest neighbouring ski area,

timing of adoption: dummy variable for the period of adoption of snow making facilities,

snowpoor: dummy variable for the presence of snow poor winter seasons,

GDP growth: annual real growth rate of GDP in percent.

Among the time invariant variables, we include a dummy variable whether or not snowmaking exists at the beginning of the sample period. We do this because snowmaking can be an effective means of compensating for a poor natural snow record. In the Austrian Alps in the last two decades weather and snow conditions have been influenced by global warming with a number of warm and snow poor winter seasons. Early adopters of snowmaking facilities are expected to survive longer. Furthermore, early adoption of snowmaking is expected to have a larger effect on firm survival than investments in later periods.

In addition, we include a dummy for early adoption of fast lifts. It is obvious that fast lifts make skiing more attractive since it reduces the time spent in the queue waiting for the ski lift. Therefore, early adopters of new fast lifts are less likely to exit during the sample period because of the potential to make profits. Failures may be less likely for companies that invested in both fast lifts and introduced snowmaking facilities. Therefore, we include an interaction term between introduction of fast lifts and introduction of snow making facilities.

As a measure of firm size, we include total length (in kilometres) of ski runs of the ski area. It is expected that large ski areas survive longer. Alternatively, size is measured as a set of dummy variables. The relationship between year of entry and survival is not clear cut. On the one hand, the relationship is expected to be positive since the longer a firm has been in operation, the more productive it will become and likelihood of exit is reduced. On the other hand, the relationship between survival and firm age might be weak since the majority of firms have been in business for a long time. Evidence based on our data set reveals that 90 percent of ski lift operators have been in business for 35 years or longer. The ski business can be considered as a typical example of a mature industry with few entries in the last few decades. Age of ski area is measured as the year of installation of the first ski lift.

Location-specific factors include the maximum elevation of ski areas and the distance to the nearest town and to its nearest neighbouring ski area. In order to test whether ski areas in low elevation locations face a higher failure risk, we include maximum elevation measured as the elevation of the highest uphill lift station. The preferred measure of elevation is a set of four dummy variables. Alternatively one can use the logarithm of elevation in metres. One can expect that the survival probability depends on the elevation of ski areas.

In addition, the distance to the nearest town can also influence the survival probability. One may argue that ski areas that are further away from the nearest regional city have a disadvantage because of the lower potential local demand. In contrast, ski areas in close proximity to regional centres have a clear advantage because of local market potential. We use road distance to the nearest regional town with a population of at least 50,000 following Eurostat's definition of agglomerations.

The time varying explanatory variables include an indicator of snow poor winter seasons and indicators of the business cycle. We use a dummy variable for the occurrence of snow poor winters. It is expected that snow poor winters increase the likelihood of exit. We also use snow conditions in the past winter season because of lagged reactions. A key question of the paper is whether snow poor winter seasons in the Alps (e.g. 2006-2007) led to an increase in the exit probability.

In addition, we also include time of introduction of snowmaking facilities in later time periods (after 1996) and timing of introduction of fast lifts (after 1996). As a measure of the business cycle we use the growth rate of GDP per capita. Given that German tourists account for the highest share of visitors during the winter period, we use the real GDP growth rate for Germany. Alternatively, we use the weighted growth rate of the most important visitor countries. However, preliminary estimates show that the results are not sensitive to the choice of the business cycle variable.

There are of course some other factors that cannot be controlled for because they are difficult to measure or data are not readily available. These factors include management skills, ownership and shareholder characteristics and pre-exit information on productivity levels (Fariñas & Ruano, 2005).

The main research question in this paper is, what are the main factors influencing failure risk of ski areas? Another interesting question is whether the probability of failure (chance of survival) changes during and after warm winter seasons and to what extent early introduction of snowmaking facilities and fast lifts influence the probability of failure (chance of survival). Another question is, to what extent does the failure risk depends on the elevation of ski slopes and how important are location-specific factors such as distance to other ski areas and distance to large population centers?

Previous research shows that the factors influencing firm exit vary significantly across different forms of exits (e.g. Harhoff et al., 1998). In our case, it is important to distinguish between temporary closures and permanent shutdowns since only the latter represents "true exits". One might expect that the factors are different for the two alternative forms of closures. In order to investigate the failure risk across the two failure types, we use the competing risk survival model introduced by Fine & Gray (1999). The case specific hazard rate can be modeled as:

$$h_j(t, X_i, Z_{it}, L_i) = h_{j0}(t)\exp(X_i\beta + Z_{it}\gamma)$$

where h_j represents the jth cause-specific hazard function with j =1, 2. X represents a set of time invariant variables and Z are the time varying covariates. β denotes the effect of covariates on the subhazard function caused by the jth reason. hj(t) is the probability of exits for type j conditional on exit in the previous period and conditional on the fact that the firm has not experienced the other form of exit.

3. Data and descriptive statistics

We create a representative unbalanced sample of about 242 ski areas in Austria. The unit of analysis is the level of ski areas rather than the company level. The data covers all ski areas with a length of slopes of 4 km or more and 3 ski lifts or more. Failures and closures are collected for the period 1996 to 2011. Firm level information is combined with macroeconomic variables and location characteristics. We collect the database from several sources (i.e. lift database, water services regulation authority for information of introduction of snowmaking facilities, insolvency statistics, Austrian Institute for Meteorology). The lift statistics are used to calculate the year of first appearance of fast lifts. Data on the first time adoption of snowmaking technologies are drawn from the water services regulation authority.[2] Note that water withdrawals used for snowmaking are regulated by the federal state authorities. The presence of fast lifts and snowmaking is collected for the year 1996 and earlier as well as for the later periods. In 1996, 61 percent of ski areas were equipped with snowmaking facilities based on the Federal water service regulation authorities.

Information on exits is based on several sources. Exits of ski lift companies include (formal) bankruptcies and voluntary closures, including discontinuance of a ski lift company for any reason. First we draw data from the Insolvency Statistics (http://www.edikte.justiz.gv.at/). This database contains information on compulsory liquidations. These bankrupt firms often continue to operate and/or are able to reopen in the next winter season. Permanent discontinuance of ski areas can be measured using lift statistics. We define permanent closure of the ski area if ski lifts are out of operation and do not open at any time from that date or ski lifts are even removed. Two neigbouring ski areas that are linked through new lifts during the sample period and offering a joint lift pass are treated as one ski area, except for the new lift linkages in the last three years. Between the period 1996-2011, the number of exits is 44 of which 20 are permanent closures and 24 temporary.

Road distance to the nearest town with 50,000 or more inhabitants is calculated from the centre of the city to the centre of the ski resort and measured in kilometres. If the closest town is located in another country (e.g. Germany), the road distance to that city is used. The distance to the nearest ski area is also measured by the road distance.

