# Adapting Ski Area Operations to a Warmer Climate in the Swiss Alps through Snowmaking Investments and Efficiency Improvements

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# Abstract

Economic consequences of climate change for the Swiss winter tourism have been assessed in two studies. Though estimates of the potential annual costs highly differ between them, they however agree on two points. On the one hand, winter tourism will be one of the most affected economic sectors. On the other hand, impacts of climate change on this sector will be very disruptive. In this context, adaptation strategies must play an important role in the Swiss winter tourism sector in order to alleviate these impacts. When thinking of technical adaptation measures, snowmaking facilities very often come to the fore. Hence, our first task in this thesis work was to picture the achieved level of investments towards this kind of facility. The umbrella organization of the cableway sector indicates that 42 $km^2$ (19% of the total slopes' area) which represents roughly 1400 km of ski slopes could already be snowed artificially in 2005. In the three most important Swiss ski regions (Valais, Grisons and Bern), we found that the percentage of the total slopes' area that could be snowed in 2005 was lying in the same range (i.e. from 18% to 22%).

With respect to the numerous investments that will probably be planned in the years to come, an important issue deals with the commitment of cantonal authorities in the adaptation process carried out by the ski area operation companies located on their territory. Are these commitments different from one canton to another and how could they evolve in the short and mid-term? What are the consequences of regional differences in the authorities' commitments for the companies' vulnerability towards climate change? Among the reviewed cantons, we found that Bern is clearly the canton where the investments are less dependent to the authorities' support. On the contrary, Fribourg, Vaud, Ticino and (to a lesser extent) Saint-Gall are the cantons in which ski area operation companies are most dependent on authorities' support for their snowmaking investments. Based on these results, it was however difficult to determine clear-cut consequences for the vulnerability of companies located in different regions. In addition, we found that companies with transport revenues ranging between 1 to 5 Mio CHF have constituted the core of the beneficiaries. While small companies are generally not eligible for large support towards snowmaking investments, the highest companies of the sector were only rarely recipient of authorities' support mainly because they did not need it to finance their investment. Despite the different forms and features of financial support provided in the different cantons, we have also derived a unique value for the financial support provided at the cantonal and federal levels towards snowmaking investments in Switzerland. This overall financial support (overall equivalent subsidy) has been estimated at 12.5 Mio CHF (state at the end of 2006).

After having analyzed to which extent public authorities have already supported snowmaking investments and verified under which conditions these facilities will continue to be supported in the future, a crucial question was then to determine whether snowmaking investments could actually reduce the potential costs of climate change. This question arises since snowmaking facilities implies large investment and operating costs. In order to answer this question, several statistical models of the ski area operation companies' operating results have been assessed. While such models were only estimated with the data concerning the 2003/04 and 2004/05 winter seasons, estimation results derived from them nonetheless prepare the ground for assessing more precisely the impacts of snowmaking investments under climate change. First, our results show that the partial effect of snowmaking investments on EBITDA is positive but tends to decrease for higher level of investments. Secondly, we were also able to show to which extent additional snowmaking investments could have potentially improved the financial situation of Swiss ski area operation companies. Under the conditions of the winter season 2003/04, 69.5% of the Swiss companies operating more than 15 kilometers of ski slopes would have increased their net income with a one kilometer increase in snowmaking facilities. Because we have tried to explain or predict the companies' EBITDA, variables other than those related to snowmaking investments were added in our statistical models. This feature has allowed us discussing ongoing issues such as the impacts of horizontal reconfiguration, modernization of the transport facilities and increase in the ski resorts' lodging capacity on the ski area operation companies' profitability.

Besides snowmaking facilities, we have also analyzed efficiency improvements of companies as another potential adaptation measure to climate change. For a sample of 20 valaisan companies, we have evaluated their performance using a DEA approach. However, few firms were rated as inefficient when making use of this approach. This result is mainly due to the limited number of companies included in our analysis. Indeed, gathering data was not an easy task for this research.

*Keywords*: Winter tourism sector; Ski area operation sector; Climate change; Vulnerability to climate change; Adaptation measures; Snowmaking facilities; Econometric models; Endogenous variables; Authorities' support; LIM law; Data Envelopment Analysis; Efficiency improvements.

