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A survival analysis of ski lift companies

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HIGHLIGHTS

► Early adoption of snowmaking leads to a significantly lower exit probability.
► Failure risk is lower for ski areas with an average elevation of 1700 m and above.
► Exit probability rises significantly during economic downturns.
► No significant relationship between snow depth and the exit probability.
► Only 2 percent of the total length (7780 slope kilometres) are shut down permanently.

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ABSTRACT

This article investigates the factors influencing the survival of 244 ski lift operators in Austria over the period 1995–2011. Both Cox proportional hazard and competing risk models with time-varying covariates are utilized to distinguish between ski lift operators that temporarily suspended operations (e.g. due to insolvency) and those that permanently stopped their service. The results show that early adoption of snowmaking facilities led to a significantly lower risk of failure. Introducing snowmaking at later periods (i.e. from 2000 onwards) did not have a significant impact. Size, elevation of the ski areas, local competition, and regional effects also play a significant role in the survival of ski areas, but these factors cannot explain temporary failures. Surprisingly, the probability of permanent exits and temporary failures is independent of variations in snow depth at the nearest weather station. A lack of accommodation capacity and economic recessions lead to a higher risk of both types of failures.

1. Introduction

Due to pressure introduced by climate change, changing demographics, increasing competition, intensified concentration, and saturated markets, the number of ski resorts has significantly decreased over the last decade (Hudson, 2004; Taylor, Yang, & Strom, 2007). According to the National Ski Areas Association (NSAA), the number of ski resorts operating in the US dropped from 735 in the 1982–1983 winter season to 471 in 2009–2010.[1] For New Hampshire, Hamilton, Rohall, Brown, Hayward, and Keim (2003) suggest that not only the number of small ski areas, but also the number of larger and chairlift-served ski areas decreased over time. With data up until 2007, Kureha (2008) showed that 147 ski areas closed in Japan. However, the decline in the number of ski areas seems to be uneven across world regions. In Austria and other European Alpine countries, the number of ski area shutdowns has been much lower. For instance, in Austria in the period 1995–2011, roughly 20 percent of 244 ski lift companies with three or more ski lifts went formally bankrupt or voluntarily closed their operations permanently for various reasons. With 23 ski areas having permanently disappeared from the market, the closure rate is still low in Austria: Just two percent of a total slope length (7780 km) was shut down between 1995 and 2011. Currently, little is known about the factors influencing the survival of ski lift companies. Possible determinants include firm characteristics, as well as location-specific and macroeconomic factors.

The aim of this paper is to provide an initial investigation into the survival determinants of ski lift companies. Investigated in particular are the impact of firm-specific effects (e.g. year of entry, extent and timing of adoption of snowmaking equipment and new, fast ski lifts), location-specific and regional effects (e.g. average elevation of ski areas, variations in snow depth, distance to nearest city and local competition), and macroeconomic factors (e.g. the business cycle). Special emphasis is also placed on how introducing snowmaking machines influences the survival probability of ski lift companies. Another key variable is ski area elevation: In particular, we investigate whether low- and high-elevation ski areas have different chances of survival, as a recent study by the OECD suggests that low-

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

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elevation ski stations are the most vulnerable to global warming and future climate change (Agrawala, 2007). The database consists of a new and unique data set covering 244 ski lift companies.

The empirical model is based on a Cox proportional hazard survival model, which describes both the occurrence and timing of exits. In the first step, we analyse the determinants of survival irrespective of whether the ski areas stopped their operations permanently or temporarily. In the second step, the determinants of permanent exits are investigated. Moreover, we use the competing risk survival model developed by Fine and Gray (1999), in which 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; Park & Hancer, 2012, for the hospitality industry; Kaniovski, Peneder, & Smeral, 2008, for the accommodation sector; and Santarelli, 1998, for new tourism service firms). The studies show that firm survival is significantly and positively related to firm size.

To the best knowledge of the authors, 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 the 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 because some ski lift companies are partially under public ownership or supported by public funds. The study will make a number of significant contributions to the related literature: First, it provides an indication of the relative importance of technology adoption, location factors, business cycles, and weather factors to the failure risk of ski lift companies. Second, this paper contributes to the literature regarding the effects of innovation on the performance of tourism firms. Hjalager (2010) and Hall and Williams (2008) suggest that there is still limited empirical evidence of how innovation activities and technology adoption affects tourism enterprises. Third, our findings could be helpful in formulating a guideline on how to reduce the rate of failure in the future. The present paper is structured as follows. Section 2 presents the theoretical background and 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

2.1. Theoretical background and previous empirical literature

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 (1996, 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. The failure probability is also 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. However, Agarwal and Audretsch (2001) suggest that firm size is less relevant as a determinant of firm survival in the mature stage of the industry life cycle.

The literature widely agrees that innovative firms are more likely to be survivors. Cefis and Marsili (2006) suggest that innovation is an insurance against failure. Innovations can be measured in various ways. One can distinguish between market novelties and introduction of new products, services or production processes that are already introduced onto the market, but new to the firm. Other types of innovations includes organizational and management innovations (see Camisón & Monfort-Mir, 2012; Hjalager, 2010). In the skiing business, the major new technologies are the introduction of snow-making machines and detachable chairlifts and gondolas, which can be regarded as both a process innovation and a new and improved service.

Previous empirical literature has shown that the implementation of new products and production processes leads to a lower exit risk of firms (Agarwal, 1996; Cefis & Marsili, 2006; Doms, Dunne, & Roberts, 1995; Fontana & Nesta, 2009; Helmers & Rogers, 2010). For instance, using firm level data for manufacturing and service sectors in the Netherlands, Cefis and Marsili (2005) found that innovating firms (measured as introduction of product and/or process innovations) have an 11 percent higher chance of survival than non-innovating firms. The Capital Vintage Theory also has 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).

In tourism research, few studies are available. Notable exceptions include Hall and Williams (2008), who revealed that tourism innovation plays an important role in determining the survival probability using data for tourism firms in New Zealand. For Switzerland, based on data for 147 Valaisan hotels, Scaglione, Schegg, and Murphy (2009) found that website adoption is positively related to revenue growth.

In this connection, it is useful to consider the theory of diffusion introduced by Rogers (1995), which 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) have 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: early technology adoption will increase the likelihood of firm survival (H1); adoption prior to the maximum penetration will increase the likelihood of survival (H2); adoption of a greater number of technologies will increase the likelihood of survival (H3). Using firm level data for the UK manufacturing sector, the authors found that early adoption increases the likelihood of survival.

Another factor that is likely to affect company survival is the intensity of local competition. It is well established in business and economic literature that the intensity of local competition is important for productivity growth. Porter (1990, 1998, 2000) argues that strong competition in the same market provides significant incentives for innovation, which in turn accelerates the rate of productivity growth and the chance of survival. Similarly, Schmidt (1997) suggests that increased competition pressure may reduce bankruptcy risk because of a higher managerial effort to avoid bankruptcy risk. In addition, co-location of firms can have positive effects for neighbouring firms because of geographically localized spillovers or agglomeration advantages. However, competitive pressure may drive the less efficient firms out of the market. Agarwal and Gort (1996) suggest that the exit rate can increase in the late (mature) stage of the industry life cycle when the level of competition intensifies and the concentration rises. This is particularly relevant for the market of ski lift operators. In Austria, the ski business has already entered the mature stage of the industry life cycle with no entry after the mid 1990s and rising exits (see Fig. 6 in the Appendix A). Chung and Kalnins (2001) suggest that co-location of firms may lead to more intensive competition and, thereby, may increase the exit rate of weaker firms. Whether the presence of ski areas in close proximity leads to a lower or higher shut down rate is an empirical question.

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). In summarizing the literature on firm exits, Caves (1998) found 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, Higson, Holly, & Kattuman, 2009; Salvanes & Tveterås, 2004).

Since ski business is a weather dependent industry, current and past weather and snow conditions may also affect the survival of ski lift companies. In particular, the failure risk is expected to increase during snow poor winter seasons or late arrival of snow. Based on a survey of 61 ski lift companies in Austria, Bank and Wiesner (2011) found that in the snow poor and warm winter season of 2006–2007, 42 percent of ski lift operators suffered severe losses, whereas 32 percent of the companies experienced small losses. Only 27 percent were 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, Agrawala, Crick, & Montfalcon, 2007; Agrawala, 2007; Steiger, 2011). In fact, in Austria, mean winter temperatures increased significantly in the last 50 years (Auer et al., 2007). Snow depth and snowfall shows a downward trend (Schöner, Auer, & Böhm, 2009). Much of that change occurred from the end of the 1980s onwards. Agrawala (2007) predicts that with a +2 °C temperature increase scenario by 2050, the number of snow reliable ski areas will drop between 62 percent (Eastern Austria) and eight percent (Western Austria). Thus, 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. Previous empirical evidence suggests that lower elevation resorts experienced the largest reductions in skier visits and lift transports during snow poor winter periods (Steiger, 2011). Therefore, average or maximum slope height may play an important role in the performance and survival of ski lift companies. Overall, one can expect that the exit rate is higher for low elevation ski areas. However, recent studies in Austria show that the magnitude of relationship between weather factors (e.g. snow depth and temperatures) and the performance of ski resorts measured as overnight stays is quite modest and other factors are much more important (Falk, 2010; Töglhofer, Eigner, & Prettenthaler, 2011). In contrast, Pickering (2011) found for Australia that skier visits are highly sensitive to variations in snow depth.