Matching data of the location of each ski area to the nearest weather stations makes it possible to investigate the impact of weather variables on firm survival. Snow poor winter periods and

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[2] The data is retrieved from http://www.geoland.at/, http://www.tirol.gv.at/themen/umwelt/wasser/wis/ and http://vogis.cnv.at/biotope/wasserbuch_wichtiger_hinweis_start.htm during May 2011.

extraordinarily warm winter seasons are defined when both indicators are of at least one standard deviation below or above the long term mean.

Figure 2 plots the incidence of closures and the business cycle. In addition, we indicate poor winter periods. During the recession between 2001-2003 we observe a higher number of exits. There seems to be an increase in failures among ski lift companies following the financial and economic crisis from 2008. Surprisingly, the number of exits has not increased much after the extraordinary winter season 2006-2007.

Figure 2 Evolution of closures, business cycle and presence of snow poor winter periods

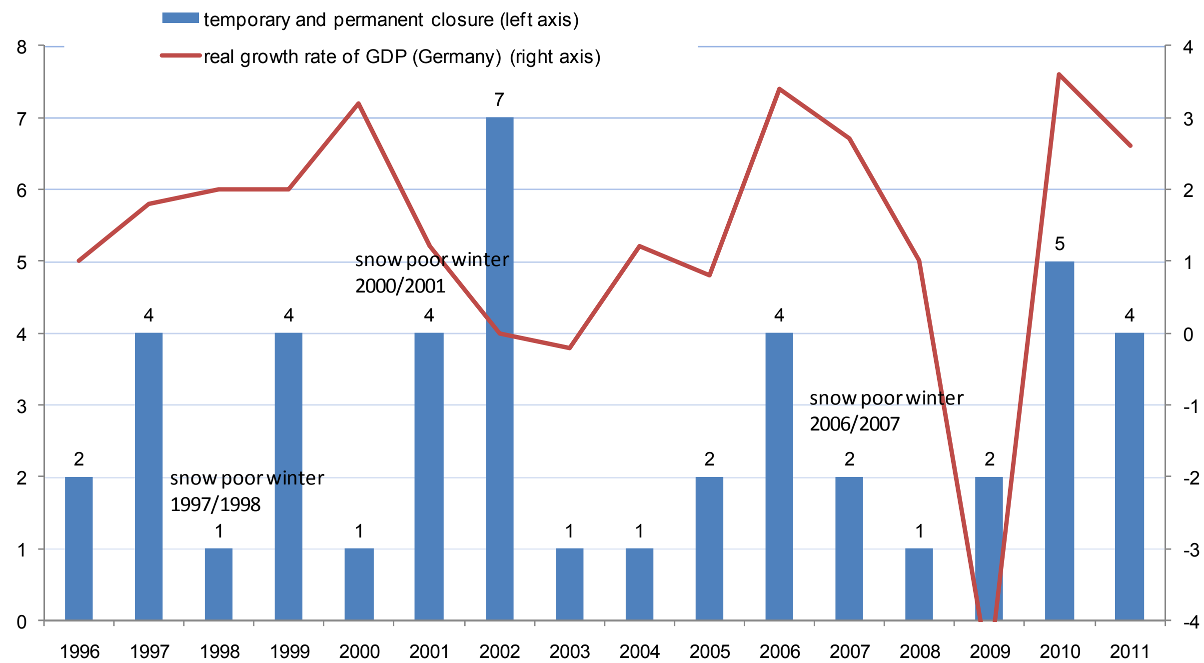


Table 1 presents the number of failures by type of failure across time. Over the period 1996-2011 out of the 222 surviving ski areas, 44 ski areas failed which gives a failure of about 20 percent over the total period. Only 20 ski areas have been shut down permanently. These ski areas account for less than 2 percent of the total length of slopes of all ski areas.

Table 1: Annual descriptive statistics on the number of closures by type

	permanent exits	temporary closures
1996	2	0
1997	1	3
1998	0	1
1999	3	1
2000	0	1
2001	2	2
2002	4	3
2003	1	0
2004	1	0
2005	1	1
2006	3	1
2007	0	2
2008	1	0
2009	0	2
2010	1	4
2011	0	3

Table 2 presents means and percentages of the main variables influencing company failure for surviving and non-surviving firms. We find that surviving firms are larger and exhibit a higher share of both adopters of snowmaking facilities and fast lifts. Unreported results show that these differences are significant at the 1 percent level.

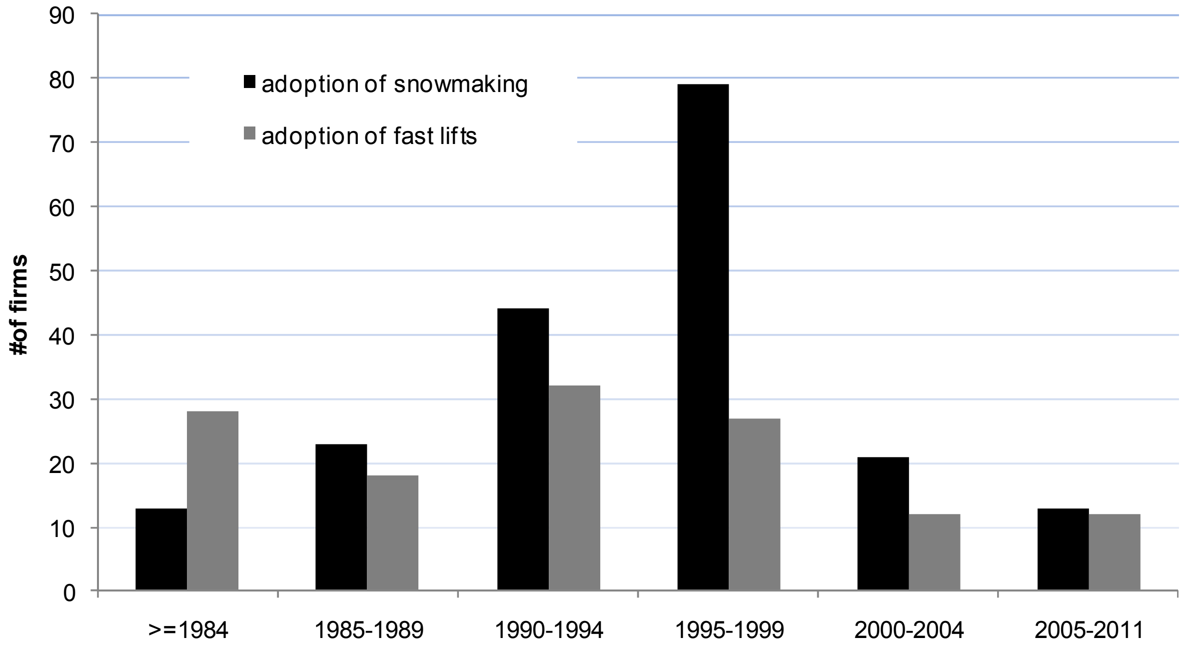
Table 2: Descriptive statistics for surviving and non surviving firms