# Résumé

Jusqu'à présent, les conséquences économiques potentielles des changements climatiques sur le secteur suisse du tourisme d'hiver ont été évaluées par deux études. Bien qu'elles fournissent des estimations fort différentes l'une de l'autre, elles se rejoignent néanmoins sur deux points essentiels. Ces deux études admettent en effet que le secteur du tourisme d'hiver sera l'un des secteurs économiques les plus durement touchés par les changements climatiques et qu'il subira en conséquence des bouleversements importants. Dès lors, on comprend l'importance et la nécessité pour ce secteur de s'adapter. A l'heure actuelle, le recours à la neige artificielle est la mesure d'adaptation la plus répandue dans le secteur des remontées mécaniques. Par conséquent, notre première tâche dans ce travail fut de dépeindre l'état actuel des investissements pour l'enneigement technique. Pour les trois régions de ski les plus importantes de Suisse (Valais, Grisons et Berne), nous avons trouvé que le pourcentage de la longueur totale des pistes qui pouvait être enneigée artificiellement en 2005 s'échelonnait de 18% à 22%.

La question de l'attitude des pouvoirs publics se pose face aux nombreux investissements dans l'enneigement artificiel qui seront très vraisemblablement planifiés dans les prochaines années. Dans la structure fédérale qui caractérise la Suisse, existe-t-il des différences notables entre cantons au niveau de l'aide aux investissements apportée aux sociétés de remontées mécaniques pour l'enneigement artificiel? Comment les politiques d'aide vont-elles évoluer ces prochaines années ? Quelles sont les conséquences des différences dans les politiques cantonales sur la vulnérabilité des sociétés de remontées mécaniques suisses face aux changements climatiques? Dans notre étude, nous avons pu constater que Berne est le canton où les investissements dans l'enneigement artificiel dépendent le moins de l'aide publique aux investissements. A l'opposé, les cantons de Fribourg, de Vaud, du Tessin et également de Saint-Gall (ce dernier dans une moindre mesure) sont les cantons où les investissements dans des installations d'enneigement artificiel dépendent jusqu'à maintenant le plus fortement de l'aide publique. Sur la base de ces seuls éléments, il est toutefois difficile de déterminer clairement si la vulnérabilité des entreprises de ces régions va réellement diminuer du fait d'un soutien apparemment plus fort des pouvoirs publics. Ce que nous avons pu également montrer dans notre analyse, c'est le fait que l'aide publique a surtout profité aux entreprises dont les revenus de transport se situent entre 1 et 5 Mio CHF. En ce qui concerne les plus petites entreprises du secteur, elles ne sont pas réellement visées par l'aide publique ce qui explique que les montants qui leur ont été octroyés sont relativement faibles. De leur côté, les grandes entreprises ne sont pas non plus concernées au premier chef par ces aides du fait qu'elles n'en ont simplement généralement pas besoin. D'un point de vue quantitatif, notre étude a permis de dégager une estimation du montant de l'aide financière cumulée octroyée en Suisse pour les installations d'enneigement artificiel (niveau cantonal et fédéral uniquement). A la fin de l'année 2006, nous avons estimé qu'une subvention équivalente totale de 12.5 Mio CHF avait déjà été versée pour aider les investissements dans l'enneigement artificiel.