2.2. Empirical model

Given the theoretical and empirical literature, the failure risk can be modelled as a function of firm size, age, timing of technology adoption, local competition, location specific factors, variations of snow depth and macroeconomic factors. The empirical model is based on a survival model. 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, indicated by t, conditional on having survived until the beginning of time (t). Exit is defined as bankruptcy, insolvency or voluntary liquidation. Voluntary liquidation includes discontinuance of a ski lift company for any reason. Exit can be either temporary or permanent. Exits that occur because either ski areas are sold to another ski lift company or are merged with another ski lift company are not treated as exits.

Survival models can 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 collected from 1994 onwards. The dependent variable is the amount of years a ski lift operator has stayed in business calculated as age at exit, minus year of incorporation of the ski area. The first possible year of exit is 1995 (equal to the survival time of one year) (see Fig. 1 for the definition of the analysis time). Both left truncation and right censoring is taken into account. For the survival model, we choose the Cox (1972) 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:

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

where $h_0(t)$ is the baseline hazard with $T = 0$ in 1994 and $T = 17$ in 2011.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 = [snowmaking, liftquality, size, entryyr, elevation, distcity, distneigh, beds ratio, region]
Z = [snow depth, GDP growth, timing of adoption]

These variables are defined as follows:

snowmaking: adoption of snowmaking machines installed in 1994 or earlier,
liftquality: adoption of at least one fast lift installed in 1994 or earlier (e.g. detachable chairlifts, modern gondola ropeways or MGDs, and funitel systems),
size: total length of slopes, in kilometres,
entryyr: year of installation of first lift,
elevation: average elevation of the ski area measured as a set of five dummy variables (i) average elevation 1100 m or below, (ii) average elevation between 1100 and 1299 m, (iii) average elevation between 1300 and 1449 m (iv) average elevation between 1450 and 1699 m and (v) average elevation of 1700 m or higher with the first group as the reference group,
distcity: road distance to the nearest largest town in kilometres (with population of 50,000 or more), alternatively travel time in minutes,
distneigh: road distance to the nearest neighbouring ski area or, alternatively, a dummy variable equal to one if the nearest competitor is located within 10 km,
beds ratio: ratio of tourist beds to the length of slopes in 1994,
region: regional dummy variables (six federal states) with Tyrol as the reference category,
snow depth: average monthly snow depth in cm for the months November–March of the nearest weather station (where individual means are subtracted),
GDP growth: annual real growth rate of GDP per capita (for Germany) in percent,

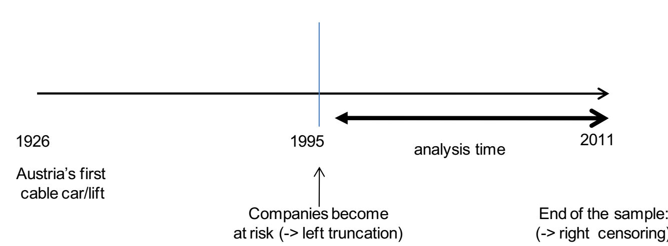

Fig. 1. Definition of the analysis time.

timing of adoption: dummy variable for the period of adoption of snowmaking machines at later periods.

Among the time invariant variables, we include a dummy variable indicating whether or not snowmaking equipment 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. Early adopters of snowmaking machines 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 order to account for the effect of later adoptions, dummy variables measuring the introduction of snowmaking machines in later time periods (between 1995 and 2000 and between 2001 and 2006) are included.

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 waiting queue 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 profit. Failures may be less likely for companies that invested in both fast lifts and introduced snowmaking machines at the same time. Therefore, we include an interaction term between introduction of fast lifts and introduction of snowmaking machines.

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 the lower the failure risk will be. 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 about 90 percent of ski lift operators have been in business for 35 years or longer (see Fig. 6 in the Appendix A). The ski business can be considered as a typical example of a mature industry with few entries in the last decades. Age of ski area is measured as the year of installation of the first ski lift transformed into the logarithm.

In order to test whether ski areas in low elevation locations face a higher failure risk, average elevation measured as a set of dummy variables is included. Following the literature (e.g. Abegg et al., 2007; Steiger, 2011; Töglhofer et al., 2011), average elevation rather than maximum elevation is used. In this case, average elevation of the ski area is measured as the average of the highest uphill lift station and the bottom of the valley slope. The preferred measure of elevation is a set of five dummy variables. One can expect that the survival probability depends on the elevation of ski areas with a higher exit probability for low-lying ski areas.

The geographical distance to the nearest neighbouring ski area is considered as an indicator of local competition (Becerra, Santaló, & Silva, 2013). The underlying idea is that the strength of competition is a function of the distance between competitors. Alternatively, distance to the nearest neighbouring ski area is measured as a dummy variable that equals one if the distance between the ski area and its nearest competitor is 10 km or less. In addition, the distance to the nearest town can also influence the survival probability. Close proximity to a large number of consumers can have a positive impact on the survival probability. In contrast, ski areas that are further away from the nearest regional city have a disadvantage because of the lower potential for local demand. We use road distance to the nearest regional town with a population of at least 50,000 following Eurostat's definition of agglomerations.

The inclusion of regional dummy variables makes it possible to investigate whether the failure risk differs across regions. In particular, seven regional dummy variables (i.e. Federal states) are calculated with Tyrol as the reference category. Finally, a measure of accommodation capacity is included. The exit rate is expected to be higher for ski areas with a lack of accommodation capacity.[2] In order to account for possible heteroscedasticity, the ratio of tourist beds in the initial year (within a distance of 5 km of the slopes) to the length of slopes is used as the measure of accommodation capacity.

The time varying explanatory variables include average snow depth for the winter months November–March. In order to allow for comparisons of the different weather stations located at different elevations, individual means are subtracted. Alternatively, dummy variables for the occurrence of snow poor winters – defined as one if snow depth is 15, 20 or 25 cm below the average – are included. It is expected that snow poor winters increase the likelihood of exit. We also experiment with snow conditions in the past winter season because of lagged reactions. As a measure of the business cycle, we use the real 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 growth rate of GDP per capita 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).

Previous research shows that the factors influencing firm exit vary significantly across different forms of exits (e.g. Harhoff, Stahl, & Woywode, 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 and Gray (1999). The case specific hazard rate can be modelled as follows:

$$h_j(t, X_i, Z_{it}) = h_{j0}(t)\exp\left(\beta_j' X_i + \gamma_j' Z_{it}\right),$$

where h_j represents the jth cause-specific hazard function with $j = 1$ for permanent exits and $j = 2$ for temporary exits. X represents a set of time invariant variables, Z includes the time varying covariates and β and γ denote the effect of covariates on the subhazard function caused by the jth reason. $h_j(t)$ 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.

The main research questions to be answered in the empirical section of the paper are as follows: (i) What are the main factors influencing the failure risk of ski areas? (ii) Whether and to what extent the exit probability (chance of survival) depends on the timing of adoption of snowmaking machines. Lastly, (iii) to what extent the factors affecting the survival chance differ by type of survival, namely temporary failures or permanent closures.

3. Data and descriptive statistics

We created a representative unbalanced sample of 244 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/or three ski lifts or more. Ski areas with

[2] In addition, to accommodation capacity the quality of accommodation measured as the proportion of beds in four and five stars hotels play a role in determining the failure risk. However, the quality measure was never significant and therefore not considered in the final regression.

less than three ski lifts, but served by at least one chairlift and/or gondola are also included. Failures and closures are collected for the period 1995–2011. Firm level information is combined with macroeconomic variables and location characteristics. We collected the data from several sources (i.e. lift database, water services regulation authority for information of introduction of snowmaking machines, insolvency statistics, Austrian Institute for Meteorology and Statistics Austria). The annual lift database provided by the Federal ministry of transport and infrastructure is used to calculate the year of first appearance of fast lifts and the year of foundation of the ski lift company. Data on the first time adoption of snowmaking technologies are drawn from the water services regulation authority.[3] Note that water withdrawals used for snowmaking are regulated by the federal state 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 drew 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. Second, permanent discontinuance of ski areas is measured using the annual 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 if ski lifts are removed. Two neighbouring ski areas that are linked through new lifts during the sample period and offer a joint lift pass are treated as one ski area, except for new lift linkages in the last three years.

At the end of 1994, the number of ski areas was 244. The number of ski areas decreased to 221 at the end of 2011. Thus, the number of ski areas that exited the market is 23. These ski areas account for less than two percent of the total length of slopes of about 7780 km. In addition, there were 29 ski lift companies that went bankrupt, became insolvent or closed their operations temporarily during the sample period. This group accounts for eight percent of the total length of slopes. The decrease in the number of ski areas together with an increase in aggregate skier visits indicates rising concentration and/or increasing scale economies.

Distance to a large urban centre is measured as the shortest travelling time to the closest agglomeration with 50,000 or more inhabitants in minutes. Alternatively, 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.

