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Are Multi-resort Ski Conglomerates More Efficient?

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This paper compares the efficiency of large ski resort conglomerates with independent ski resorts using data on four countries (Canada, France, United States, Switzerland). Using the stochastic frontier production approach, I find that ski resorts that are owned and managed by the Intrawest group are significantly more efficient than independent ski resorts. The efficiency gap is about nine percentage points on average. The remaining ski resort conglomerates (American Skiing, Vail Resorts Inc., and Compagnie des Alpes SA) do not operate more efficiently than independent ski resorts. Copyright © 2009 John Wiley & Sons, Ltd.

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1. INTRODUCTION

In the last two decades there has been a wave of consolidations via mergers and acquisitions among ski lift operators. In Europe, the changes began in 1989 when Compagnie des Alpes (CDA) was founded. Recently, there have been other takeovers in France (e.g. CDA's acquisition of Sofival). In North America the ski market is dominated by three large ski conglomerates (see Hudson, 2004; Gill and Williams, 2005). For instance, the Intrawest group, founded in 1976 as a real estate company, moved into the ski lift operator industry in the late 1980s and now dominates the market in some parts of North America. Vail Resorts Inc. is another ski resort conglomerate and was founded in 1996. Finally, American Skiing is a ski conglomerate comprising eight resorts in the eastern United States. This shows that the market for ski lift operators has transformed from independent resorts, including family-owned businesses and ski resorts that are owned by a municipality, into ski resort conglomerates that are often publicly traded on stock exchanges. One reason for the increased concentration among ski lift operators is climate change. Indeed, three low-snow winters in the late 1980s forced managers of ski lift companies to look for ways to become more productive, such as by increasing merger and acquisition activities.

There are several reasons why large ski conglomerates might have a greater level of efficiency than independent resorts. One reason is that ski resort conglomerates have better access to financial and marketing resources (OECD, 2007). It is obvious that publicly traded companies have better access to equity markets and thus to financial resources for new equipment. Flagestad and Hope (2001) suggest that North American ski conglomerates have lower transaction costs in the form of savings in marketing, information, reservations, etc., and are thus more efficient (referred to as the 'corporate model'). In contrast, in the Austrian and Swiss Alps the single independent ski operator with multiple owners and little ownership concentration is the

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predominant type of ownership. This model is referred to as the 'community model' by Flagstad and Hope (2007).

Given the increasing concentration, it is natural to ask whether large enterprise groups are more efficient than independent ski resorts. The stochastic frontier production function developed by Aigner *et al*. (1977) and Meusen and Van den Broeck (1977) seems appropriate for assessing the technical efficiency of ski lift operators.

Despite the widespread use of the production frontier approach to assess the efficiency of firms, there are no studies on ski lift operators (see Anderson *et al*., 1999; Barros, 2005; or Chen, 2007 for an efficiency analysis of the hotel industry; Bishop and Brand, 2003 for museums; Kerstens, 1996 for urban transit companies, or Kern and Süssmuth, 2005 for an efficiency analysis of coaches in German football). The lack of technical efficiency studies can be largely attributed to the lack of data. Therefore, to the best of our knowledge this is the first paper that provides empirical evidence on this relevant topic. In particular, using the stochastic frontier framework, I investigate whether enterprise groups are more efficient than independent ski lift operators. The data is based on a sample of ski resorts in four countries. The results suggest that large enterprise groups are in general no more efficient than independent ski resorts. Ski resorts owned by the Intrawest group prove to be an exception. Furthermore, I find that ski resorts in North America and France are more efficient on average than those in Switzerland.

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. EMPIRICAL MODEL

2.1. Stochastic Frontier Function

In order to investigate the technical efficiency of ski resorts, I use the stochastic frontier production approach (for surveys on the methodology see Coelli *et al*., 1998; Kumbhakar and Lovell, 2000; Murillo-Zamorano, 2004). In the following step, I investigate the differences in efficiency between multi-resort ski conglomerates and independent ski resorts. There are two approaches to estimating the determinants of inefficiency. The first approach is the two-step procedure, where the stochastic production frontier is first estimated and then the technical efficiency of each firm is calculated. In the second step the technical efficiency scores are regressed against a set of exogeneous variables, which may influence the firms' efficiency. However, it is well known that the two-stage procedure is inconsistent because in the first stage the inefficiencies are assumed to be independently and identically half-normally distributed (iid), while in the second stage the estimated inefficiencies are assumed to be a normally distributed and a function of a number of firm-specific factors (Coelli *et al*., 1998; Wang and Schmidt, 2002). Therefore, the coefficients of the efficiency determinants in the second stage are biased. Another problem with the second stage is that the technical efficiency scores are bounded between 0 and 1, making OLS inappropriate (Dawson and Dobson, 2002).