Après avoir préalablement estimé à combien se montait l'aide déjà octroyée aux installations de remontées mécaniques et déterminé la manière dont les politiques d'aide concernant le secteur des remontées mécaniques allaient évoluer ces prochaines années, l'analyse de l'impact financier des investissements dans l'enneigement artificiel s'imposait. Au vu des coûts d'investissements et d'exploitation conséquents qu'ils engendrent, nous voulions savoir si l'enneigement artificiel est une mesure d'adaptation qui peut réellement réduire les coûts futurs des changements climatiques. Dans ce but, nous avons développé plusieurs modèles économétriques des résultats d'exploitation (EBITDA) des entreprises de remontées mécaniques. Un modèle incluant des variables explicatives variées a été développé mais n'a pu être estimé que pour les données des saisons d'hiver 2003/04 et 2004/05. Dès lors, il est très probable que les résultats de l'estimation auraient été différents si nous avions pu estimer notre modèle à l'aide de données d'autres saisons d'hiver. Toutefois, notre analyse a clairement posé les premiers jalons d'une estimation des impacts financiers des installations d'enneigement artificiel qui prendrait en compte la détérioration des conditions d'enneigement. Concrètement, les résultats de l'analyse économétrique ont montré que l'effet partiel sur l'EBITDA des installations d'enneigement artificiel est positif mais que cet effet tend à décroître lorsque le niveau d'investissement dans ces installations augmente. A l'aide des résultats de ce modèle, nous avons également procédé à un certain nombre de prédictions. En particulier, nous avons voulu savoir quels auraient été les effets financiers pour les entreprises si chacune d'entre elles avait investi un kilomètre supplémentaire dans des installations d'enneigement artificiel. Pour les conditions de la saison d'hiver 2003/04, cet effet aurait été largement positif pour les entreprises exploitant au moins 15 kilomètres de pistes puisque 69.5% d'entre elles auraient ainsi pu augmenter leur résultat net.

Dans la dernière partie de la thèse, nous introduisons l'idée de performance relative des entreprises ainsi que celle d'entreprises inefficientes. Dans la perspective des changements climatiques, ces dernières entreprises sont particulièrement intéressantes dans la mesure où elles peuvent potentiellement améliorer leur performance tout en disposant de moins bonnes conditions d'enneigement. En d'autres termes, l'amélioration de l'efficience peut être envisagée pour ces entreprises comme une mesure d'adaptation aux changements climatiques.

*Mots-clés*: Tourisme d'hiver; Changement climatique; Vulnérabilité aux changements climatiques; Mesures d'adaptation; Enneigement artificiel; Modèles économétriques; Variables endogènes; Aides publiques; Politique régionale; Sociétés de remontées mécaniques; Amélioration de la performance; Frontière de production.

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# Abbreviations

| | |
|---|---|
| **AFC** | Administration fédérale des contributions |
| **AIC** | Akaike's information criterion |
| **BCV** | Banque Cantonale Vaudoise |
| **BLUE** | Best Linear Unbiased Estimator |
| **CEV** | Classical errors-in-variables (assumption) |
| **CDA** | Compagnie des Alpes |
| **DEA** | Data Envelopment Analysis |
| **EBDA** | Earnings before Depreciation, and Amortization |
| **EBITDA** | Earnings before Interest, Taxes, Depreciation, and Amortization |
| **FOSD** | Federal Office for Spatial Development |
| **FSO** | Federal Statistical Office |
| **GDP** | Gross Domestic Product |
| **GKB** | Graubündner Kantonalbank |
| **GLS** | Generalized Least Squares |
| **GMM** | Generalized Method of Moments |
| **HESTA** | Statistique de l'hébergement touristique |
| **IBAT** | Inventaire des sites de reproduction de batraciens d'importance nationale |
| **ITT** | Installations de Transport Touristiques (Statistique) |
| **LIM** | Loi fédérale sur l'aide aux investissements dans les régions de montagne |
| **OBM** | Ordonnance sur la protection des bas-marais d'importance nationale |
| **OcCC** | Organe consultatif sur les changements climatiques |
| **OECD** | Organisation for Economic Co-operation and Development |
| **OEIE** | Ordonnance relative à l'étude de l'impact sur l'environnement |
| **OHM** | Ordonnance sur la protection des hauts-marais et des marais de transition d'importance nationale |
| **OLS** | Ordinary Least Squares |
| **PPS** | Inventaire des prairies et pâturages secs de Suisse |
| **SBS** | Seilbahnen Schweiz (Remontées Mécaniques Suisses) |
| **Seco** | Secrétariat d'Etat à l'économie |
| **SLF** | Eidgenössischen Institut für Schnee- und Lawinenforschung |
| **SSR** | Sum of Squared Residuals |
| **TSLS** | Two Stage Least Squares |
| **WLS** | Weighted Least Squares |
| **WWF** | World Wildlife Fund |