Matching data of the location of each ski area to the nearest weather stations makes it possible to investigate the impact of natural snow depth on firm survival (for the list of the weather stations used see Table 6 in the Appendix A). Snow poor winter periods are measured using average monthly snow depth for the winter months in cm where individual station averages are subtracted in order to facilitate comparison across weather stations at different elevations. In addition, variation in snow depth is also measured as average for the months November–January and November–December in order to account for timing of snowfall.

Fig. 2 gives an idea of the evolution of snow depth and the presence of failures over the sample period.

The number of failures increased during the winter seasons of 2000–2001 and 2001–2002 with both periods characterized by lower than average snow depth (measured as average between November and March). Surprisingly, the number of exits had not increased much after the snow poor winter season of 2006–2007. Fig. 3 plots the number of closures by type of failure over time and the evolution of the business cycle. During the recession period between 2001 and 2003, we observe a higher number of ski areas that completely disappeared from the market.

There also seems to be an increase in failures among ski lift companies following the financial and economic crisis of 2008, but only in the case of temporary failures. This may indicate that the business cycle may play a significant role for the survival of ski lift companies.

Table 1 presents means and percentages of the main variables influencing company failure for the sample of surviving and non-surviving firms and for the total sample. In 1994, 33 percent of ski areas were equipped with snowmaking equipment based on data drawn from the federal water service regulation authorities. In 2011, this share increased to 76 percent. The share of ski areas with fast lifts increased from 34 to 53 percent. Maximum of the elevation of ski areas (measured as the elevation of the highest uphill lift station) is 1833 m on average. The average elevation of ski areas is 1423 m on average. The table also shows that surviving firms are larger and exhibit a higher share of both adopters of snowmaking equipment and fast lifts. Unreported results show that these differences are significant at the one percent level using a *t*-test.

When failures are differentiated between temporarily and permanently closed ski areas, we find that the group of temporarily closed ski areas exhibits a higher percentage of adopters of both fast lifts and snowmaking equipment than the latter group. Ski areas that have temporarily stopped operations and/or went bankrupt are also larger than the group of ski areas that permanently disappeared from the market. 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 new entrants reached the maximum in the first half of the 1960s (see Fig. 6 in the Appendix A). With respect to average elevation of slopes, we find little difference between surviving firms and those closed temporarily, but ski areas, which were shut down permanently, had a lower elevation than the other two groups. Fig. 4 gives information on the timing of adoption of snowmaking equipment and fast lifts. One can see that the timing of introduction of snowmaking equipment peaked in the second half of the 1990s, whereas for the introduction of fast lifts, the peak is in the late 1980s and early 1990s.

Figs. 7–10 in the Appendix A shows the Kaplan–Meier survival estimates for different groups of ski lift companies. The Kaplan–Meier survival estimates show that ski areas equipped with snowmaking equipment at the beginning of the analysis time are more likely to survive. Larger ski areas are also much more likely to survive with very few exits in the largest size class (i.e. length of slopes 40 km or less). Low-lying ski areas (at an elevation of 1100 m or below) have a higher failure risk. For the remaining elevation categories, there is no clear ranking of the failure risk with respect to the average elevation of the slopes. Furthermore, survival rates differ widely across regions with lower failure risk in the Eastern part of Austria and in Vorarlberg.

4. Estimation results

Table 2 shows the results of the Cox proportional hazard model.[4] This table displays the coefficients β 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 (β). Column (i) provides the specification with additional

[3] 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.

[4] The stcox command in STATA 11.2 is used to obtain the estimates.

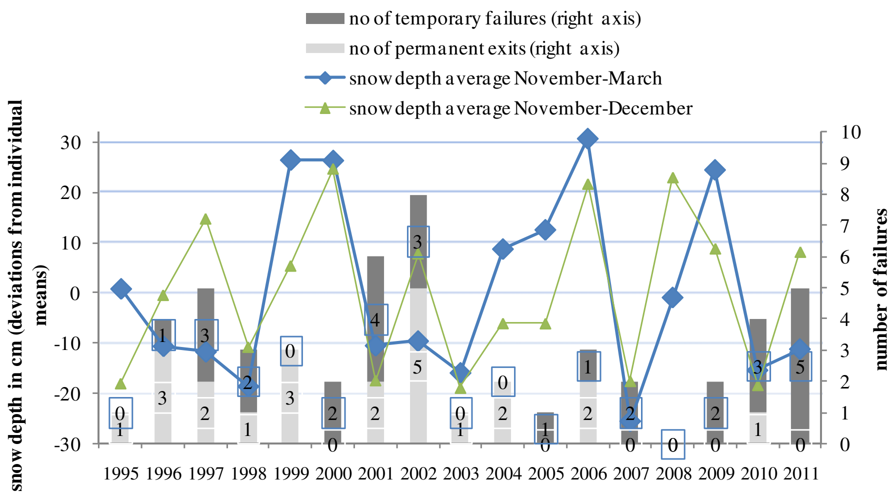

Fig. 2. Evolution of snow depth and number of failures. Notes: Data for snow depth refers to the winter season (starting November 1994–March 1995 and ending November 2010–March 2011). Individual means are subtracted from each observation (within transformation). Ski areas are matched to the nearest weather station and then the average over 244 ski areas is calculated. The number of exits refers to the calendar year. Source: Annual lift statistics, insolvency statistics and Eurostat New Cronos for GDP per capita in constant prices.

dummy variables measuring the timing of introduction of snowmaking equipment during the sample period. Column (ii) and (iii) excludes insignificant explanatory variables.[5]

The key result of the study is the negative and significant relationship between the early adoption of snowmaking equipment and the hazard rate indicating that ski areas that were equipped with snowmaking equipment in 1994 or earlier are less likely to fail in the next 17 years. The hazard ratio is exp $(-1.51) = 0.22$, indicating a 78 percent lower failure risk in any year between the period of 1995 and 2011.[6] Furthermore, controlling for the impact of size, location and the business cycle (based on specification ii), the Wald test shows that the two dummy variables for adoption of snowmaking machines introduced between 1995–2000 and 2001–2006 are jointly not significantly different from zero. This indicates that laggards and late adopters of snowmaking equipment do not influence the hazard of exiting. Overall, the results suggest that the timing of adoption of snowmaking equipment is crucial. Furthermore, the magnitude of the effect of adoption of snowmaking equipment is quite large.

To get a further idea of the magnitude, a graphical illustration is provided. Fig. 5 in the Appendix A shows the predicted survival probability of early adopters of snowmaking equipment as compared to non-adopters. One can see that the predicted survival probability is about 20 percentage points higher for the group of early adopters of snowmaking equipment than that for non-adopters.

The coefficient of early adopters of fast ski lifts has the expected negative sign indicating that early adopters have a higher survival probability, but the coefficient is only marginally significant. Furthermore, the exit probability is significantly related with the distance of the ski area to its closest competitor, average elevation of the ski area, accommodation capacity (relative to size of the ski area), evolution of the business cycle and the federal state where the ski area is located.

In particular, the exit probability of ski lift companies is significantly higher when the nearest competitor is located within a distance of 10 km or less. This indicates that co-location increases the failure risk. When local competition is measured as the geographical distance between the ski area and its nearest competitor, it is again found that exit probability increases with geographical proximity (see Table 5 in the Appendix A). The local competition effect is not only statistically relevant, but also relatively large. Ski lift companies located within 10 km of the nearest competitor had a 110 percent higher failure risk in any year between 1995 and 2011 (calculated as exp $(0.74) = 2.09$). Looking at the impact of the average elevation of the ski areas, the results show that ski areas with an average elevation of the slopes of 1700 m or above have a significantly higher survival probability as compared to ski areas at lower elevations. The effect for the highest elevation category is quite large with an almost 80 percent lower failure risk as compared to ski areas in the lowest elevation category. However, for ski areas with an average elevation of the slopes of less than 1700 m, there is no clear ranking of the impact of elevation on the hazard rate (i.e. survival), which one might expect. It should be noted that the elevation dummy variables increase in size and significance when the size variables are excluded from the regression (see specification iii).

Surprisingly, the size of the ski areas is not a significant determinant of the survival probability when both types of failures are considered. This is consistent with Audretsch, Santarelli, and Vivarelli (1999) and Agarwal and Audretsch (2001) who found that in the mature stage of the industry life cycle, size is not relevant as a determinant of firm survival. The coefficient on economic growth is significant indicating that strong macroeconomic growth reduces the failure risk, whereas economic recessions increase the failure risk.

Variations in the average snow depth of the nearest weather station for the winter months of November–March (measured as deviations from individual means) are not significantly related to exit probability (see Table 5 in the Appendix A upper panel). Unreported results show that this holds true when snow depth is measured as the average for the period between November and January and/or when based on dummy variables measuring snow poor winter periods. This result leads to the conclusion that firm specific characteristics and regional and macroeconomic factors are of much greater importance than variations in natural snow depth.

[5] To test the proportionality assumption, Schoenfeld residuals have been computed for each variable. Based on Grambsch and Therneau global tests of the Schoenfeld residuals, the null hypothesis that the hazard rates are proportional over time cannot be rejected at the five percent level. This is not surprising since in the concentration phase of an industry, as in the ski business, the assumption that the relative hazard rate is constant over time is quite plausible unlike in the earlier stages of the industry life cycle.