	Surviving (n=198)	temporary closure (n=24)	permanent exit (n=20)
ski areas with snowmaking facilites in 1996 or before, percentages	60	50	20
ski areas with snowmaking facilites in 2011, percentages	80	92	n.a
ski areas with fast lifts in 1996 or before, percentages	41	25	5
ski areas with fast lifts in 2011, percentages	58	54	n.a
length of the slopes in km in 1996	36	24	8
max elevation of the ski area in metres in 1996	1859	1931	1530
year of incorporation	1963	1967	1966
distance to the nearest neighbouring ski area in km	14	18	8
distance to the nearest town with 50, 000 inhabitants or more in km	63	63	56

When failures are differentiated between temporarily and permanently closed ski areas we find that the group of temporarily closed ski areas is larger and exhibits a higher percentage of adaptors of both fast lifts and snowmaking facilities than the latter group. With respect to year of incorporation there is little difference between surviving firms and the two groups of closed firms. In general the number of entrants reached the maximum in the first half of the 1960s. With respect to maximum elevation of slopes we find little difference between surviving firms and those closed temporarily but ski areas which are shut down permanently have a lower elevation than the other two groups.

Figure 3 gives information on the timing of adoption of snowmaking facilities and fast lifts. One can see that the timing of introduction of snowmaking facilities peaked in the second half of the 1990s, whereas for fast lifts the peak is the early 1990s.

Figure 3 Timing of adoption of snowmaking facilities and fast lifts



We proceed with Kaplan Meier survival functions to compare survival probabilities for different groups of ski lift companies and characteristics (see Figure 5 to Figure 7 in the Appendix). The Kaplan Meier functions show that non-adopters have lower survival rates. This holds true for fast lifts as well as for snow making facilities. As expected, ski areas equipped with snowmaking facilities at the beginning of the analysis time are more likely to survive. In addition, larger ski areas are much more likely to survive. Failure risks continuously decrease across the size classes with few exits in the largest size class (i.e. length of slopes 40km or less). In contrast, the impact of the maximum elevation of the ski area on survival is not clear. Furthermore, survival rates are much higher for ski areas in the Eastern part of Austria. This is somewhat surprising since these ski areas are often located in disadvantaged areas characterized by low elevation and small area size.

4. Estimation results

Table 3 shows the results of the Cox model. The stcox command in STATA 11.2 is used to obtain the estimates. This table displays the coefficients ß as well as z values which are based on robust standard errors. In order to interpret the magnitude of the effects it is useful to calculate the hazard ratio which is exp(ß). Note that a hazard ratio below (above) one implies a negative (positive) effect on the hazard ratio. Column (i) is the basic specification while in the next two columns (ii) and (iii) we add additional dummy variables measuring the timing of snowmaking during the sample period.

Table 3: Results for the Cox proportional hazard model for both types of closures

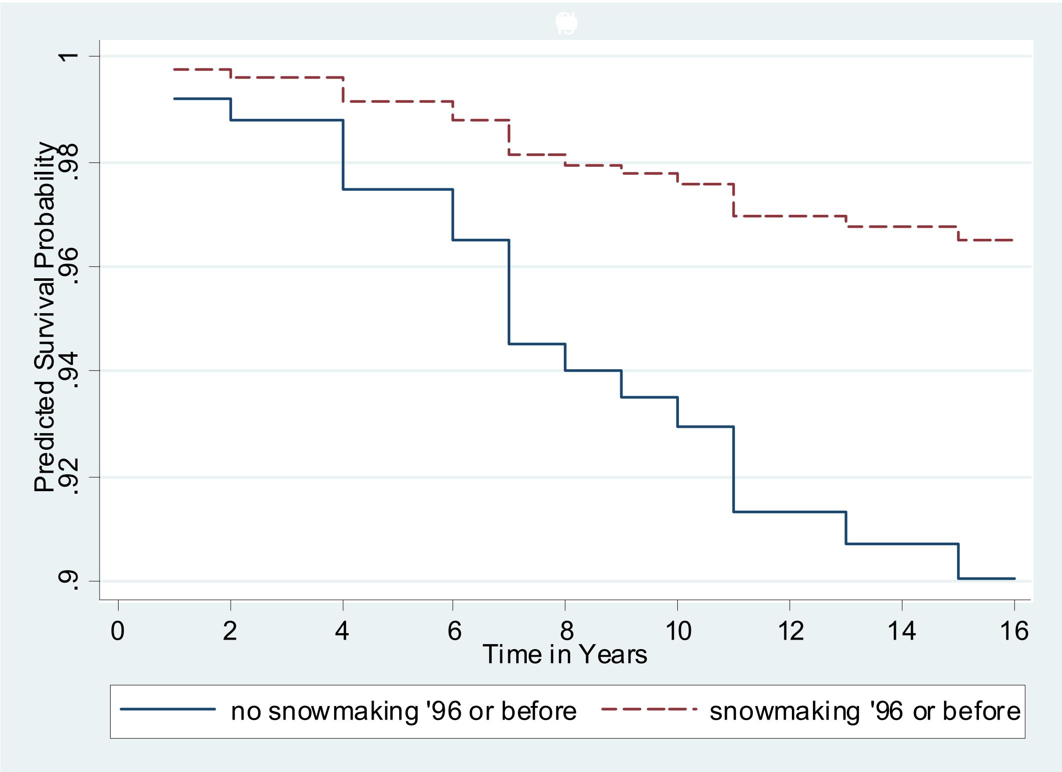
		(i)				(ii)				(iii)		
	ß	exp(ß)		z	ß	exp(ß)		z	ß	exp(ß)		Z
introduction of snowmaking facilities 1996 or earlier	-0.77	0.46	**	-2.10	-0.98	0.37	***	-2.61	-0.89	0.41	**	-2.26
log length of slopes in km	-0.52	0.59	**	-2.42	-0.50	0.61	**	-2.44	-0.55	0.58	**	-2.41
max elevation 1500m or below (ref. cat >=2000m)	0.49	1.63		1.03	0.49	1.63		1.07	0.42	1.53		0.89
max. elevation 1500-1800m	-0.31	0.73		-0.43	-0.26	0.77		-0.40	-0.25	0.78		-0.38
max. elevation 1800-2000m	1.04	2.82	**	2.44	1.15	3.15	***	2.76	1.12	3.06	***	2.63
dummy of ski areas located in Eastern Austria	-1.42	0.24	***	-3.20	-1.44	0.24	***	-3.26	-1.47	0.23	***	-3.28
time varying covariates:												
real growth rate of GDP for Germany in percent	-0.06	0.94	***	-7.55	-0.06	0.94	***	-7.72	-0.06	0.94	***	-7.72
dummy variable for snow-deficit and warm winter	0.36	1.44	***	5.09	0.44	1.56	***	4.66	0.44	1.55	***	4.55
introduction of snowmaking facilities 1998-'00					-0.12	0.89		-1.15	-0.11	0.90		-1.05
introduction of snowmaking facilities 2001-'03									0.01	1.01		0.16
introduction of snowmaking facilities 2004-'06									0.07	1.07		1.10
# of failures	44				44				44			
# of obs	242				242				242			
Wald test of joint significance of elevation v. (p-value)	0.01				0.01				0.03			
Wald test time varying snowmaking adoption(p-value)	0.52											