# 1. Introduction & Preview

Climate change adaptation measures could be potentially undertaken by the ski industry in several fields. Indeed, potential options exist in the technical, financial, operational management, behavioural and policy fields. However, truly available options are more limited and depend partly on the decisions and actions taken by certain stakeholders outside the ski industry like banks, public authorities or environmentalists. From these few lines, it becomes clear that the topic of climate change adaptation in the Swiss ski industry is very broad: many adaptation options, many stakeholders. This is the reason why this thesis will narrow the problematic on some specific elements. Regarding adaptation measures, only two options available in the technical (snowmaking facilities) and operational management (efficiency improvements) fields are discussed extensively. In regard to stakeholders, emphasis is put on the support and regional development strategies carried out by governments at cantonal and federal levels towards snowmaking investments. The role of the banks is also touched on.

Motivations behind these choices are quite different. On the one hand, the growing importance of snowmaking investments as a way to adapt to deteriorating snow conditions makes them a particularly relevant topic. This evolution is accompanied by controversies on their environmental and financial impacts. The role of public authorities in their financing also feeds these controversies. Therefore, we think it is important to tackle the way companies have financed (and will finance) their snowmaking facilities. It is also important to analyse the impacts of snowmaking investments on the companies' financial situation. On the other hand, efficiency improvements are never referred to as a way to adapt to climate change. However, they could alleviate the detrimental effects of climate change. Moreover, this is an adaptation measure that would not require any heavy investments and that would not cause any additional environmental degradation. For these reasons, analysing ski area operation companies performance and their potential efficiency improvements in the perspective of climate change seems relevant to us.

In this introductory chapter, we begin by presenting the Swiss ski industry emphasizing its economic importance for many mountain regions. The next section is devoted to understand how climate change will probably affect the sector and what could be the financial consequences associated with climate change impacts. The following section pays much attention to the place of snowmaking facilities in Switzerland. The final section gives some details on the structure and the content of the thesis.

## 1.1 Description and economic importance of the Swiss ski industry

During the accounting year 2004/05, the Swiss cableway sector generated around 871 Mio CHF from the transport activities (83.5% of this sum was generated during the winter season). More than half of these revenues were generated in the cantons of Valais and Grisons (33% respectively 28%). During the winter season 2002/03 which was excellent for operating the transport facilities, nearly 30 Mio of skier visits were counted in Switzerland (SBS 2006)[1]. Taking the transport revenues as an indicator of the company's size, *figure 1.1* shows that the cableway sector is mainly constituted of very small and small companies (i.e. of companies making less than 1 Mio CHF of transport revenues).

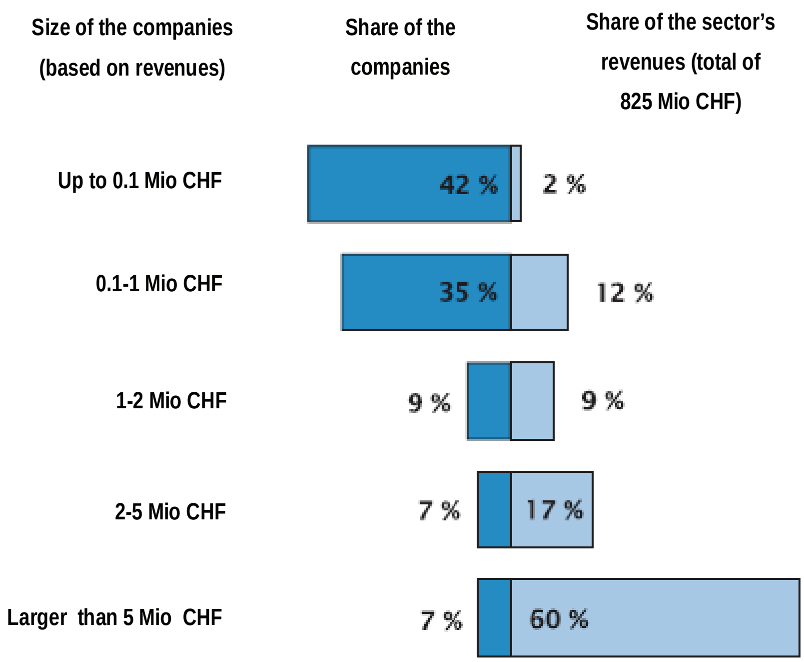


***Figure 1.1*** *- Structure of the sector based on the transport revenues generated by the companies in 2001. Source: Verband Seilbahnen Schweiz (2002)*[2].