A number of authors suggest estimating the stochastic frontier production function and the determinants of inefficiency simultaneously (see Kumbhakar *et al*., 1991; Reifschneider and Stevenson, 1991; Battese and Coelli, 1995; Stevenson, 1980). In this study, I use the stochastic frontier production function and inefficiency model for the cross-section case developed by Battese and Coelli (1995). The stochastic frontier production function and the inefficiency model can be described as follows:

$$\ln Y_i = \sum_{j=1}^{J} \alpha_j \ln X_{ij} + \sum_{j=1}^{J} \beta_j Z_{1ij} + v_i - u_i, \qquad (1)$$

$$u_i \sim N^+(\mu, \sigma_u^2) \quad \text{and} \quad v_i \sim iidN(0, \sigma_v^2), \qquad (2)$$

$$\mu_i = \delta_{o,i} + \sum_{n=1}^{N} \delta_{n,i} Z_{2n,i}. \qquad (3)$$

Subcript i refers to the ski resort, ln represents the natural logarithm, Y represents output, and the X's are input variables including land (i.e. length of slopes) and equipment (i.e. lift capacity). Z_1 are quality factors of production, such as quality of lifts and snowmaking capacity. The α's and β's are parameters to be estimated. The variable v_i is the error term that is assumed to be independently and identically distributed with $N \times (0, \sigma_v^2)$ and independent of u_i. The remaining part

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of the error term, u_i, is a non-negative random variable capturing technical efficiency, which is assumed to be independently and identically distributed and truncated at zero with mean μ_i and variance σ_u^2. ML estimation provides the parameter estimates and the variance parameters σ_u^2, σ_v^2 and $\lambda = \sigma_u^2/\sigma^2$. Following Battese and Coelli (1995), it is further assumed that the technical inefficiency distribution, μ_i, is a function of explanatory variables, Z_2, with the corresponding coefficients δ (see equation 3).

Once the stochastic frontier model has been estimated, the estimated technical efficiency index, defined as the ratio of observed output to the corresponding frontier output, is given by

$$TE_i = \exp(-\hat{u}_i).$$

2.2. Empirical Specification

Given the findings in the literature and the data availability, the stochastic production function model is modelled as follows:

$$\begin{aligned} \ln\ Y_i = \alpha + \beta_1 \ln KM_i + \beta_2 \ln SVTMH_i \\ + \beta_3 QUALITY_i + \beta_4 DAYS_i \\ + \beta_5 SNOWMAKE_i + v_i - u_i, \end{aligned}$$

where ln is the natural log, i denotes the ski resort, v_i is the two-sided error term and u_i is non-negative technical inefficiency component. The variables are as follows:

Y	Number of skier days in the 2005/2006 winter season,
KM	Total length of slopes in kilometres,
$SVTMH$	Total vertical lift capacity in persons per hour, measured as the sum of vertical transport metres per hour of each lift,[1]
$QUALITY$	Share of fast lifts (e.g. detachable chairlifts, modern gondola ropeways, or MGDs and funitel systems) in total transport capacity (i.e. vertical transport metres),
$DAYS$	Days of operation in the 2005–2006 winter season,
$SNOWMAKE$	Share of ski runs on artificial snow.

The dependent variable is the natural logarithm of the number of skier visits (i.e. one day or part of a day of skiing for one skier). Following Battese and Coelli (1995), it is further assumed that the parameter μ is a function of various ski resort-specific variables. In particular, the second equation of the simultaneous model consists of the inefficiency model, specified as

$$\begin{aligned} \mu_i = \delta_0 + \sum_{j=1}^{J} \delta_{co,j} COUNTRY_i \\ + \sum_{k=1}^{K} \delta_{gr,k} CONGLOMERATE_{ik} \\ + \beta_1 \ln\ DIST_i + \beta_2 \ln\ AGE_i + e_i, \end{aligned}$$

where $COUNTRY$ denotes the country dummy variables, $CONGLOMERATE$ indicates that the ski resorts are owned by a multi-resort conglomerate ski corporation, $DIST$ denotes distance to the nearest international airport, and AGE the age of the ski resort. The null hypothesis is that ski conglomerates and independent ski lift operators have the same level of efficiency.