[6] Given the average unconditional failure risk of 21 percent, the 78 percent lower failure risk of early adopters of snowmaking machines is equal to a failure risk of four percent.

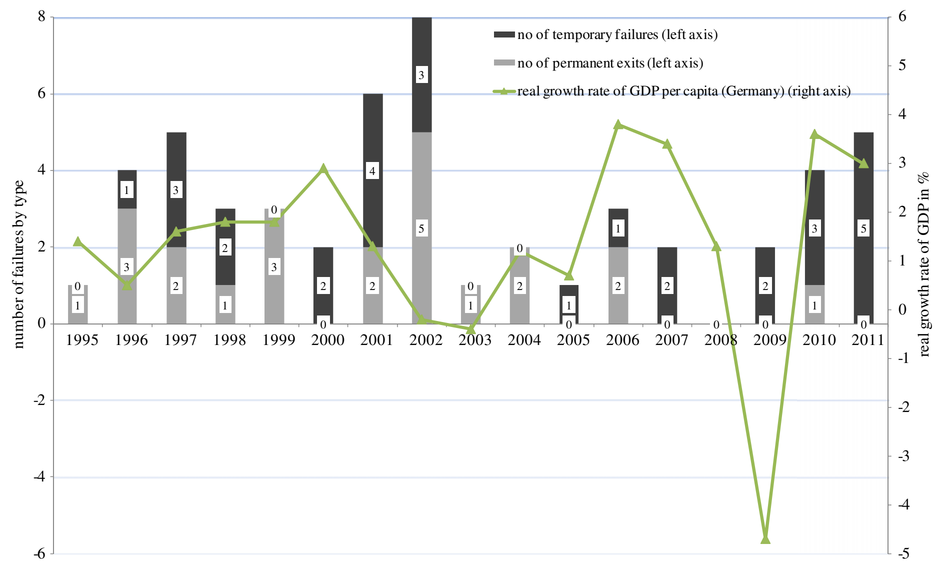

Fig. 3. Evolution of closures and the business cycle. Source: Annual lift statistics, insolvency statistics and Eurostat New Cronos for GDP per capita growth.

The results are consistent with interviews of managers of ski lift operators who do not regard fluctuations of weather and global warming as a severe threat to their operations (Saarinen & Tervo, 2007 for Finland; Wolfsegger, Gössling, & Scott, 2008 for Austria). Similar evidence is obtained from interviews with hotel managers (Hill, Wallner, & Furtado, 2010). Overall, the results are also consistent with Töglhofer et al. (2011) and Falk (2010) who found for Austria that variations in snow depth only play a modest role in determining changes in overnight stays during the winter season.

The regional dummy variables for ski areas located in Styria and Vorarlberg are significantly negative, indicating that ski areas located in these provinces survive significantly longer as compared to those located in Tyrol, which is the reference category. A number of variables are not significantly different from zero and are, therefore, not included in the final specification. For instance, the logarithm of the year of incorporation of the ski area as a measure of age is not significant. The insignificance of a firm's 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 due to the fact that the ski business industry is a saturated industry in the mature stage of the industry life cycle with no entries after the early 1990s. Table 5 in the Appendix A shows that the distance to the nearest city and travel time are each not significantly related to the survival probability when controlling for firm and other characteristics. Similar results were found when travel time is used to estimate the impact of proximity to a large number of potential consumers.

Having found significant determinants of exits, not distinguishing between bankruptcy and permanent exits, it is interesting to solely investigate the determinants of permanent exits since they can be regarded as true exits. Table 3 shows the coefficients together with the hazard ratios for the Cox proportional hazard model for permanent exits where temporary closures are not treated as exits.

Again, the results show that early adoption of snowmaking is crucial in regard to the probability of being shut down permanently. The hazard ratio is 0.15 (=exp [−1.89]) indicating that early adoption of snowmaking leads to an 85 percent lower hazard rate (i.e. increase in the survival probability). Furthermore, ski lift companies that installed snowmaking equipment at later periods (1995–2000) also survive longer than non-adopters. This is consistent with Sinha and Noble (2008), who stated that adoption prior to the maximum penetration will increase the likelihood of survival. However,

Table 1
Descriptive statistics for surviving and non surviving firms.

	Total ($n = 244$)		Surviving ($n = 192$)		Temporary closure ($n = 29$)		Permanent exit ($n = 23$)	
	Means	Median	Means	Median	Means	Median	Means	Median
Length of the slopes in km in 1995	32	17	36	20	21	17	8	7
Maximum elevation of the ski area in metres in 1995	1833	1820	1873	1862	1823	1836	1518	1470
Average elevation of the ski area in metres in 1995	1423	1373	1457	1401	1407	1404	1201	1091
Year of incorporation	1964	1965	1963	1964	1967	1965	1966	1965
Number of tourist beds	2956	1475	3189	1476	1223	941	3222	2193
Ratio of tourist beds to the length of slopes	159	70	131	67	67	48	511	417
Distance to the nearest neighbouring ski area in km	13	11	14	11	18	13	8	7
Distance to the nearest town, 50,000 pop. or more, km	64	62	65	67	59	56	57	55
Travel time to the nearest town, 50,000 pop. or more, min	58	56	59	58	58	48	54	50
	percentages		percentages		percentages		percentages	
Ski areas with snowmaking facilities in 1994	33		37		21		13	
Ski areas with snowmaking facilities in 2011	76		81		83		n.a	
Ski areas with fast lifts in 1994	34		40		17		4	
Ski areas with fast lifts in 2011	53		59		48		n.a	

Source: Annual lift statistics, Statistics Austria and own calculations.

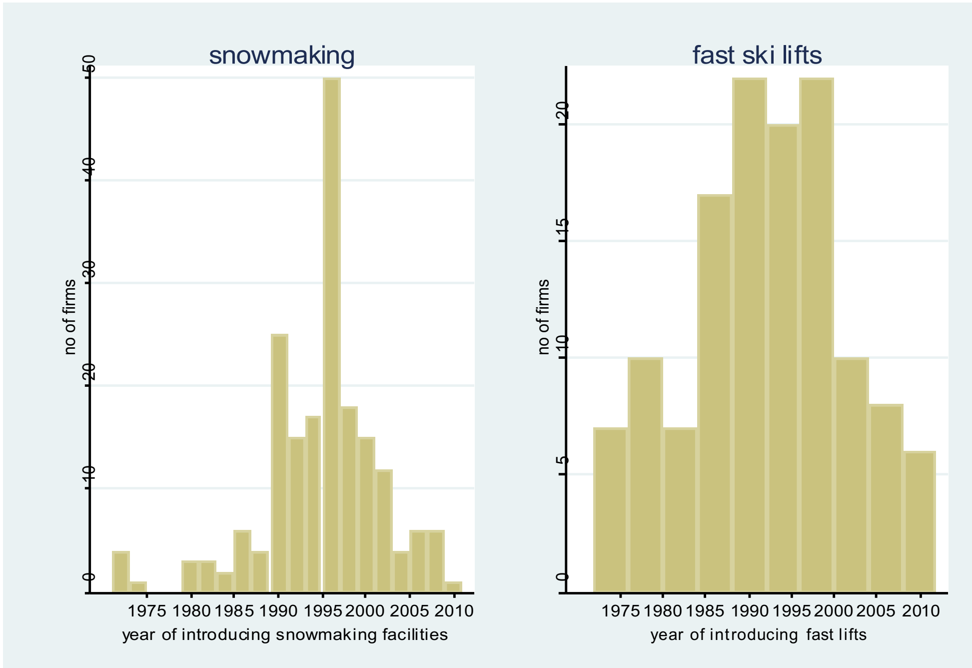

Fig. 4. Timing of adoption of snowmaking equipment and fast lifts. Source: Annual lift statistics, Water services regulation authority.

Table 2
Results for the Cox proportional hazard model for both types of failures.

	(i)			(ii)			(ii)		
	exp (β)	β	z	exp (β)	β	z	exp (β)	β	z
Introd. of snowmaking equip. 1994 or earlier	0.20	−1.61***	−3.35	0.22	−1.51***	−3.53	0.21	−1.54***	−3.62
Introduction of snowmaking equip. 1995–'00	0.78	−0.25	−0.58						
Introduction of snowmaking equip. 2001–'06	0.91	−0.09	−0.17						
Introduction of fast lifts 1994 or earlier	0.34	−1.08	−1.35	0.32	−1.15	−1.52	0.23	−1.49**	−2.18
Log length of slopes	0.72	−0.34	−0.97	0.72	−0.33	−1.02			
Average elevation 1100–1299 m	0.46	−0.78*	−1.76	0.44	−0.81*	−1.88	0.38	−0.96**	−2.48
Average elevation 1300–1449 m	0.59	−0.52	−0.91	0.52	−0.66	−1.34	0.42	−0.87**	−2.06
Average elevation 1450–1699 m	0.78	−0.24	−0.36	0.74	−0.30	−0.46	0.58	−0.55	−1.00
Average elevation ≥1700 m	0.21	−1.54**	−2.42	0.22	−1.52**	−2.54	0.18	−1.74***	−2.93
Real growth rate of GDP for Germany in %	0.42	−0.87***	−8.34	0.42	−0.87***	−8.31	0.42	−0.87***	−8.66
Log distance to the nearest neighbour ≤10 km	2.07	0.73**	2.30	2.09	0.74**	2.29	2.22	0.80**	2.50
Ratio of no. of beds to length of slopes in '94	1.00	0.00**	−2.25	1.00	0.00**	−2.27	1.00	0.00*	−1.93
Carinthia (ref category Tyrol)	2.13	0.76	1.63	2.13	0.76*	1.84	2.20	0.79*	1.88
Lower Austra	0.53	−0.64	−1.16	0.54	−0.62	−1.15	0.56	−0.58	−1.06
Upper Austria	0.83	−0.18	−0.35	0.83	−0.19	−0.35	0.87	−0.14	−0.26
Salzburg	1.12	0.11	0.21	1.13	0.13	0.25	1.12	0.12	0.24
Styria	0.01	−4.92***	−6.70	0.01	−5.08***	−6.68	0.01	−4.93***	−7.11
Vorarlberg	0.24	−1.41**	−2.53	0.25	−1.38***	−2.57	0.24	−1.42***	−2.75
# of failures	52			52			52		
# of obs	244			244			244		