Notes: Estimation from the Cox proportional hazard model. The dependent variable is years of operation from 1995 onwards. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. z-values are based on robust standard errors. Negative coefficients indicate a decrease in the hazard (increase in survival).

We test the proportionality assumption. The null hypothesis that the hazard rates are proportional cannot be rejected at the 5 percent level.

We find a negative and significant relationship between the early adoption of snowmaking facilities and the hazard rate indicating that ski areas that are equipped with snowmaking facilities in the mid 1990s are less likely to fail in the next 15 years. The corresponding hazard ratio is exp(-0.77)=0.46 indicating a 54 percent lower failure risk in any year between the period 1996-2011 controlling for the impact of size, location and external factors such as weather and business cycle. Overall, the magnitude of the effect is quite large. As a measure of the magnitude of effect we also provide a graphical illustration. Figure 4 shows the predicted survival probability of early adopters of snow making facilities.

Figure 4: Predicted survival probability for adopters and non-adopters of snowmaking



These survival probabilities are calculated for ski areas with a length of slopes of 18 km, with a distance from the nearest neighbour of 10km and at an elevation between 1500 and 1800 metres. One can see that the predicted survival probability is about 5 percentage points higher for the group of early adopters of snowmaking facilities than that for non-adopters.

Furthermore, the Wald test shows that the two dummy variables for snowmaking introduced between 1998-2003 and 2003-2006 are jointly not significantly related to the survival probability. This indicates that laggards and late adopters of snowmaking facilities can not influence the hazard of exiting. Overall, the results suggest that the timing of adoption of snowmaking facilities is crucial.

In contrast to adoption of snowmaking technologies, the impact of early adopters of fast ski lifts is never significant and is therefore not included in the final regression (see Table 7 in the Appendix).

Looking at the impact of the elevation, we find that the impact of the maximum elevation on survival is not clear cut. In particular, there is no clear ranking of the impact of elevation on the hazard rate (i.e. survival) as one might expect. For instance, ski areas located at 1500 metres or below do not have a significantly higher exit probability than those located at an elevation of 2000 metres or higher. Similar findings can be observed for ski areas with a maximum slope height between 1500m and 1800m. However, for ski areas between 1800 and 2000m the hazard rate is two times larger than the high elevation ski areas with a maximum of 2000m and the coefficient is significant at the 1 percent level.

As expected size of the ski areas has a strong positive effect on the survival probability. The coefficient estimates implies that a 10 percent increase in the length of the slopes reduces the exit probability by 4 percent. Furthermore, we find that ski areas located in Eastern Austria survive significantly longer. One possible reason is the high share of public ownership among ski lift companies in these regions. Nearly all ski areas in Eastern Austria are directly and indirectly subsidized by the public government and/or partly state owned. New investment projects are also partly financed by public funds (e.g. European regional development fund).

Furthermore, the exit probability is significantly higher in snow poor winter seasons. The magnitude of the effect is quite sizable given the hazard ratio of 1.44 indicating a 44 percent higher hazard rate. This contrasts the interviews of managers of ski lift operators who do not regard global warming and climate change as a severe threat to their operations (Saarinen & Tervo, 2007 for Finland; Wolfsegger et al., 2008 for Austria). Similar evidence is obtained from interviews with hotel managers (Hill et al., 2010). Overall, our findings show that snow deficient winter seasons are a threat to the survival of ski areas. Note that this paper also includes the very small firms that are difficult to capture in surveys and interviews.

Year of incorporation of the ski area as a measure of age is not significant. The insignificance of firms' age stands in contrast to the literature which finds that younger firms are more likely to fail. Our different finding for the sample of ski areas is likely to be due to the fact that the ski business industry is a saturated industry with no entries after the early 1990s. Table 7 in the Appendix shows that the distance to the next neighboring ski area and the distance to the nearest city are each not significantly related to the survival probability when controlling for size, early adoption of snowmaking facilities, business cycle and occurrence of snow poor winter periods.

Table 4 shows the coefficients for the Cox proportional hazard model for permanent exits. Hazard ratios can be simply obtained by the exponent of the coefficients. Here, temporary closures are not treated as exits. It is interesting to solely investigate the determinants of permanent exits since they can be regarded as true exits. Again we find that early adoption of snow making is crucial for survival. The magnitude of the effect is even larger than that for both types of failures with a hazard ratio of 0.21 (=exp(-1.57)) indicating a 79 percent decrease in the hazard rate (i.e. increase in the survival probability).

In contrast to the previous regression results not distinguishing between different exit types, we find that distance to the next nearest ski area leads to a lower hazard (i.e. increase in the survival probability). This implies that co-located ski areas have a higher probability of being shut down permanently. The impact of the presence of snow poor winter periods is significant in three out of four specifications. In specification (ii) the hazard ratio of snow poor winter periods 1.27 (=exp(0.24)) indicating a 24 percent decrease in the survival probability. This indicates that the effect of snow-deficient winter periods on survival is much smaller than the effect of early adoption of snowmaking (in absolute terms).