*Figure 1.2* plots the transport revenue against the maximum altitude of the ski area for a sample of Swiss ski area operation companies. The figure gives some insights on the location of the different classes of companies.

[1] For the accounting year 2002/03, the Swiss cableway sector generated around 927 Mio CHF from the transport activities. The excellent conditions encountered during the winter season are also reflected in the lower share of the Valais and Grisons cantons in the total amount of generated transport revenues (i.e. companies located both in the Jura and in the foothills of the Alps were able to operate their transport facilities).

[2] Later on *Verband Seilbahnen Schweiz* will be abbreviated by SBS.

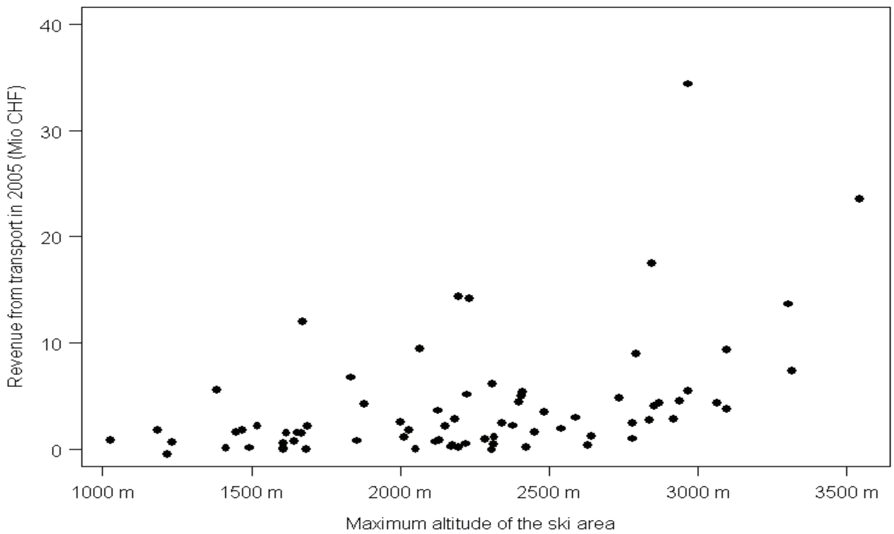


***Figure 1.2*** *- Link between the transport revenue generated in 2005 and the maximum altitude of the ski area for 75 companies. Source: SBS for the financial data.*

For the data used in *figure 1.2*, the sample correlation coefficient between the transport revenue and the maximum altitude is equal to 0.46. By looking at *figure 1.2* or by interpreting the value of the sample correlation coefficient, we can state that the ski area operation companies operating their installations in high locations tend to generate more revenues than those in medium and low locations. Moreover, high located ski areas tend to concentrate in some cantons as in the Grisons and Valais cantons suggesting that the largest companies be located there[3]. Indeed, the Grisons and Valais cantons generated 48% of the transport revenues though they were only representing 27% of the companies from the cableway sector during the accounting year 2002/03 (SBS 2004).

In a tourism economy that is highly dependent on the winter season, the ski lift branch is of the utmost importance because it ensures important services, such as customers' transport to and within the ski area, as well as the preparation, maintenance and operating of ski runs. In such an economy, the branch is often thought to be the backbone of the tourism sector. This explains why public authorities have a big interest in preserving and subsidizing transport infrastructures in regions with such economies, as they also help in maintaining a decentralized territorial occupancy. Indeed, many mountain cantons and regions located far from the Swiss plateau's economic centers are examples of such tourism economies. For instance, tourism (direct and indirect contributions) represents 29.4% of the GDP in the Vaud Alps, 26.6% in the "Berner Oberland", 25.4% in the Valais canton (35.5% in the "upper" part of the

[3] Most of the ski areas in Grisons are located above 1600m. In the Valais region, the mean altitude of ski slopes is about 2000m.