As specified in the literature (e.g. Echelberger and Shafer, 1970; Berwert *et al*., 1996; Mulligan and Llineares, 2003), I use several indicators of ski resort quality for this study. First, I include the size of the ski resort, measured as the total length (in kilometres) of ski runs, including ski routes. Second, I use lift capacity as a proxy for equipment. Note that lift capacity (measured in passengers per hour) is adjusted by vertical distance. For each ski lift I multiply lift capacity in passengers/skiers per hour, CAP, by vertical distance in metres, VM

$$VTMH = \frac{CAP \times VM}{1000}.$$

This measures the number of persons that can be transported uphill at approximately 1000 m/h. For each ski resort I calculate the sum of vertical transport metres per hour (SVTMH)

$$SVTMH = \sum_{j=1}^{J} VTMH_j,$$

where j denotes the ski lift, regardless of type (i.e. surface lifts, fixed and detachable chairlifts, aerial tramways, gondola ropeways such as MGDs, and funitel systems).

Besides lift capacity, the quality of lift facilities may also have an impact on efficiency. Quality of transport capacity is measured as a share of vertical transport metres per hour of modern

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high-speed lifts and cable cars divided by total vertical transport metres per hour. This category of ski lifts includes fast and detachable chairlifts, modern gondola ropeways (e.g. monocable gondola detachables, or MGDs), and funitel systems but excludes surface lifts, fixed-grip chairlifts and aerial tramways. Note that the share of fast chairlifts and modern cable cars in lift capacity is not transformed into logarithms since the variable includes a number of observations with zero values. Alternatively, for each ski resort I calculate the weighted average age of the chairlifts and cable cars, where the weights are the share of each lift in the total lift capacity (measured as vertical transport metres per hour).

Besides age of technology or equipment, firm age may also affect productivity. It is often hypothesised that the longer a firm has been in operation, the more productive it will become. This effect is often referred to as the 'learning by doing' or 'learning curve' effect (Bahk and Gort, 1993). Resort age can be measured in an inverse manner based on the date the resort opened.

Snow is the most essential input factor for skiing. In principle, one can use average slope height as a proxy for snow conditions because snow lasts longer at high altitudes. However, due to differences in latitude between ski resorts in the United States and in the Alps, altitude cannot be employed as a measure of snow conditions. Therefore, I employ snowmaking capacity, measured by the percentage of ski runs with artificial snow. Furthermore, I use the (planned) duration of the ski season, measured as the number of ski days in operation in the 2005–2006 season, as an indicator of snow cover. One can assume that a longer ski season reflects good snow cover.

Proximity to population centres may also affect output (Mulligan and Llineares, 2003). Output is expected to decrease with the distance of the ski resort from where skiers live or stay. In order to account for proximity to population centres, I include the distance to the nearest international airport (e.g. Innsbruck, Salzburg, Munich, Geneva, Denver etc.) as a proxy.

Note that I do not include a measure for labour input in the production function. The main reason is that employment data is only available for a small number of ski resorts. My own calculations for select ski resort operators, based on balance sheet data drawn from the AMADEUS database, suggests that ski lift operators are one of most capital-intensive industries, with labour shares ranging between 20 and 30%.

3. DATA AND DESCRIPTIVE STATISTICS

For this study I collected data for ski resorts in four countries, namely Canada, France, Switzerland, and the United States (see Table A5 in Appendix for a list of included ski resorts). The selected ski resorts are representative of each country, with shares in the total number of skier visits of 60% in Switzerland, 80% in France, and 40% in the United States. The data comes from a number of sources. Lift capacity and elevation, as well as the measured quality of ski lifts, are calculated based on national ski lift databases (see Table A1 in the Appendix for a description of the data sources). Generally, the lift databases are very detailed, including information on mountain lift capacity in persons per hour, elevation in metres, year of installation, and altitude of the highest lift station. Mountain lift systems include detachable chairlifts (for two, four, six, or eight passengers, with lift capacity of up to 4000 persons per hour), fixed-grip chairlifts (for one, two, four, and six passengers), funitel systems (up to 4000 persons per hour), MGD gondola lifts (with lift capacity of up to 3600 persons per hour), as well as aerial ropeways and surface lifts, such as T-bars (with lift capacity of up to 1400 persons). Information on output (number of skier visits) was obtained from national sources.

Descriptive statistics are found in Tables A2–A4 in the Appendix. Table A2 reports the mean, median, standard deviation, and minimum and maximum values. The ski resorts show considerable heterogeneity in terms of size, quality characteristics, distance, and resort age. The number of skier visits range between 115 106 and 2.51 million, with an average of 693 517. The average length of ski runs is 1156 km. Vertical transport metres per hour ranges between 1635 and 30 881, with an average of 11 525. This indicates that 11 525 skiers can be transported up a mountain with an elevation of about 1000 m every hour. The mean length of the ski season is 149 days. The share of high-speed (detachable) chairlifts and modern gondola lifts in total lift capacity is 53% on average. On average, snowmaking facilities are in place on 23% of the runs. The average age of the resort (measured starting from the installation of the first lift) is 47 years.