Table 4: Results for Cox proportional hazard model for permanent exits

	(i)			(ii)			(iii)			(iv)		
	ß		z	ß		Z	ß		Z	ß		z
introduction of snowmaking facilities 1996 or earlier	-1.57	**	-2.12	-1.23	*	-1.74	-1.35	*	-1.95	-1.20	*	-1.70
log length of slopes in km	-1.13	**	-2.54	-1.28	***	-2.61	-1.50	***	-3.42	-1.20	**	-2.28
max. elevation 1500m or below (ref. cat >=2000m)	1.22		1.09	1.03		0.91	1.30		1.21	1.00		0.89
max. elevation 1500-1800m	0.92		0.81	0.81		0.71	0.81		0.71	0.71		0.61
max. elevation 1800-2000m	1.92	*	1.84	1.73		1.63	1.79		1.82	1.63		1.46
log distance to the next neigbouring ski area	-0.43	**	-2.17	-0.49	**	-2.43				-0.50	**	-2.44
dummy of ski areas located in Eastern Austria							-1.18	**	-2.33			
introduction of fast lifts 1996 or earlier										-0.61		-0.55
time varying variables:												
real growth rate of GDP for Germany in percent	-0.05	**	-3.01	-0.05	***	-3.09	-0.06	***	-3.38	-0.05	***	-3.00
dummy variable for snow-deficit and warm winter	0.41	*	1.68	0.24	*	1.89	0.17		1.28	0.24	*	1.92
snowmaking 1997-2006	-0.23		-0.84									
# of failures	20			20			20			20		
# of obs at beginning of analyse time	242			242			242			242		
Wald test elevation p-value	0.24			0.32			0.24			0.41		

Notes: Estimation from the Cox proportional hazard model for permanent exits. The dependent variable is years of operation from 1995 onwards. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. z-values are based on robust standard errors. Negative coefficients indicate a decrease in the hazard (increase in survival).

Table 5 shows the results of the competing risk survival model proposed by Fine & Grey (1999) and estimated using the Stcrreg package in STATA 11.2. Here the ski lift companies are exposed to two alternative exits, one is temporary closure and the other is permanent exit. Since parameters (and also the sub hazard ratios) are difficult to interpret, we focus on the sign and significance of the parameters only.

Overall, the results indicate that the factors affecting failures vary significantly across the two failure forms. For permanent exits we find a negative coefficient of early adoption of snowmaking facilities indicating that ski areas with snowmaking facilities are less likely to exit permanently. However, snow making facilities cannot lower the risk of going bankrupt or being closed temporarily. For permanent exits we find that size is significant whereas for temporary closure size is not significant.

Table 5: Results for the competing risks survival model

	permanent exits			temporary closures		
	coef.		z	coef.		z
introduction of snowmaking facilities 1996 or earlier	-1.57	**	-2.10	1.56	*	1.75
log length of slopes in km	-1.46	***	-2.71	-0.05		-0.14
log distance neighbouring ski resort	-0.16		-0.64	1.07	***	3.06
max. elevation below 1500m (ref. cat >=2000m)	1.26		1.19	-0.08		-0.09
max. elevation between 1500-1800m	1.30		1.23	-0.50		-0.36
max. elevation between 1800-2000m	1.81	*	1.68	0.89		1.54
dummy of ski areas located in Eastern Austria (upper & lower Austria, Styria)	-1.00	*	-1.80	-2.22	***	-2.82
introduction of fast lifts 1996 or earlier	-0.35		-0.31	-0.94		-1.15
time varying covariates:						
introduction of snowmaking facilities 1997-'03	-0.013	***	-41.48	0.001	***	2.60
introduction of snowmaking facilities 2004-'06	0.000		0.58	0.002	***	3.52
introduction of fast lifts 1997-2006	-0.012	***	-37.55	0.000		1.05
real growth rate of GDP for Germany in percent	-0.000	***	-3.49	-0.000	***	-4.72
dummy variable for snow-deficient and warm winter	0.001	***	2.56	0.002	***	3.50
# of obs	242			242		
# of failed	20			24		
# of competing	24			20		

Notes: Estimation from the Competing risk survival model. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. z-values are based on robust standard errors. Negative coefficients indicate a decrease in the subhazard rate (increase in survival).

For both types of failures, we find that the failure risk decreases with a real growth rate of GDP for Germany (as a proxy for the business cycle) and increases in snow poor winter seasons. Later adoption of snowmaking facilities is significant in the case of permanent exits. However, the findings for the significant coefficient for the introduction of snowmaking after 1996 should be interpreted with caution since there are only 20 exits on a permanent basis and few firms introduced snowmaking facilities in this period. In cases of temporary exits, we find that nearness to neighbouring ski areas increases the failure risk, while it is not significant in cases of permanent exits.

The remaining variables, growth rate of real GDP for Germany and the presence of snow poor winters are significant at the 5 percent level indicating that economic downturns and snow poor winter periods increase the failure risk for both types of failures. Location in Eastern Austria leads to a significantly lower risk for temporary failures. For permanent failures we also find that ski lift companies located in Eastern Austria survive longer but the effects are only significant at the 10 percent level.

We conducted several robustness checks to strengthen the credibility of our empirical results. First, it is crucial to account for possible endogeneity of technology adoption in the survival equation. It is well known that technological innovations are not exogenous to the firm. The usual determinants of technology adoption are firm size, market structure, level of competition and other firm characteristics. In the case of ski lift companies, Mulligan & Llinares (2003) find that adoption of faster chairlifts is significantly negatively related to the number of direct competitors that have already adopted the innovation based on data for 344 US ski areas. In order to take into account potential endogeneity of technology adoption in the survival equation, one can estimate a treatment effects model or an instrumental variables approach. However, practical implementation of the instrumental variable approach requires valid exclusion restrictions - variables that significantly affect technology adoption but do affect the survival time. We experiment with a number of possible instrumental variables. However, these instruments are either jointly significant in both equations (e.g. size and distance to the nearest ski areas) or never significant in either of the equations (e.g. elevation) and therefore the exclusion restrictions are not valid. Hence, instrumental variable methods can be not used because of the lack of a plausible instrumental variable.

Another robustness check concerns the definition of some variables and the choice of functional form. First we include alternative measures of snow poor winter seasons using different definitions for snow poor winter periods. For instance, we use current (same year) and lagged effects of snow poor winter periods. The general finding is that the results are not sensitive with respect to the measurement of snow poor winter periods. The coefficient of snow poor winter periods is even becoming more significant when lagged effects are allowed for. Similarly, we include a recession dummy variable that takes a value of 1 when the German or the Austrian economy is in a downturn and zero otherwise. Unreported results show that the recession dummy variable, as expected, is both positive in sign and statistically significant at the 1 percent level. Using specification (i) in Table 3 the hazard ratio of the recession dummy is 1.52 indicating that in the recession years the hazard rate increases by 52 percent as compared to other phases of the business cycle.

Second, we include the logarithm of age and its squared term instead of a set of elevation dummy variables. In addition, we experiment with alternative measures of size such as left capacity (adjusted for the vertical) and measure firm size as a set of size dummy variables. The main findings are robust to the definitions and measurement of the independent variables. We also include interaction terms between elevation and early adoption of snowmaking as well as between size and snowmaking. The underlying hypothesis is that the impact of snowmaking on survival is larger for low elevation ski areas. However, the interaction terms are only marginally significant in most of the cases.