Notes: Estimation from the Cox proportional hazard model. The dependent variable is years of operation from 1994 onwards. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. z-values are based on robust standard errors. Negative β-coefficients indicate a decrease in the hazard rate (i.e. increase in survival). Note that a hazard ratio below one indicates a lower probability of failure.

installation of snowmaking machines between the period of 2001 and 2006 does not have an impact on the survival probability.

Furthermore, the size of the ski area has a strong positive effect on the survival probability, unlike in the regressions, which do not distinguish between different exit types. The coefficient estimates imply that a 10 percent increase in the length of the slopes reduces the exit probability by two percent. Furthermore, co-located ski areas (within a distance of 10 km) have a higher probability of being shut down permanently. Accommodation capacity (relative to the size of the ski area) and economic growth are positively related with the survival probability of ski lift companies. Finally, ski areas in lower Austria, Styria and Vorarlberg have a lower risk of being driven out of the market as compared to ski areas in Tyrol. Possible explanations for the lower failure risk in Eastern Austria is the rising demand from skiers and snowboarders from Eastern Europe and the lower level of local competition in these provinces as compared to Tyrol with the highest concentration of ski areas in Austria. Table 5 in the Appendix A shows that variations in snow depth are not significantly related to survival probability (of being shut down permanently).

Table 4 shows the results of the competing risk survival model proposed by Fine and Gray (1999).[7] Here the ski lift companies are exposed to two alternative exits, one is a temporary closure and the

[7] The model is estimated using the Stcrreg package in STATA 11.2.

Table 3
Results for Cox proportional hazard model for permanent exits.

	(i)			(ii)		
	exp (β)	β	z	exp (β)	β	z
Introduction of snowmaking machines 1994 or earlier	0.10	−2.27**	−2.48	0.10	−2.30***	−2.97
Introduction of snowmaking machines 1995–'00	0.13	−2.00*	−2.04	0.13	−2.00**	−2.14
Introduction of snowmaking machines 2001–'06	1.39	0.33	0.31			
Introduction of fast lifts 1994 or earlier	1.07	0.07	0.04			
Log length of slopes in km	0.15	−1.89**	−2.04	0.17	−1.80***	−2.96
Average elevation 1100–1299 m (ref. cat <1100 m)	0.52	−0.65	−0.76	0.51	−0.67	−0.83
Average elevation 1300–1449 m	1.02	0.02	0.02	0.99	−0.01	−0.01
Average elevation 1450–1699 m	0.97	−0.03	−0.03	0.87	−0.14	−0.12
Average elevation ≥1700 m	0.19	−1.68*	−1.79	0.17	−1.77**	−2.09
Real growth rate of GDP per capita for Germany in percent	0.36	−1.03***	−5.38	0.36	−1.01***	−5.74
Log distance to the nearest neighbour	5.31	1.67***	2.59	5.10	1.63**	2.46
Ratio of number of tourist beds to length of slopes in 1994	0.31	−1.18***	−2.81	0.31	−1.17***	−2.68
Carinthia (ref category Tyrol)	1.11	0.10	0.12	1.19	0.17	0.24
Lower Austra & Styria	0.02	−3.84*	−1.93	0.02	−3.79*	−1.93
Upper Austria	0.75	−0.29	−0.34	0.77	−0.26	−0.30
Salzburg	1.74	0.55	0.72	1.82	0.60	0.85
Vorarlberg	0.04	−3.11***	−4.28	0.05	−3.08***	−4.35
# of failures	23			23		
# of observations	244			244		

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 β-coefficients indicate a decrease in the hazard rate (i.e. increase in survival).

Table 4
Results for the competing risks survival model.

	(i)			(ii)		
	SHR	β	z	SHR	β	z
Introduction of snowmaking machines 1994 or earlier	0.10	−2.27**	−2.42	0.44	−0.82	−1.52
Introduction of snowmaking machines 1995–2000	0.17	−1.78**	−2.15	1.43	0.36	0.68
Introduction of fast lifts 1995 or earlier	0.89	−0.12	−0.08	0.42	−0.86	−1.32
Log length of slopes in km	0.16	−1.81**	−2.17	0.94	−0.06	−0.16
Average elevation 1100–1299 m (ref. cat <1100 m)	0.56	−0.58	−0.64	0.30	−1.20*	−1.72
Average elevation 1300–1449 m	0.79	−0.23	−0.23	0.76	−0.27	−0.39
Average elevation 1450–1699 m	0.80	−0.22	−0.17	0.63	−0.46	−0.57
Average elevation ≥1700 m	0.24	−1.41*	−1.70	0.33	−1.10	−1.38
Real growth rate of GDP for Germany in percent	0.38	−0.96***	−4.87	0.57	−0.55***	−6.54
Distance to the nearest neighbour 10 km or less	5.30	1.67**	2.55	1.22	0.20	0.38
Ratio of number of tourist beds to length of slopes in 1994	0.37	−0.99**	−2.44	0.00	−6.62***	−3.00
Carinthia (ref category Tyrol)	0.91	−0.10	−0.11	3.62	1.29**	2.46
Lower Austra + Styria	0.02	−4.11**	−2.13	0.24	−1.41**	−2.52
Upper Austria	0.86	−0.15	−0.17	0.35	−1.06	−1.02
Salzburg	1.91	0.64	0.92	0.94	−0.06	−0.08
Vorarlberg	0.05	−3.01***	−4.34	0.58	−0.55	−0.69
# of obs	244			244		
# of failed	23			29		
# of competing	29			23		

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).

other is a permanent exit. Since parameters (and also the subhazard ratios, SHR) are difficult to interpret, focus is placed on the sign and significance of the parameters only. Overall, the results show 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 machines indicating that ski areas with snowmaking machines are less likely to exit permanently. However, snowmaking machines 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.

For both types of failures, we find that the failure risk decreases with a real growth rate of GDP per capita for Germany (as a proxy for the business cycle) and with the supply of tourist beds relative to the size of the ski area. In cases of permanent exits, we find that nearness to neighbouring ski areas increases the failure risk, while it is not significant in cases of temporary exits. Ski lift companies in Styria and lower Austria and Vorarlberg have a significantly lower risk for permanent failures, whereas the survival probability for temporary failures does not vary much across regions.

Several robustness checks were conducted to strengthen the credibility of the empirical results. First, alternative measures of snow depth according to the timing of snowfall and different definitions of snow poor winter seasons were included. For instance, current (same year) and lagged effects of snow poor winter periods and variations in snow depth (with individual means subtracted) were used. The general finding is that snow depth is never significant at conventional significance levels.[8] The insignificance of snow depth remains when it is measured as the percentage of days with 30 cm snow depth or more.[9]

Second, a recession dummy variable that takes a value of one when the German or the Austrian economy is in a downturn and zero otherwise is used to measure the business cycle. Unreported results show that the recession dummy variable, as expected, is both positive in sign and statistically significant at the one percent level indicating a higher failure risk in recessions.

Third, alternative measures of size, such as left capacity (adjusted for the vertical) and measure firm size as a set of size dummy variables, were experimented with. The main findings are robust to the definitions and measurement of the independent variables. Also included were 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.

5. Conclusion and policy implications

This study provided a detailed investigation of the determinants of failures of ski areas in Austria for the period between 1995 and

[8] In a previous version of the paper, we found that the presence of snow poor winter periods had a negative impact of the survival probability when defined as dummy variables for the winter seasons 1997/1998, 2001/2002 and 2006/2007. However, in doing so it does not take into account the local weather conditions.

[9] Detailed results are available upon request.

2011. Over this sixteen-year period, roughly 20 percent of the 244 ski areas went bankrupt or completely disappeared from the market. However, surprisingly, few ski areas have shut down their operations on a permanent basis. The group of ski areas that completely disappeared from the market accounts for only two percent of the total length of 7780 slope kilometres during the sample period. It is interesting to note that the number of permanent closures mainly occurred in 2001 and in 2002 and have not increased after the extraordinary winter season of 2006/2007.