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Table 1. ML Estimates of Stochastic Production Frontier and Technical Inefficiency

	Specification 1		Specification 2		Specification 3	
	Coeff	*z*-Value	Coeff	*z*-Value	Coeff	*z*-Value
Stochastic production frontier function						
ln length of ski runs in km	0.211**	2.46	0.214**	2.48	0.210**	2.54
ln vertical transport metres per hour	0.531***	6.83	0.483***	6.10	0.421***	5.23
ln days of operation	0.171	0.83	0.231	1.11	0.417**	2.02
Share of fast lifts in %	0.781***	4.07	0.615***	3.05	0.621***	2.96
Share of slopes with snowmaking facilities in %	0.589***	2.57	0.461*	1.87	0.412*	1.78
Constant	6.389***	5.94	6.873***	6.08	6.498***	5.82
Technical inefficiency model						
ln distance from nearest international airport	0.608	1.24	0.280**	2.28	0.115	1.15
ln age of resort	−0.255	−0.59	−0.216	−1.04	−0.419*	−1.80
Dummy variable for conglomerate ski resort operator companies (ref. independent ski resorts)						
American Skiing Corp.			0.175	0.78	0.263	1.16
CDA			−0.211	−1.11	−0.210	−1.19
Intrawest Corp.			−0.778*	−1.93	−0.682*	−1.73
Vail Resorts, Inc.			−0.572	−1.32	−0.557	−1.29
Country dummy variables (reference category: Switzerland)						
France					−0.448***	−2.68
North America					−0.353**	−2.49
Constant	−2.022	−0.71	0.114	0.13	1.917**	1.99
σ^2	0.305	1.57	0.163***	3.78	0.139***	4.43
$\lambda = \sigma_u^2/\sigma^2$	0.764***	4.64	0.747***	4.57	0.654***	2.72
σ_u^2	0.233	1.20	0.122***	2.70	0.091**	2.15
σ_v^2	0.072***	2.84	0.041***	1.53	0.048	1.45
LR-test chi^2 statistics	6.1		20.2		35.9	
Elasticity share of fast lifts	0.41***		0.32***		0.33***	
Elasticity share of slopes with snowmaking facilities	0.14***		0.11*		0.10*	

Notes: ***,** and * denote significant at the 1, 5 and 10% level, respectively. The parameters in the inefficiency model are the coefficients and cannot be interpreted as marginal effects. The dependent variable is the logarithm of number of skier days.

Of the 119 ski resorts, 30 are owned by a large enterprise group. I identify four large enterprise groups, namely Intrawest, CDA SA, Vail Resorts, Inc., and American Skiing Company. All have been or still are listed on their respective national stock exchange and consist of three or more legally defined enterprises under common ownership. Sovial in France is not treated as an enterprise group because only two resorts in France are part of this group; the Sovial group was also recently acquired by CDA SA. For similar reasons, I do not investigate the efficiency of the ski resorts that are part of Booth Creek Ski Holdings, Inc.

On average ski resorts that are part of a large enterprise group are generally larger in terms of lift capacity than others. Similarly, ski resorts belonging to large enterprise groups have a higher share of fast lifts, and a higher snowmaking capacity (see Table A3 in the Appendix). Table A4 in the Appendix shows that the means of the variables differ across countries. Both the average length of slopes and transport capacity of the resorts are higher in France than those of the remaining countries.

4. ESTIMATION RESULTS

The ML estimates of the stochastic production frontier model and technical inefficiency model are reported in Table 1.[2] I provide three different specifications. Column 3 includes the most general specification, including country dummy variables for France and North America (with Switzerland as the reference group) and dummy variables indicating whether the ski resort is part of one of the four multi-resort ski conglomerates, as well as distance from the nearest international airport and age of the ski resort. Column 2 includes the same variables except country dummy variables, and column 1 excludes both country and ownership dummy variables. The LR tests indicate that the null hypothesis—that the technical inefficiency effects are not present—is rejected at the 1% level based on the critical values provided by Kodde and Palm (1986). In addition, the estimated value of the ratio of the inefficiency component's standard deviation to the standard deviation of the idiosyncratic component is statistically different from zero.

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In the stochastic frontier production function all coefficients of the input factors have the correct sign and are significant at the 5% level in most of the cases. However, snowmaking capacity is only significant at the 10% level. The elasticity of output with respect to capacity of the mountain lift systems (measured in vertical transport metres) is 0.42 in the preferred specification (iii). Total length of ski runs is less important, as indicated by the elasticity of 0.20. The magnitude of the output semi-elasticity of the share of fast lifts (measured as the share of high-speed chairlifts and modern cable cars in total lift capacity) is about 0.63. This coefficient translates into an elasticity of 0.33 ($=0.63*0.53$). The magnitude of the output elasticity of snowmaking capacity is about 0.10.