Valais) and 30% in the Grisons canton[4]. As we will see in chapter 2, it is not a coincidence if the federal law that aimed at promoting the mountain regions' development plays a prominent role in the support provided to the ski lift sector.

## 1.2 Impacts of climate change on the Swiss ski area operation sector and its financial consequences

As any other tourism and outdoor recreation sector, the ski industry will have to face the consequences of climate change. The future impacts of climate change on the sector are now well identified. First, it is acknowledged that climate change will be harmful, as many ski resorts will see their snow conditions deteriorate, and for that reason, will not be able to continue on operating with profit. With respect to this impact, several authors have introduced two fundamental and intimately related notions: the snow-reliability of a given ski area and the line of snow-reliability. The notion of snow-reliability has gradually emerged in the Swiss scientific community and from the early "100 days rule" has evolved towards more and more comprehensive definitions. The proposal by Bürki (2000) seems up to now to remain the most accomplished definition of snow reliability. It states that: *"A Swiss ski resort can be considered snow-reliable if, in 7 out of 10 winters, a sufficient snow covering of at least 30 to 50 cm is available for ski sport on at least 100 days between December 1 and April 15."*[5]. Snow-reliability is generally understood as a necessary condition for ensuring the long-term profitability of any given company. Among other things, the snow-reliability of a given ski area is dependent upon altitudes, ski runs' exposure to solar radiations, ground texture, regional climatic conditions and the use of artificial snow cover. The line of snow-reliability is the lower limit in terms of altitude under which the snow conditions would not anymore respect the snow-reliability requirements. Föhn (1990) has set this line at an altitude of 1200 m for Switzerland[6]. He also emphasized that, due to climate change, the line will probably lie at a higher altitude in the future: he along with other researchers mention an altitude of 1500 m for the time horizon 2025-2050[7]. The altitude given for the line of snow-reliability allows assessing the overall present and future snow-reliability of the Swiss ski areas in a time-saving way. This is done by simply comparing this altitude with the relevant altitudes of each Swiss ski area and then deciding on a case by case basis and according to some simple rules on whether the ski areas are snow reliable or not[8]. The outcome of these comparisons is shown in *table 1.1*.

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[4] All figures are from Rütter & Partner and are cited in BCV (2006) except for the Grisons. The latter information was provided by the Graubündner Kantonalbank (Vinzens 2005). At the Swiss level, note that the direct share of the tourism sector in the GDP lies between 3% and 4% whereas the total share could reach 6.5% (Rütter & Partner 2004).

[5] At least, a ski resort should be constituted of two installations with more than 100 m of altitude difference between the base and the upper station. Only from this ski resort's size, the 100 operating days requirement is economically relevant.

[6] In concordance with the date of his research, Föhn used the "100 days rule" to evaluate the line of snow reliability.

[7] Föhn (1990) and Abegg (1996) used different climate change scenarii though they eventually conclude on the same value of 1500m. As depicted in Bürki (2000), SBS also conducted a snow-reliability study for the Swiss ski resorts. A line of snow reliability has been defined given the snow reliability notion that was employed for the study. Using its Swiss experience, SBS chooses a value of 1200 m. Following a scenario of 3°c warming up, SBS also concluded that the line of snow reliability will lie 300 m higher at an altitude of 1500m.

[8] This is a simple and time-saving method in the sense that among the elements influencing the snow-reliability of a given ski area, the altitude is the only one to be accounted for.