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. The results show that early adoption of snowmaking (1994 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 the nearest urban agglomeration were not significant. The effect of the early adoption of snowmaking equipment is quite large. Ski areas, which are equipped with snowmaking machines at the beginning of the sample, have a 78 percent lower hazard rate (i.e. higher survival) as compared to those without snowmaking. Average elevation of the slopes also plays a significant role for survival. In particular, the failure risk is significantly lower for ski areas with an average elevation of 1700 m and above. Furthermore, this research found that the exit probability rises significantly during economic downturns. The probability of exit decreases with the distance between the ski area and its nearest neighbour indicating that co-location is associated with a higher failure risk. No significant impact of variations of snow depth of the nearest weather station (measured as deviations from individual means) on the exit probability once firm specific and regional effects have been taken into account were found.

Strong differences were revealed in the effects of firm level and location specific characteristics on the two types of failures. When permanent exits are considered, we again find that early adoption of snowmaking and size of the ski areas leads to a lower failure risk. Furthermore, nearness to the next competitor increases the failure risk. However, early adoption of snowmaking cannot reduce the risk of being closed on a temporary basis or the probability of going bankrupt. Overall the results suggest that the less efficient ski areas with no snowmaking machines and/or characterized by a small size are more likely to be driven out of market. At the same time, local competition measured as the geographical distance to the closest competitor (ski area) also leads to a higher failure risk. Both findings are typical in the later stage of the industry life cycle when the level of competition intensifies.

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 seems to be not as relevant in determining the failure risk of ski areas as one might have expected. Other factors such as installation of snowmaking machines, size of the ski areas, local competition and macroeconomic growth are much more important. This is consistent with anecdotal evidence indicating that a number of ski areas have shut down not because of snow poor winter periods, but rather due to increased competition due to new lift linked ski areas in close proximity. In particular, early adoption of snowmaking machines is crucial for the survival of ski lift companies, whereas non-adopters face a higher failure risk. This factor must be taken into account when calculating the rate of return on investment projects for the first time introduction of snowmaking.

Another important result of the paper is that except for the high elevation ski areas (at an average elevation of 1700 m and above), elevation is not a major determinant of survival when firm characteristics (particularly size) are controlled for. This finding suggests 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 medium elevation ski resorts since the failure risk does not increase with average elevation of slopes.

Size is one the most powerful predictors of the long-term survival of ski areas, but is not significant in cases of bankruptcy and temporary exits. Thus, small ski areas have a significant disadvantage. The question is then raised regarding 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 led to restrictions to the further development of ski areas. Many ski areas are located close to national parks and, therefore, extensions are difficult or impossible to achieve. 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.

The main limitation of the study is related to the nature of the data. The use of data for a single country limits its ability to generalise. More importantly, the empirical analysis is based on a survival model where the number of ski lift companies that permanently stopped their operations is quite small. Future work should also analyse the determinants of performance measured as the number of transports using data drawn from the annual lift statistic. There are also other areas that deserve more attention in future work. Additional empirical work is needed to determine bankruptcy and temporary exits for other reasons since few variables have been found to be significant. Another area of future research is to directly ask the failed firms about the causes of 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 manager's human capital. However, information on these variables is difficult to obtain. Furthermore, survival models should also be applied to other destinations where a much larger number of exits are reported (e.g. for Japan or the US). Another area that deserves more attention is the relationship between variations in weather conditions (i.e. snow depth and temperatures) and the failure risk. This relationship should be re-examined using detailed data of the past and current winter seasons along with additional resort specific weather data. Doing so would provide a more accurate picture of the impact of extraordinarily mild and/or snow poor winter seasons on the failure risk. Furthermore, because the very small lift companies with two or less ski lifts are underrepresented, it would be desirable to investigate whether the results of the present study also hold true for the very small lift operators.

Acknowledgements

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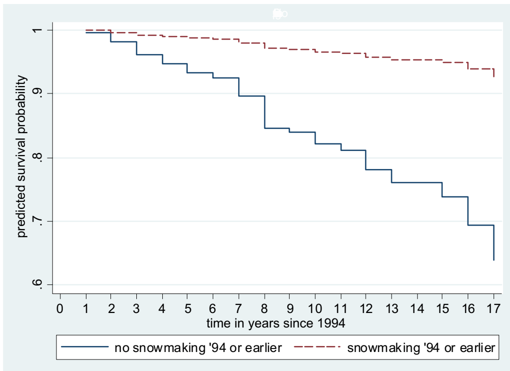
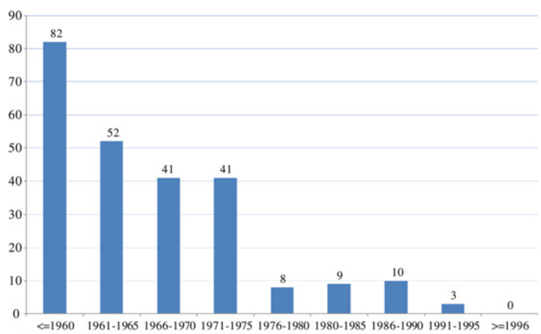
Appendix A



Notes: The survival probabilities are calculated for an example of ski area with the following characteristics: length of slopes of 9 km, within a distance from the nearest neighbour of 10km, at an average elevation of 1100 metres or below, located in the province Tyrol and with an accommodation capacity of 159 beds per kilometer of slopes.

Fig. 5. Predicted survival probability for adopters and nonadopters of snowmaking.



Notes: Entry is measured as the year of installation of the first ski lift. Source: Annual lift statistics.

Fig. 6. Evolution of entries of ski areas by entry year.

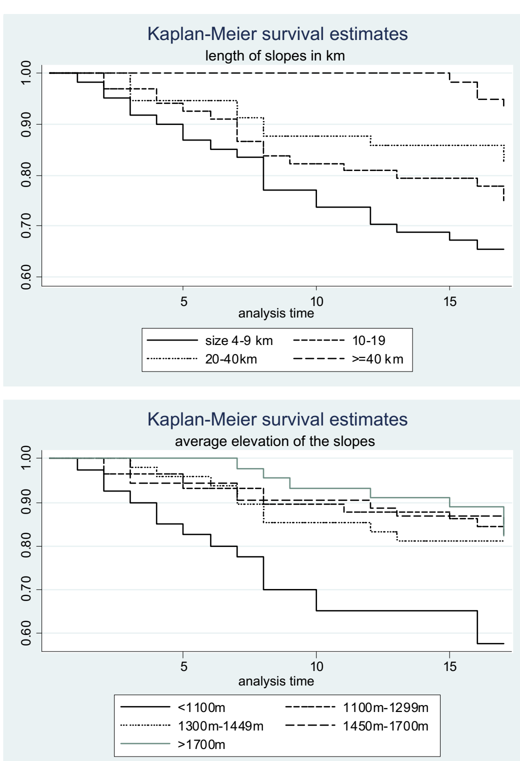


Fig. 7. Kaplan–Meier survival functions by firm size and average elevation of the slopes.

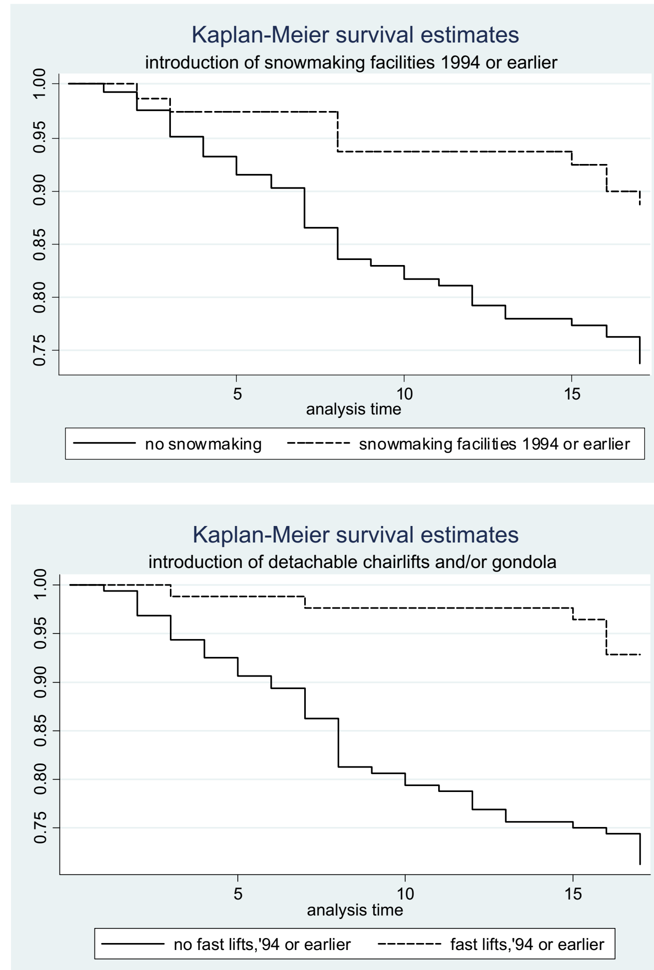


Fig. 8. Kaplan–Meier survival functions by early adoption of snowmaking and fast lifts.