Table 1 also includes the parameters for the inefficiency equation.[3] I find a negative sign for Intrawest, CDA, and Vail Resorts, Inc., indicating that ski resorts that are owned and managed by an enterprise group seem to operate more efficiently than independent ski resorts. In contrast, resorts that are owned by American Skiing are on average less efficient than independent ski resorts. However, the coefficient sign is only significant for the ski resorts that are part of the Intrawest group. Therefore, one can find little evidence supporting the hypothesis that large ski conglomerates perform better than independent resorts. Specification 3 also includes country dummy variables for Swiss and North American ski resorts. The coefficients for both dummy variables are negative and significant at the 5% level indicating that French and North American ski resorts are more efficient than Swiss ski resorts. Regarding the other control variables, I find that distance from the nearest international airport is positive and significant, indicating that inefficiency is an increasing function of distance. However, the coefficient is no longer significant when country dummy variables are included. Figure 1 in the Appendix shows the distribution of the technical efficiency scores for the sample ski lift operator companies based on the first specification. The estimated technical efficiency scores range between 0.30 and 0.92, with a mean efficiency level of 0.75.

Table 2 reports the efficiency levels for the different enterprise groups. The mean technical efficiency for the ski resorts that are owned and managed by American Skiing, CDA, Intrawest, and Vail Resorts, Inc. are 0.62, 0.74, 0.80, and 0.78, respectively. The mean efficiency level of the independent ski resorts is 0.71. In order to test whether the mean differences in the technical efficiency scores between ski resorts that are managed and owned by a large enterprise groups and independent ski resorts are significant, I apply *t*-tests. The results of the *t*-tests show that Intrawest ski resorts operate significantly more efficiently than independent ski resorts. In other words, the hypothesis that the mean of both groups is statistically equal can be rejected. On average, ski resorts of the Intrawest group have a level of technical efficiency nine percentage points higher than that of independent ski resorts. For the remaining ski resort conglomerates, I cannot reject the null hypothesis that the true mean efficiency levels are identical for independent ski resorts and conglomerates at the 5% level. Looking at the differences in mean technical efficiency across the countries, I find a significantly higher level of technical efficiency of ski resorts in North America and France compared with Swiss ski resorts.

In addition, I use the Wilcoxon–Mann–Whitney test to determine whether there is evidence of a difference in the median. The Wilcoxon–Mann–Whitney test is a non-parametric test and thus can be used when the dependent variable is not normally distributed, as is the case with the technical efficiency scores. The null hypothesis is whether the samples are the same (i.e. rank sums are the same). The results of the Wilcoxon–Mann–Whitney tests show that this null hypothesis is again rejected for the ski resorts owned by the Intrawest group. I also find that ski

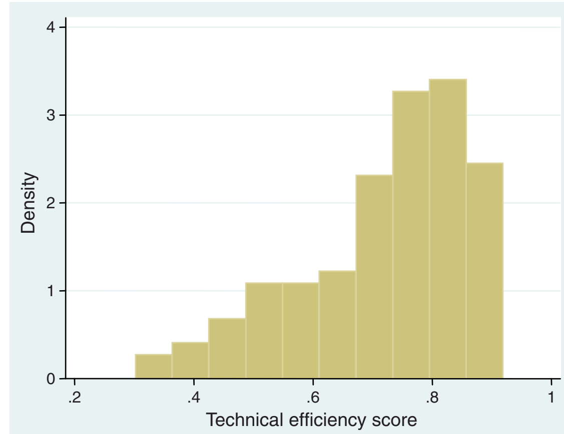

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Figure 1. Distribution of the technical efficiency scores. Notes: Technical efficiency scores are based on the specification (1) in Table 1.

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Table 2. Technical Efficiency Scores for the Full Sample and Various Subsamples

	# of obs	Technical efficiency score				t-Test		Wilcoxon–Mann–Whitney test	
		Median	Mean	Mean (control group)	Difference	t-Value	p-Value	z-Value	p-Value
Full sample	119	0.75	0.72						
All enterprise groups	30	0.79	0.74	0.71[a]	0.03	−0.90	0.37	1.33	0.18
American Skiing	10	0.64	0.62	0.71[a]	−0.09	−1.65	0.10	−1.98	0.05
CDA	9	0.81	0.74	0.71[a]	0.03	0.55	0.58	1.06	0.29
Intrawest	6	0.86	0.80	0.71[a]	0.08	1.77	0.08	2.31	0.02
Vail Resorts, Inc.	5	0.79	0.78	0.71[a]	0.07	1.08	0.28	1.13	0.26
Switzerland	33	0.65	0.63	0.75	−0.12	−4.49	0.00	−4.04	0.00
France	51	0.78	0.77	0.68	0.09	3.55	0.00	−3.17	0.00
North America	35	0.74	0.73	0.71	0.01	0.41	0.41	−0.53	0.60

[a]The control group consists of resorts that are not managed and owned by a large enterprise group. The technical efficiency scores are based on specification 1 in Table 1.

resorts that are owned and managed by American Skiing seem to be significantly less efficient.