| Region | Number of ski resorts | Snow-reliability | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1200 masl | | 1500 masl | | 1800 masl | |
| | | No. | % | No. | % | No. | % |
| Jura | 15 | 4 | 27 | 1 | 7 | 0 | 0 |
| Alps (Vaud + Frib.) | 19 | 16 | 84 | 7 | 37 | 4 | 21 |
| Valais | 54 | 54 | 100 | 52 | 96 | 40 | 74 |
| Bern (ex. Jura) | 35 | 30 | 86 | 20 | 57 | 12 | 34 |
| Central Switzerland | 35 | 26 | 74 | 13 | 37 | 7 | 20 |
| Ticino | 8 | 8 | 100 | 3 | 38 | 2 | 25 |
| Eastern Switzerland | 18 | 11 | 61 | 6 | 33 | 3 | 17 |
| Grisons | 46 | 46 | 100 | 42 | 91 | 33 | 72 |
| Switzerland | 230 | 195 | 85 | 144 | 63 | 101 | 44 |

***Table 1.1*** *- Snow-reliability of Swiss ski resorts for different line of snow-reliability (1200m, 1500m and 1800m). Source: Bürki (2000) (two last columns added to the original table of Abegg (1996)).*

Would the line of snow-reliability climbs to 1500 m, the overall percentage of snow reliable ski areas would decrease from 85% to 63%. However, the decrease would be higher in the regions where ski resorts are mainly located in the foothills of the Alps. For instance, only 37% of the ski resorts located in the Vaud and Fribourg Alps would still be snow reliable against 84% for the actual situation. On the contrary, in the Valais and Grisons regions, only 5 to 10% of the ski resorts will not present good snow conditions anymore as a consequence of climate change. More recent evaluation of the future snow-reliability of the Swiss ski resorts has been carried out by the OECD (Abegg et al 2007). While keeping the same methodology, the results however slightly change because the OECD study has chosen to focus the analysis on a subset of the ski resorts reviewed under the two earlier studies on snow-reliability. Another point worth noting is that the OECD study has expanded the analysis of snow-reliability to ski resorts in other countries including Austria, Italy, France and Germany. This allows interesting comparison of the impacts of climate change across different countries. In this way, the OECD study has shown that 26% of the total number of currently snow-reliable ski areas are located in Switzerland. With a warmer climate characterized by a temperature increase of 1ºc, 2ºc and 4ºc, this percentage increases up to 28%, 32% and 39% respectively. Therefore, these results seem to indicate that the impacts of climate change on the Swiss winter tourism sector could be somewhat alleviated due to a strengthened position in the international context.

Other negative repercussions are also to be expected due to permafrost thawing (weakening constructions), glacier retreat, water shortage (for artificial snow) or the probable increase in winter precipitation, which entails a greater risk of high altitude avalanches. Climate change will also influence the touristic flows towards mountain areas, but in contradicting ways according to the season. While warmer summers in the regions usually attractive for tourists at that time of the year might draw some to the mountains, snow scarcity in the winter might have the opposite effect in regions of medium altitude. It is usually admitted that such conditions would turn the inhabitants of the plains away from skiing, due to an unfavourable psychological setting and/or to a misguided belief that snow conditions in the resorts are not good ones.

Overall, the sector's companies which will be most affected by climate change will probably be those located in areas of medium mountains, in other words, those close to cities. Nonetheless, their problems could in turn affect resorts of higher altitude. In the mid-term, the foreseen decrease of medium altitude resorts could also prevent the renewal of skiers, as young city dwellers will be prevented from skiing in the vicinity of their dwelling. On the other hand, resorts in higher altitude could also possibly recoup part of the customers of the low altitude ski resorts that will be forced to close down. This phenomenon is, in substance, similar to the phenomenon already observed during very poor snow winters when some of the largest companies of the branch operating their ski area at high altitudes make greater earnings than expected[9]. By and large, these observations motivate some scholars to state that climate change will accelerate some ongoing trends in the ski area operation sector thereby favoring the creation of losers and winners among it.