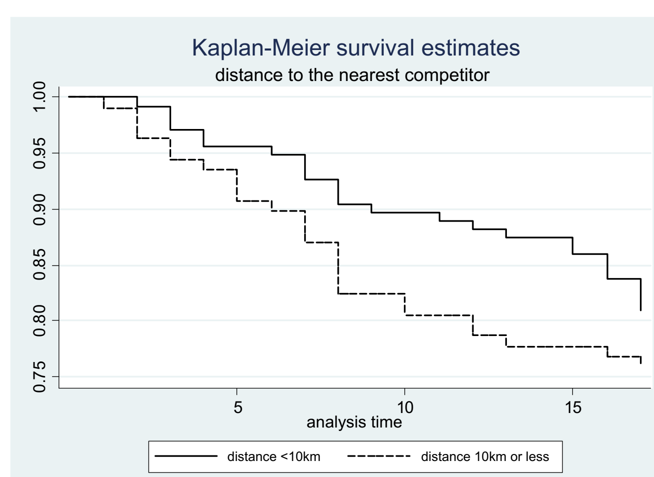


Fig. 9. Kaplan–Meier survival functions by distance to the nearest competitors.

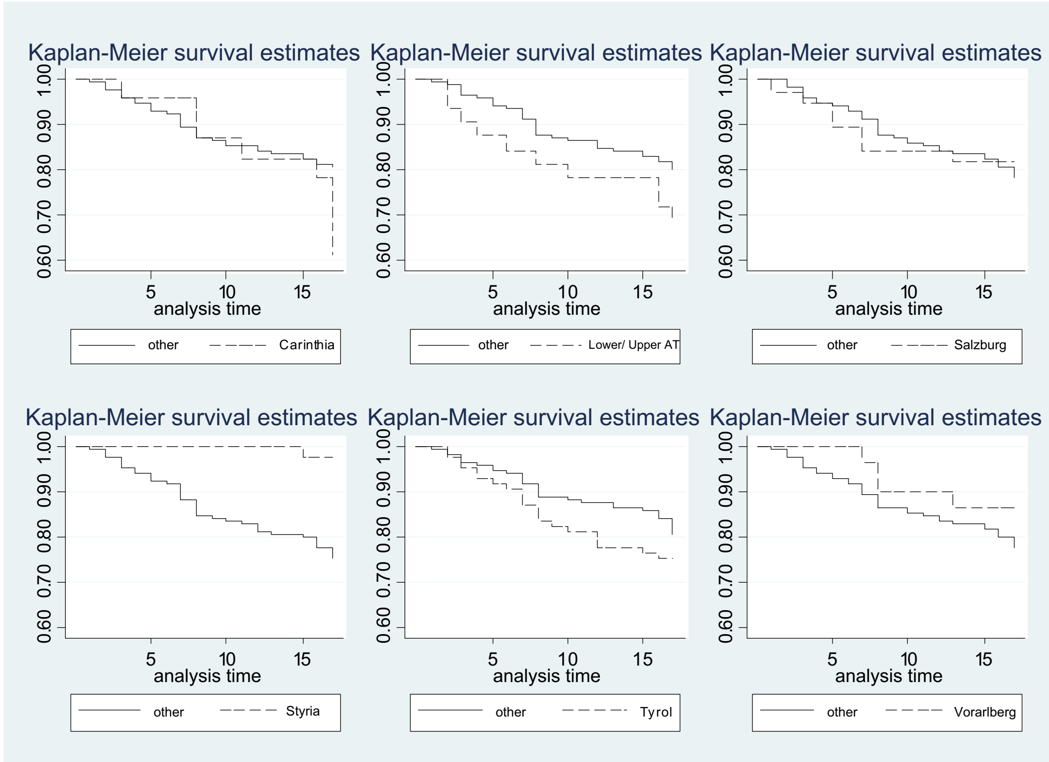


Fig. 10. Kaplan–Meier survival functions by province.

Table 5
Results for Cox proportional hazard model for both types of failures and permanent exits.

	(i)		(ii)		(iii)		(iv)	
	β	z	β	z	β	z	β	z
Failure risk for both types of failures								
Introd. of snowmaking mach. 1994 or earlier	−1.53***	−3.30	−1.52***	−3.28	−1.57***	−3.51	−1.66***	−3.22
Introd. of snowmaking machines 1995–2000	−0.26	−0.62	−0.26	−0.62	−0.21	−0.50	−0.24	−0.56
Introd. of fast lifts 1995 or earlier	−1.13	−1.43	−1.12	−1.42	−1.13	−1.45	−1.21	−1.32
Log length of slopes in km	−0.43	−1.37	−0.43	−1.37	−0.28	−0.84	−0.49	−1.52
Av. elevation 1100–1299 m (ref. cat <1100 m)	−0.63	−1.39	−0.63	−1.40	−0.84*	−1.81	−0.66	−1.48
Average elevation 1300–1449 m	−0.41	−0.74	−0.41	−0.74	−0.57	−1.02	−0.42	−0.77
Average elevation 1450-1699 m	0.03	0.05	0.03	0.05	−0.24	−0.36	0.02	0.04
Average elevation ≥1700 m	−1.33**	−2.43	−1.32**	−2.40	−1.42**	−2.47	−1.40**	−2.53
Real growth rate of GDP in percent	−0.84***	−7.88	−0.84***	−7.85	−0.86***	−8.77	−0.79***	−7.15
Ratio of number of tourist beds to length of slopes in 1994	−0.38	−1.23	−0.38	−1.22	−0.66**	−2.21	−0.38	−1.29
Log travel time in minutes	0.02	0.10						
Log road distance to the nearest large city			0.01	0.03				
Log road distance to the nearest neighbour					−0.42**	−2.01		
Av. snow depth of the nearest weather station (time means subtracted)							0.01	1.18
Regional dummy variables	yes		yes		yes		yes	
# of failures	52		52		52		52	
# of observations	244		244		244		244	
Failure risk for the permanent shutdowns								
Introd. of snowmaking mach. 1994 or earlier	−2.59**	−2.51	−2.52**	−2.46	−2.72**	−2.47	−2.66**	−2.10
Introd. of snowmaking machines 1995–2000	−1.57**	−2.42	−1.55**	−2.40	−1.25	−1.55	−1.53**	−2.33
Introd. of fast lifts 1995 or earlier	−0.09	−0.04	−0.32	−0.15	−0.59	−0.29	−0.64	−0.29
Log length of slopes in km	−2.71***	−3.04	−2.59***	−2.98	−1.88**	−2.11	−2.35***	−3.14
Av. elevation 1100–1299 m (ref. cat <1100 m)	−0.01	−0.01	0.07	0.09	−0.57	−0.83	0.06	0.08
Average elevation 1300–1449 m	0.13	0.12	0.16	0.14	−0.42	−0.40	0.05	0.05
Average elevation 1450–1699 m	0.96	0.91	0.99	0.98	−0.09	−0.07	0.81	0.91
Average elevation ≥1700 m	−2.09***	−3.10	−2.08***	−2.83	−2.26***	−3.47	−2.14**	−2.25
Real growth rate of GDP in percent	−1.47***	−5.52	−1.44***	−5.41	−1.32***	−5.29	−1.32***	−4.67
Ratio of number of tourist beds to length of slopes in 1994	−0.99*	−1.85	−0.98*	−1.86	−1.08**	−2.23	−0.88*	−1.88
Log travel time in minutes	−0.65*	−1.78						
Log road distance to the nearest large city			−0.39	−1.23				
Log road distance to the nearest neighbour					−0.69**	−2.20		
Av. snow depth of the nearest weather station (time means subtracted)							0.00	0.25
Regional dummy variables	yes		yes		yes		yes	
# of failures	23		23		23		23	
# of observations	244		244		244		244	

Notes: Estimation from the Cox proportional hazard model for permanent exits. The dependent variable is years of operation from 1995 onwards. *, **and *** 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 6
List of weather stations used to calculate variations in snow depth.

Weather station	Sea level in metres
Langen/Arlberg	1270 m
Latschau/Tschagguns	1006 m
Schoppernau	835 m
Warth	1475 m
Achenkirch	905 m
Ehrwald	1030 m
Galtür	1587 m
Kitzbühel	763 m
Nauders	1360 m
Obergurgl	1938 m
Patscherkofel	2247 m
Reutte	850 m
Seefeld	1182 m
St.Anton/Arlberg	1298 m
St.Leonhard/Neurur	1462 m
Badgastein/Böckst.	1100 m
Enzingerboden	1480 m
Krimml	1009 m
Mariapfarr	1153 m
Mooserboden	2036 m
Radstadt	858 m
Rauris	931 m
Saalbach	1022 m
St.Michael/Lungau	1049 m
Zell am See	766 m
Feuerkogel	1618 m
Krippenstein	2050 m
Hirschenkogel	1318 m
Hohe Wand/Hochkogel.	941 m
Lilienfeld/Tarschb.	681 m
Mönichkirchen	991 m
Rax/Seilbahn	1547 m
Aflenz	784 m
Bad Aussee	665 m
Bad Mitterndorf	808 m
Murau	916 m
Rohrmoos	1080 m
Ramsau	1210 m
Gröbming	766 m
Oberwölz	810 m
Stolzalpe	1305 m
Döllach	1010 m
Flattnitz	1438 m
Iselsberg	1196 m
Kanzelhöhe	1526 m
Mallnitz	1196 m
Villacher Alpe	2140 m
Weißensee	945 m
Kals	1336 m
Sillian	1075 m
St.Jakob/Def.	1400 m

Source: ZAMG.