5. CONCLUSIONS

This paper has analysed the efficiency of ski resorts in France, Switzerland, and North America for the 2005/2006 season. In particular, I compare the efficiency of ski resorts that are managed and owned by a large enterprise group with independent ski resorts. The empirical methodology is based on simultaneous estimation of the stochastic production function and the determinants of inefficiency. The results for the stochastic production frontier model indicate that output can be explained by length of ski runs, lift capacity (i.e. vertical transport metres per hour), share of fast lifts, snowmaking capacity, and length of season. Furthermore, the results for the determinants of the inefficiency model show that ski resorts owned and managed by Intrawest operate significantly more efficiently than independent ski resorts. This is also confirmed by the Wilcoxon non-parametric test for difference in the median of the two groups. On average, ski resorts of the Intrawest group have a 9% advantage in level of technical efficiency. Furthermore, I find that French and North American ski resorts are significantly more efficient than Swiss ski resorts.

One obvious limitation of this study, due to data constraints, is the use of cross-section data. With regard to future research, applying the stochastic frontier production model to panel data could thus produce promising results.

APPENDIX

A description of the data sources is given in Table A1. Descriptive statistics are given in Tables A2–A4. A list of included ski resorts is given in Table A5.

Table A1. Description of the Data Sources

Number of skier days	CH: Laurent Vanat F: ski magazines: Montagne Leaders No. 197. USA: Media Center Home: http://www.skilifts.org/; http://media-coloradoski.com/Home/
Total length of ski runs (km), terrain area in acres Percentage of slopes with artificial snowmaking facilities (%); (planned) length of ski season (days)	CA, CH, F, US: personnel correspondence, web sites of individual ski resorts, ski area brochures; ski guides 'Where to ski and snowboard' by Chris Gill and Dave Watts; ADAC Ski-Atlas 2005/2006, 'DSV-Atlas' 2005/2006 and 'Der Große Falk Ski Atlas Alpen' 2006; website www.bergfex.com.
Lift capacity measured as vertical transport metres in persons per hour divided by 1000 Share of detachable chairlifts, detachable cable cars and funitel systems (%) Weighted mean altitude of uphill lift stations (m)	CH: Swiss ministry of transport and regional development, F: Fichier Informatisé des appareils de Remontées Mécaniques, Ministère des Transports, de l'Equipement, du Tourisme et de la Mer. Available at the internet from: http://firm.application.equipement.gouv.fr/

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Table A1. *Continued*

	FirmInternetAction.do?choix = Init retrieved 5/2006 US: web site: www.skilifts.org Online Lift database www.remontees-mecaniques.fr; retrieved Ma 2006. CA, CH, F, and US: Online database for Alpine Ski resorts, Retrieved 4/2006.(http://www.lift-world.info/english.php)

Table A2. Descriptive Statistics (Winter 2005/2006)

	Mean	Median	Standard deviation	Minimum	Maximum
Number of skier visits	693 517	482 869	476 928	115 106	2 509 000
Length of runs in km	116	100	73	4	355
Vertical transport metres per hour divided (passengers per hour divided by 1000)	11 525	8 472	7 608	1 635	30 881
Days of operation	149	142	34	91	316
Share of fast lifts in%	52.6	53.6	19.1	0.0	91.1
Share of slopes with snowmaking facilities in%	23.4	16.7	24.3	0.0	100.0
Distance from nearest international airport in km	131.1	124.0	59.3	34.7	317.0
Age of resort in years	46.9	42.0	16.3	22	114

Table A3. Means for the Large Enterprise Groups

	American	CDA	Intrawest	Vail Resorts, Inc.
Number of skier visits	444 500	1 256 289	973 112	1 257 487
Length of runs in km	40	179	83	132
Vertical transport metres per hour divided (passengers per hour divided by 1000)	7925	21 850	11 200	14 258
Days of operation	170	165	145	150
Share of fast lifts in %	51.3	54.3	64.9	81.3
Share of slopes with snowmaking facilities in %	74.3	19.2	47.5	32.5
Distance from nearest international airport in km	137	135	151	123