Furthermore, we estimate simpler models such as logit models where the dependent variable is the failure probability which is measured as the logit score between zero and one.[3] We also estimate a multinomial logit where the probability of failure (distinguishing between temporary and permanent failures) is modeled as a function of explanatory variables including economic factors and weather data. For permanent exits, we again find that early adoption of snowmaking, size and distance to other ski areas decrease the failure risk. In cases of temporary exits we find that distance to other ski areas increases the failure risk while being located in Eastern Austria decreases the failure risk. Overall, this

[3] These results are available upon request.

indicates that the main results are not sensitive with respect to the estimation method. However, the effects of time varying covariates cannot be modeled using a multinomial logit model.

5. Conclusion and policy implications

In this paper we have investigated the determinants of failure and survival based on a sample of 242 ski areas in Austria. Over the fifteen year period 1996-2011, 19 percent of the ski areas (out of 242 measured at the beginning of the sample) went bankrupt or have been shut down permanently. In order to investigate the determinants of survival of ski areas, we used the Cox proportional hazard model with time varying variables. In addition, we employed competing risk survival models in order to distinguish between temporary closures and permanent exits.

We find that early adaption of snowmaking (1996 or before) leads to a significantly lower exit probability (either temporarily or permanently), while entry year, early adoption of fast ski lifts and distance to either the nearest urban agglomeration or to the next neighbouring ski area are not significant. The effect of the early adoption of snowmaking equipment is quite large. Ski areas which are equipped with snowmaking facilities at the beginning of the sample have a 54 percent lower hazard rate (i.e. higher survival) than those without snowmaking. As expected, large ski areas survive significantly longer than small ski areas. Surprisingly, elevation of the slopes plays a minor role for survival. In particular, the failure risk does not increase with the elevation of the ski areas. There is some evidence that the failure risk is higher for ski areas between 1800-2000 m as compared to ski areas with a maximum of 2000m. Furthermore, we find that the probability of exit rises significantly during economic downturns and during snow poor winter seasons. The magnitude of the impact is sizable with the occurrence of snow poor winters leading to an increase of the hazard rate (i.e. decrease in survival) by 44 percent.

We find strong differences in the effects of firm level and location specific characteristics on the two types of failures. When permanent exits are considered, we find again that early adoption of snow making, size and location in Eastern Austria leads to a lower failure risk. It is interesting to note that the effect of early adoption of snowmaking technologies on survival is larger when only permanent exits are considered. Furthermore, nearness to the next neighbour increases the failure risk. This indicates that co-location of ski areas is not of a particular advantage since geographical proximity increase the probability of being shut down permanently. Furthermore, the exit probability is higher in snow poor winter seasons but the magnitude is a bit smaller as compared to other variables such as early adoption of snow making. Again, maximum elevation of the slopes does not play a role for the risk of being closed on a permanent basis.

For temporary exits, we find that nearness to the next ski areas significantly increases the failure risk. Recessions and presence of snow poor winter seasons also leads to a higher failure risk, while location in the Eastern Part of Austria leads to a lower failure risk.

What are the managerial implications of the paper? Understanding the determinants of survival is of great relevance for policy makers, managers, and stakeholders. First, the occurrence of snow poor winters has only a modest effect on the risk of being shut down permanently and the magnitude of effect is much smaller than that of other factors such as early adoption of snowmaking adoption and/or size of the ski area. Hence strong fears on the sustainability of ski areas in times of global warming seem to be unsupported at least to some extent. The presence of snow poor winter seasons is more relevant for temporary closures.

Early adoption of snowmaking facilities is crucial for survival of ski lift companies, whereas non adopters face a higher failure risk. This uncertainty must be taken into account when calculating the rate of return on investment projects for the first time introduction of snowmaking.

Size is one the most powerful predictors of survival. Thus small ski areas have a significant disadvantage. The question is how to increase the size of the ski area? Extensions of ski areas are problematic because of environmental concerns. In addition, the implementation of the Alpine Convention which is an international agreement for the sustainable development of the Alps has lead to restrictions to the further development of ski areas. Many ski areas are located inside or close to national parks and are therefore protected. However, in some parts of Austria it is still possible to install ski lift connections between two neighbouring ski areas if the terrain allows. New lift linkages between two neighbouring ski areas leads to a larger size of the combined ski area which may help to reduce the failure risk.

One key result of this paper is that low elevation ski resorts do not have lower chances of survival than high elevation ski areas when size and early adoption of snow making facilities are controlled for. Our findings suggest that investors and stakeholders should not rely too heavily on the elevation of the ski areas in making investment decisions. This also means that there is no reason to give different treatment to low and high elevation ski resorts since the failure risk does not depend on elevation.

Our research has some implications for future research in a number of areas. Additional empirical work is needed to determine temporary exits since few variables have been found to be significant. Another area of future research is to directly ask the failed firms on the causes of its failure (Everett & Watson, 1998). There might be several reasons for closing, such as limit losses, not reaching financial goals or lacking approval for lift replacements or extreme weather events such as storms. Another area for future work is to include additional variables into the survival model. One suggestion is to include pre exit information on the productivity level or the managers' human capital. However, information on these variables is difficult to obtain. Another issue to be addressed by future research is to extend the survival model to a competing risk survival model distinguishing between voluntary liquidations and insolvencies. In addition, it might be useful to distinguish between exit by closure and exit by mergers (via connection ski lifts or ski buses) although this would be empirically difficult to analyze for some countries because of the limited number of observations. Finally, survival models should be also applied to other destinations where we have a much larger number of exits (e.g. for Japan or the US).

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Appendix.

Figure 5: Kaplan-Meier survival functions by firm size and maximum elevation of the slopes