References

Abegg, B., Agrawala, S., Crick, F., & Montfalcon, A. (2007). Climate change impacts and adaptation in winter tourism. In S. Agrawala (Ed.), *Climate change in the European Alps: Adapting winter tourism and natural hazards management* (pp. 25–61). Paris: OECD.

Agarwal, R. (1996). Technological activity and survival of firms. *Economics Letters, 52*, 101–108.

Agarwal, R., & Audretsch, D. B. (2001). Does entry size matter? The impact of the life cycle and technology on firm survival. *Journal of Industrial Economics, 49*, 21–42.

Agarwal, R., & Gort, M. (1996). The evolution of markets and entry, exit and survival of firms. *Review of Economics and Statistics, 78*(3), 489–498.

Agrawala, S. (Ed.), (2007). *Climate change in the European Alps: Adapting winter tourism, and natural hazards management*. Paris, France: OECD.

Audretsch, D. B., Santarelli, E., & Vivarelli, M. (1999). Start-up size and industrial dynamics: some evidence from Italian manufacturing. *International Journal of Industrial Organization, 17*, 965–983.

Auer, I., Böhm, R., Jurkovic, A., Lipa, W., Orlik, A., Potzmann, R., et al. (2007). HISTALP—historical instrumental climatological surface time series of the Greater Alpine Region 1760–2003. *International Journal of Climatology, 27*, 17–46.

Bank, M., & Wiesner, R. (2011). Determinants of weather derivatives usage in the Austrian winter tourism industry. *Tourism Management, 32*(1), 62–68.

Becerra, M., Santaló, J., & Silva, R. (2013). Being better vs. being different: differentiation, competition, and pricing strategies in the Spanish hotel industry. *Tourism Management, 34*, 71–79.

Bhattacharjee, A., Higson, C., Holly, S., & Kattuman, P. (2009). Macroeconomic instability and business exit: determinants of failures and acquisitions of UK firms. *Economica, 76*(301), 108–131.

Camisón, C., & Monfort-Mir, V. M. (2012). Measuring innovation in tourism from the Schumpeterian and the dynamic capabilities perspectives. *Tourism Management, 33*(4), 776–789.

Caves, R. E. (1998). Industrial organization and new findings on the turnover and mobility of firms. *Journal of Economic Literature, 36*, 1947–1982.

Cefis, E., & Marsili, O. (2005). A matter of life and death: innovation and firm survival. *Industrial and Corporate Change, 14*(6), 1167–1192.

Cefis, E., & Marsili, O. (2006). Survivor: the role of innovation in firms' survival. *Research Policy, 35*, 626–641.

Chung, W., & Kalnins, A. (2001). Agglomeration effects and performance: a test of the Texas lodging industry. *Strategic Management Journal, 22*, 969–988.

Cox, D. R. (1972). Regression models and life tables. *Journal of the Royal Statistical Society, 34*, 187–220.

Doms, M., Dunne, T., & Roberts, M. J. (1995). The role of technology use in the survival and growth of manufacturing plants. *International Journal of Industrial Organization, 13*(4), 523–542.

Everett, J., & Watson, J. (1998). Small business failure and external risk factors. *Small Business Economics, 5*(3), 271–285.

Falk, M. (2010). A dynamic panel data analysis of snow depth and winter tourism. *Tourism Management, 31*(6), 912–924.

Fariñas, J. C., & Ruano, S. (2005). Firm productivity, heterogeneity, sunk costs and market selection. *International Journal of Industrial Organization, 23*(7/8), 505–534.

Fine, J. P., & Gray, R. J. (1999). A proportional hazards model for the subdistribution of a competing risk. *Journal of the American Statistical Association, 94*(446), 496–509.

Fontana, R., & Nesta, L. (2009). Product innovation and survival in a high-tech industry. *Review of Industrial Organization, 34*, 287–306.

Gu, Z. (2002). Analyzing bankruptcy in the restaurant industry: a multiple discriminant model. *International Journal of Hospitality Management, 21*(1), 25–42.

Gu, Z., & Gao, L. (2000). A multivariate model for predicting business failures of hospitality firms. *Tourism and Hospitality Research, 2*(1), 37–49.

Hall, C. M., & Williams, A. M. (2008). *Tourism and innovation*. London: Routledge.

Hamilton, L. C., Rohall, D. E., Brown, B. C., Hayward, G. F., & Keim, B. D. (2003). Warming winters and New Hampshire's lost ski areas: an integrated case study. *International Journal of Sociology and Social Policy, 23*(10), 52–73.

Harhoff, D., Stahl, K., & Woywode, M. (1998). Legal form, growth and exit of west German firms – empirical results for manufacturing, construction, trade and service industries. *Journal of Industrial Economics, 46*(4), 453–488.

Helmers, C., & Rogers, M. (2010). Innovation and the survival of new firms in the UK. *Review of Industrial Organization, 36*(3), 227–248.

Hill, M., Wallner, A., & Furtado, J. (2010). Reducing vulnerability to climate change in the Swiss Alps: a study on adaptive planning. *Climate Policy, 10*, 70–86.

Hjalager, A.-M. (2010). A review of innovation research in tourism. *Tourism Management, 31*, 1–12.

Hudson, S. (2004). Winter sport tourism in North America. In B. Ritchie, & D. Adair (Eds.), *Sport tourism. Interrelationships, impacts and issues* (pp. 77–100). Clevedon, England: Channel View Books.

Jovanovic, B. (1982). Selection and the evolution of industry. *Econometrica, 50*(3), 649–670.

Kaniovski, S., Peneder, M., & Smeral, E. (2008). Determinants of firm survival in the Australian accommodation sector. *Tourism Economics, 14*(3), 527–543.

Kim, H., & Gu, Z. (2010). Predict US restaurant firm failures: the artificial neural network model versus logistic regression model. *Tourism and Hospitality Research, 10*, 171–187.

Klepper, S. (1996). Entry, exit, growth, and innovation over the product life cycle. *American Economic Review, 86*, 562–583.

Klepper, S. (2002). Firm survival and the evolution of oligopoly. *RAND Journal of Economics, 33*(1), 37–61.

Kureha, M. (2008). Changing ski tourism in Japan: from mass tourism to ecotourism? *Global Environmental Research, 12*, 137–143.

Manjón-Antolín, M., & Arauzo-Carod, J.-M. (2008). Firm survival: methods and evidence. *Empirica, 35*(1), 1–24.

Park, S.-S., & Hancer, M. (2012). A comparative study of logit and artificial neural networks in predicting bankruptcy in the hospitality industry. *Tourism Economics, 28*, 311–338.

Pickering, C. M. (2011). Changes in demand for tourism with climate change: a case study of visitation patterns to six ski resorts in Australia. *Journal of Sustainable Tourism, 19*, 767–781.

Porter, M. E. (1990). *The competitive advantage of nations*. London: MacMillan.

Porter, M. E. (1998). Clusters and the new economics of competition. *Harvard Business Review, 76*(6), 77–90.

Porter, M. E. (2000). Location, competition, and economic development: local clusters in a global economy. *Economic Development Quarterly, 14*(1), 15–34.
Rogers, E. M. (1995). *Diffusion of innovation* (4th ed.). New York: The Free Press.
Saarinen, J., & Tervo, K. (2007). Perceptions and adaptation strategies of the tourism industry to climate change: the case of Finnish nature-based tourism entrepreneurs. *International Journal of Innovation and Sustainable Development, 1*, 214–228.
Salvanes, K. G., & Tveterås, R. (2004). Plant exit, vintage capital and the business cycle. *Journal of Industrial Economics, 52*(2), 255–276.
Santarelli, E. (1998). Start-up size and post-entry performance: the case of tourism services in Italy. *Applied Economics, 30*, 157–163.
Scaglione, M., Schegg, R., & Murphy, J. (2009). Website adoption and sales performance in Valais' hospitality industry. *Technovation, 29*(9), 625–631.
Schmidt, K. (1997). Managerial incentives and product market competition. *Review of Economic Studies, 64*, 191–213.
Schöner, W., Auer, I., & Böhm, R. (2009). Long term trend of snow depth at Sonnblick (Austrian Alps) and its relation to climate change. *Hydrological Processes, 23*, 1052–1063.
Sinha, R. V., & Noble, S. H. (2008). The adoption of radical manufacturing technologies and firm survival. *Strategic Management Journal, 29*(9), 943–962.
Steiger, R. (2011). The impact of snow scarcity on ski tourism. An analysis of the record warm season 2006/07 in Tyrol (Austria). *Tourism Review, 66*, 4–13.
Taylor, M., Yang, X., & Strom, R. (2007). *The ski resorts industry in the twenty-first century's first decade a world-wide competition between continents, countries, and regions*. North American Case Research Association 2007 annual meeting, 18–20 October, Keystone, USA.
Töglhofer, C., Eigner, F., & Prettenthaler, F. (2011). Impacts of snow conditions on tourism demand in Austrian ski areas. *Climate Research, 46*, 1–14.
Wolfsegger, C., Gössling, S., & Scott, D. (2008). Climate change risk appraisal in the Austrian ski industry. *Tourism Review International, 12*(1), 13–23.

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