Table A4. Means of the Variables Across Countries

	Switzerland (CH)	France (F)	United States (US)	Canada (CA)
Number of skier visits	526 348	799 013	663 470	901 052
Length of runs in km	122	137	79	86
Vertical transport metres per hour Divided (passengers per hour divided by 1000)	10 205	14 306	8248	11 543
Days of operation	159	139	149	174
Share of fast lifts in %	47.1	48.8	60.8	78.5
Share of slopes with snowmaking facilities in %	18.5	15.8	39.0	40.4
Distance from nearest international airport in km	162	100	148	145
Age of resort in years	54.0	48.1	38.7	40.2

Table A5. List of the Selected Ski Resorts

Country	Name	Country	Name	Country	Name
France	Alpe d'Huez	Switzerland	Adelboden-Lenk	USA	Alta
France	Avoriaz	Switzerland	Anzère	USA	Arapahoe Basin
France	Ax les Thermes	Switzerland	Arosa	USA	Aspen Highlands

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Table A5. *Continued*

Country	Name	Country	Name	Country	Name
France	Barèges-La Mongie/ Tourmalet	Switzerland	Blatten-Belalp	USA	Aspen Mountain
France	Cauterets	Switzerland	Brigels	USA	Attitash
France	Chamonix	Switzerland	Champéry-Les Croset (Les Portes du Soleil)	USA	Beaver Creek
France	Chamrousse	Switzerland	Crans-Montana	USA	Breckendrige
France	Châtel	Switzerland	Davos-Klosters	USA	Buttermilk Aspen
France	Combloux Jail La Giettaz	Switzerland	Engelberg-Titlis	USA	Copper Mountain
France	Courchevel	Switzerland	Flims-Laax	USA	Crested Butte
France	Flaine (Grand-Massif)	Switzerland	Flumserberg	USA	Heavenly
France	Font Rmeu Pyr 2000	Switzerland	Grächen	USA	Jackson Hole
France	Gourette	Switzerland	Grimentz (Val d'Anniviers)	USA	Keystone
France	Isola 2000	Switzerland	Gstaad-Region	USA	Killington
France	La Clusaz	Switzerland	Jungfrauregion	USA	Mammoth
France	La Plagne	Switzerland	Lenzerheide	USA	Mount Snow
France	La Rosiere	Switzerland	Leysin	USA	Mountain Creek
France	La Toussuire (LES SYBELLES)	Switzerland	Meiringen-Hasliberg	USA	Snowbasin
France	Le Corbier (st. D'Arves)	Switzerland	Morgins Les Portes du Soleil	USA	Snowbird
France	Le Grand Bornand	Switzerland	Nendaz, thyon 4-Vallées	USA	Snowmass
France	Les Angles	Switzerland	Ovronnaz	USA	Snowshoe
France	Les Arcs	Switzerland	Riederalp Bettmeralp Fiescheralp	USA	Solitude
France	Les Carroz d Arâches	Switzerland	Saas Fee	USA	Steamboat
France	Les Deux Alpes	Switzerland	Savognin	USA	Stratton Mountain
France	Les Gets-Morzine	Switzerland	Scuol	USA	Sugarloaf
France	Les Houches	Switzerland	Sedrun-Disentis	USA	Sunday River
France	Les Menuires st martin	Switzerland	St. Moritz	USA	Telluride
France	Les Orres	Switzerland	St-Luc Chandolin (Val d'Anniviers)	USA	The Canyons
France	Les Saisies	Switzerland	Verbier 4-Vallées	USA	Vail
France	Les Sept Laux	Switzerland	Villars-Gryon	USA	Winter Park
France	Megeve, Combleux Saint-Gervais/Saint-Nicolas /La Giettaz/ Cordon/ Les Contamines	Switzerland	Wiler-Lauchernalp	Canada	Blue Mountain
France	Méribel-Mottaret	Switzerland	Zermatt	Canada	Lake Louise
France	Montgenevre	Switzerland	Zinal	Canada	Mont Tremblant
France	Monts Jura Mijoux			Canada	Sunshine Village
France	Orcieres 1850			Canada	WhistlerBlackcomb
France	Peyragudes				
France	Puy Saint Vincent				
France	Risoul 1850 vars Crevoux				
France	Saint Lary Soulan				
France	Serre-Chevalier (SC 1350+SCSD)				
France	St. Francois longchamp				
France	Super besse (Le Mont-Dore)				
France	Superdevoluy La joue du Loup				
France	Tignes				
France	Val Cenis				
France	Val d Isère				
France	Val d'Allos				
France	Val Thorens				
France	Valloire-Valmeinier				
France	Valmorel la belle				
	Saint-François Longchamp				
France	Villard des Lans				

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NOTES

1. Ski lifts include t-bar and surface lifts, fixed and detachable chairlifts, aerial tramways, gondola ropeways such as MGDs, and funitel systems.
2. I use the software package FRONTIER 4.1 (Coelli, 1996) and STATA 10.2.
3. Note that the parameters cannot be interpreted as marginal effects (see Wang, 2002 for a calculation of the marginal effects).