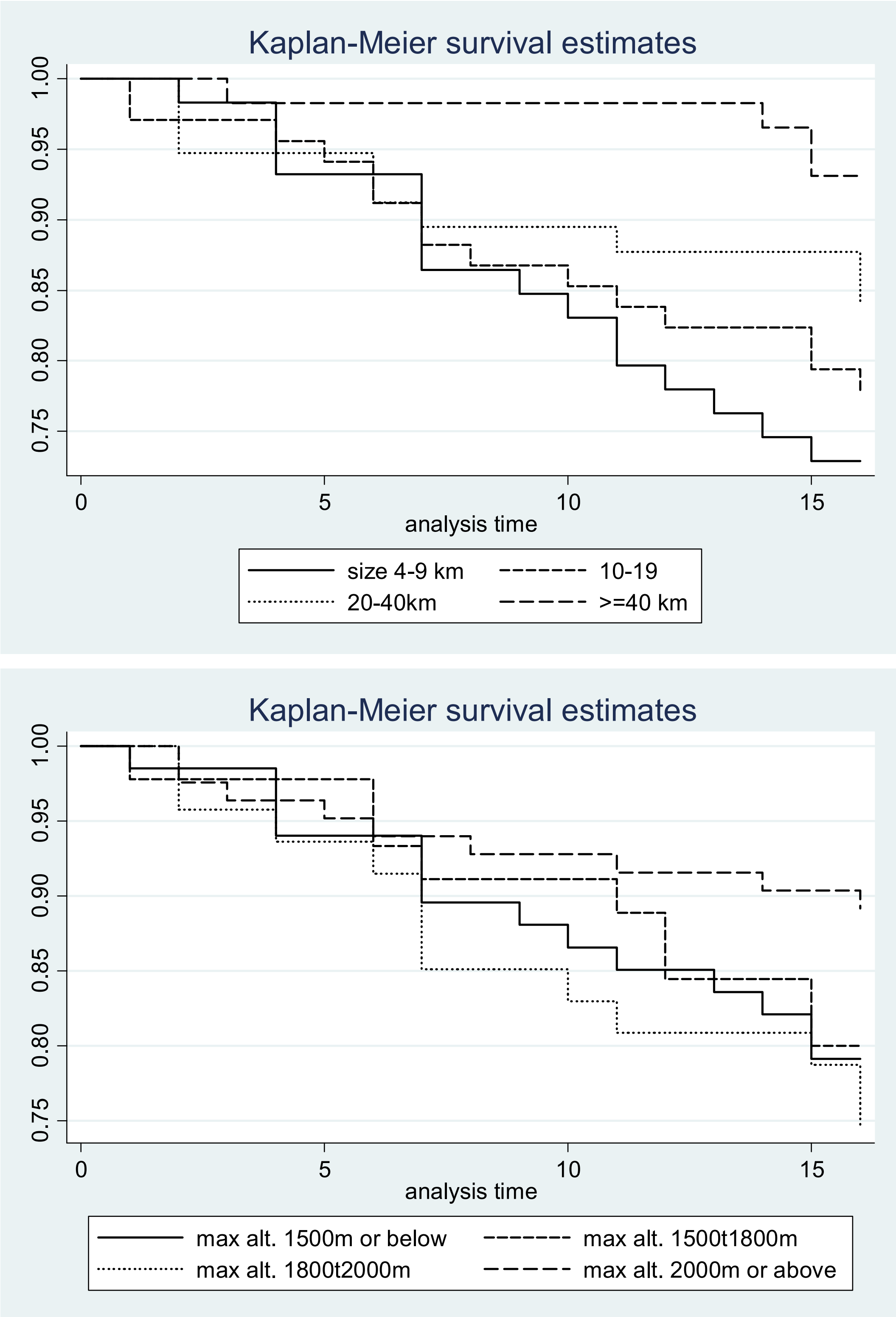
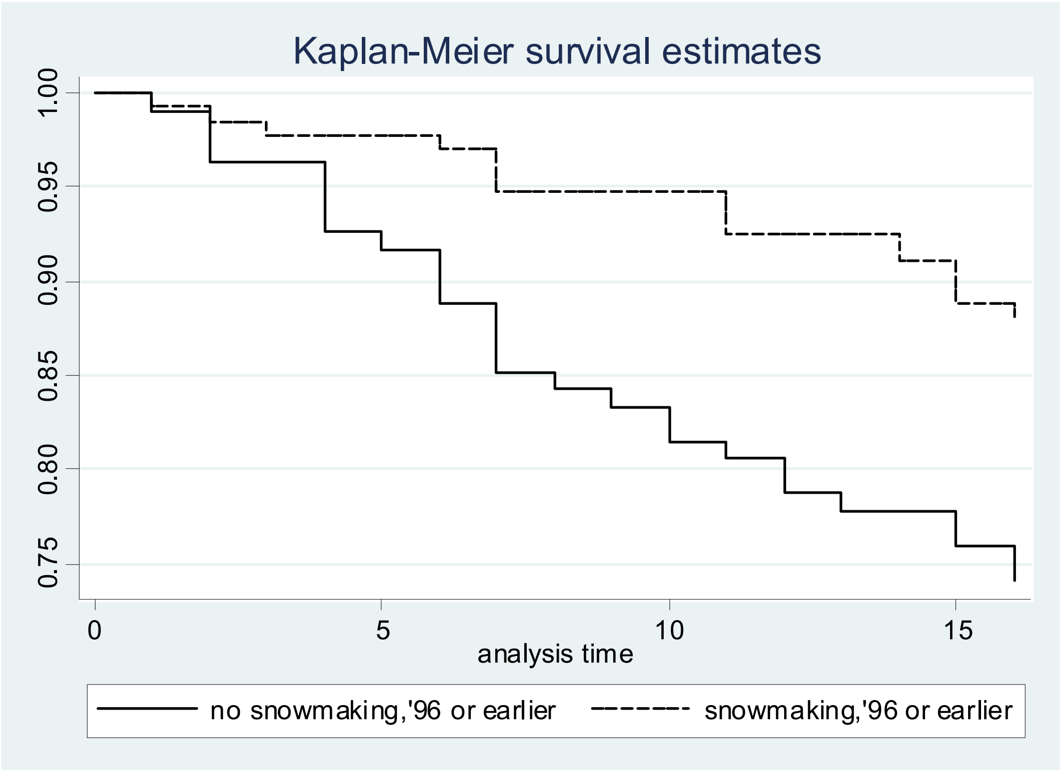


Figure 6: Kaplan-Meier survival functions by early adoption of snow making and fast lifts



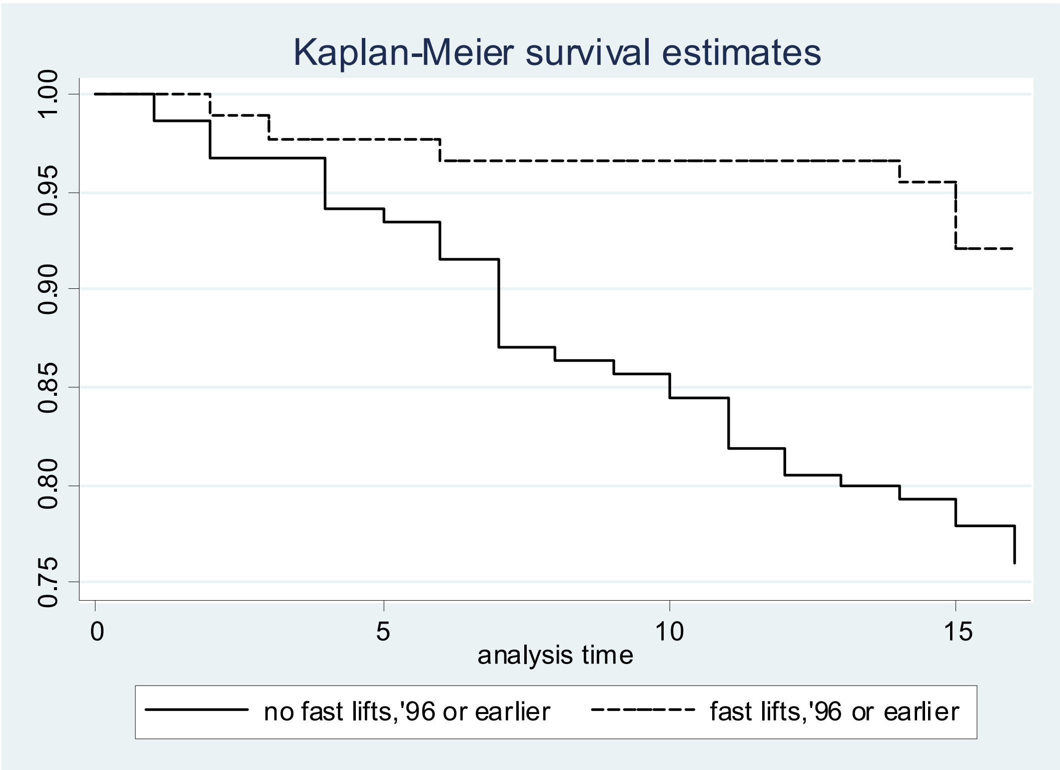


Figure 7: Kaplan-Meier survival functions by location of ski areas in East and West Austria

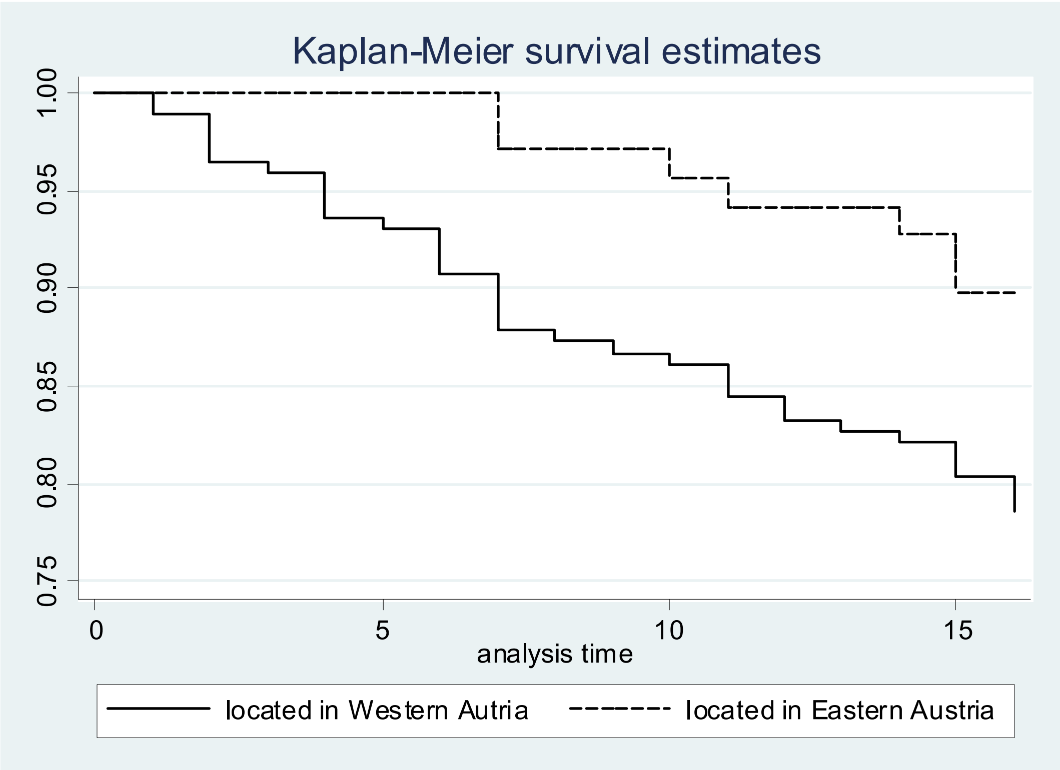


Table 6: Results of the multinomial logit model for temporary and permanent closures

	permanent exits			Temporary closures		
	dy/dx		z	dy/dx		z
introduction of snowmaking facilities 1996 or earlier	-0.07	*	-1.85	-0.03		-0.71
log length of slopes in km	-0.09	***	-3.26	0.00		0.08
log distance neighbouring ski resort	-0.04	**	-2.80	0.11	***	3.14
max elevation below 1500m	0.07		1.12	-0.01		-0.24
max elevation between 1500-1800 metres	0.05		0.62	0.03		0.44
max elevation between 1800-2000 metres	0.08		1.16	0.08	*	1.71
dummy of ski areas located in Eastern Austria (upper & lower Austria, Styria)	-0.05	*	-1.63	-0.21	***	-3.04

Notes: The Table displaces marginal effects based on the multinomial logit model. Z values are based on robust standard errors.

Table 7: Results for the Cox proportional hazard model for both types of closures: impact of other variables

	(i)			(ii)			(iii)			(iv)		
	ß		Z	ß		z	ß		z	ß		z
introduction of snowmaking facilities 1996 or earlier	-0.73	*	-1.91	-0.69	*	-1.88	-0.67	*	-1.79	-0.72	*	-1.91
ln length of slopes in km	-0.43	**	-2.01	-0.47	**	-2.14	-0.35		-1.40	-0.46	**	-2.04
max elevation 1500m or below (ref. cat. >=2000m)	-0.06		-0.13	-0.15		-0.32	-0.18		-0.38	-0.09		-0.19
max elevation between 1500-1800m	-0.45		-0.65	-0.47		-0.68	-0.51		-0.73	-0.40		-0.59
max elevation between 1800-2000m	0.83	**	1.99	0.81	**	1.99	0.73	*	1.68	0.87	**	2.12
ln distance to the next neigbouring ski area	-0.18		-1.01									
ln distance to the nearest city				-0.28		-1.61						
introduction of fast lifts 1996 or earlier							-0.49		-0.91			
ln entry year										5.14		0.26
time varying variables:												
real growth rate of GDP for Germany	-0.05	***	-6.61	-0.05	***	-6.72	-0.05	***	-6.48	-0.05	***	-6.67
dummy variable for snow-deficit and warm winter	0.40	**	5.62	0.39	**	5.56	0.39	***	5.40	0.39	***	5.42
# of failures	44			44			44			44		
# of obs	242			242			242			242		

Notes: Estimation from the Cox proportional hazard model. *, ** and *** denote statistical significance at the 10, 5 and 1 percent level respectively. z-values is based on robust standard errors. Negative coefficients indicate a decrease in the hazard (increase in survival). The dependent variable is years of operation from 1995 onwards.