REFERENCES

Aigner DJ, Lovell CAK, Schmidt P. 1977. Formulation and estimation of stochastic frontier production functions. *Journal of Econometrics* **6**: 21–37.

Anderson RI, Fish M, Xia Y, Michello F. 1999. Measuring efficiency in the hotel industry: a stochastic frontier approach. *International Journal of Hospitality Management* **18**: 45–57.

Bahk B–H, Gort M. 1993. Decomposing learning by doing in new plants. *Journal of Political Economy* **101**: 561–583.

Barros CP. 2005. Measuring efficiency in the hotel sector. *Annals of Tourism Research* **32**: 456–477.

Battese GE, Coelli TJ. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* **20**: 325–332.

Berwert A, Bignasca F, Filippini P. 1996. Preise und Qualitätseigenschaften schweizerischer Skigebiete: Schätzungen mit dem hedonischen Preisansatz unter Berücksichtigung räumlicher Autokorrelation. *Jahrbuch für Regionalwissenschaften* **16–17**: 67–97.

Bishop P, Brand S. 2003. The efficiency of museums: a stochastic frontier production function approach. *Applied Economics* **35**: 1853–1858.

Chen C-F. 2007. Applying the stochastic frontier approach to measure hotel managerial efficiency in Taiwan. *Tourism Management* **28**: 696–702.

Coelli TJ, Rao DSP, Battese GE. 1998. *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers: USA.

Dawson P, Dobson S. 2002. Managerial efficiency and human capital: an application to English association football. *Managerial and Decision Economics* **23**: 471–486.

Echelberger HE, Shafer Jr. EL, 1970. Snow+(X) = use of ski slopes. *Journal of Marketing Research* **7**: 388–392.

Flagestad A, Hope CA. 2001. Strategic success in winter sports destinations: a sustainable value creation perspective. *Tourism Management* **22**: 445–461.

Gill AM, Williams PW. 2005. Corporate-community relations in the tourism sector: a stakeholder perspective. In *Rural Change and Sustainability: Agriculture, The Environment and Communities*, Gily A, Yarwood R, Essex S, Smithers J (eds). AQ3

Hudson S. 2004. Winter sport tourism in North America. In *Sport Tourism: Interrelationships, Impacts and Issues, 77–100*, Ritchie B, Adair D (eds). Multilingual Matters: Clevedon, NY.

Kern MB, Süssmuth B. 2005. Managerial efficiency in German top league soccer: an econometric analysis of club performances on and off the pitch. *German Economic Review* **6**: 485–506, doi:10.1111/j.1468–0475.2005.00143.x.

Kerstens K. 1996. Technical efficiency measurement and explanation of French urban transit companies. *Transportation Research—A* **30**: 431–452.

Kodde DA, Palm FC. 1986, Wald criteria for jointly testing equality restrictions. *Econometrica* **54**: 1243–1248.

Kumbhakar SC, Ghosh S, McGuckin JT. 1991. A generalized production frontier approach for estimating determinants of inefficiency in U.S. dairy farms. *Journal of Business & Economic Statistics* **9**: 279–286.

Kumbhakar SC, Lovell CAK. 2000. *Stochastic Frontier Analysis*. Cambridge University Press: Cambridge.

Meeusen W, van den Broeck J. 1977. Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review* **18**: 435–444.

Murillo-Zamorano LR. 2004. Economic efficiency and frontier techniques. *Journal of Economic Surveys* **18**: 33–77.

Mulligan J, Llinares E. 2003. Market segmentation and the diffusion of quality enhancing innovations: the case of downhill skiing. *The Review of Economics and Statistics* **85**, 493–501.

Organisation for Economic Co-operation and Development OECD. 2007. *Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management*. OECD: Paris.

Reifschneider D, Stevenson R. 1991. Systematic departures from the frontier: a framework for the analysis of firm inefficiency. *International Economic Review* **32**: 715–723.

Stevenson RE. 1980. Likelihood functions for generalized stochastic frontier estimation. *Journal of Econometrics* **13**: 57–66.

Wang H. 2002. Heteroskedasticity and non-monotonic efficiency effects of a stochastic frontier model. *Journal of Productivity Analysis* **18**: 241–253.

Wang H-J, Schmidt P. 2002. One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis* **18**: 129–144.

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