Up to now, two studies have estimated the potential annual costs of climate change for the Swiss "alpine" tourism sector. Meier (1998) first calculated these annual costs to be equal to 1.8 to 2.3 billion CHF by the year 2050 (1.6 to 2.1 billion CHF for the winter tourism alone). However, another study has provided recently much lower estimates. Ecoplan/Sigmaplan (2007) has indeed estimated the potential annual costs of climate change at 120 Mio CHF (costs median by the year 2050)[10]. Focusing again on the ski area operation sector, we can gather from the factors developed in the previous paragraphs that, in the future, the sector's companies will have an opportunity to generate more summer revenues than is currently the case. As a reminder, in 2005, transport revenues generated in the summer accounted for only 16.5% of the sector's transport revenues[11]. Nevertheless, not only will the summer season continue to be generally costly for the companies, but the additional revenues will only partly make up for the winter losses at the sector level[12]. This leads certain authors to predict that in the future as well, most companies' financial health will continue to depend on the winter results[13]. For this reason, the measures set up to enable the companies to maintain skiing activities on the resorts they run will play a primary role. A recent study carried out for the Bernese Oberland (Müller and Weber 2007) shows that these measures are nearly as important as the increase in demand of summer products[14].

## 1.3 Adaptation strategies and snowmaking facilities in the Swiss ski industry

Since several decades, ski area operation companies are faced with the deterioration in snow cover conditions. As a response to this evolution, they have already implemented various and complementary adaptation strategies: improved trails preparation and maintenance, development of new installations situated in locations offering a more secure

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9 See Abegg (1996, p.67-68). This redistribution of the demand at the national level could also be envisaged at the international level given that climate change impacts will differ among ski tourism regions. In fact, this effect could be important for the various national tourism sectors. When assessing the costs of climate change for the Swiss alpine tourism sector, Ecoplan/Sigmaplan (2007) has for instance taken this effect into account.

10 Compared to the study carried out by Meier, lower impacts of climate change are taken into account in the Ecoplan/Sigmaplan study. This feature explains a large part of the huge difference between the two studies' estimated costs. Moreover, gains from being more competitive (due to higher impacts of climate change in other alpine countries) and reallocation of the money initially spent by the households towards winter sports oriented leisure are also accounted for in the Ecoplan/Sigmaplan study which further explains their lower costs estimates. On the contrary to the study carried out by Meier, their study however does not take into account potential positive effects of a warmer climate for mountain regions' summer tourism.

11 Summing up to CHF 871 million yearly for transport revenues (SBS 2006).

12 For the Grisons canton, a study (Zegg 2000) has for example pointed to the fact that operating in summer generates a loss for the whole sector. This loss is then compensated by the benefits of the winter season but also by tapping into reserve funds. For more about additional summer revenues and their comparing with winter losses for a particular region, refer to (Müller and Weber 2007).

13 In addition to (Müller and Weber 2007), see also (OcCC and Proclim 2007).

14 Under a pessimistic scenario of climate change consequences in 2030, the turnover increase in summer is estimated to be CHF 80 million (which represent 7% of summer turnover generated by the bernese companies in 2006) while the avoided losses of the turnover in winter due to adaptation measures is estimated to be CHF 50 million.

natural snow cover, use of artificial snow cover and finally attempts to develop and promote summer activities. In this non-exhaustive list of adaptation measures and strategies[15], the use of artificial snow cover has certainly attracted the most attention. This fact can be attributed to several reasons. First of all, its ability to cope with the variability and the reduction in natural snow precipitations makes it one of the most widely used and planned measures of the above mentioned adaptation strategies. Second, its environmental impacts are scrutinized and largely discussed. Finally, within the ski area operation sector, whether the recourse to artificial snow cover is financially worthwhile for all the companies is still an open debate. It is certain that artificial snow cover use requires expertise as well as additional expenses for which the potential is generally lacking in firms endowed with small structures which are encountered in the Swiss ski area operation sector.

Whatever the outcome of the discussion about the advantages and the drawbacks of artificial snow cover use might be, the reality is that the recourse to it has substantially increased in Switzerland since the mid nineties. From a value around 2% of the overall area of prepared ski runs in 1994, it has reached a value a little bit higher than 10% in 2003 according to the umbrella organization of the Swiss cableway sector (SBS 2004). More recently, SBS has indicated that 19% of the total slopes' area could be artificially snowed in 2005 (SBS 2006). The following table gives information on the cumulated amount of investments made towards snowmaking in 2005 for several cantons as well as for Switzerland.

| | Percentage of ski slopes' offer concerned with artificial snow. | Cumulated amount of investments towards snowmaking facilities (in Mio CHF)[16] |
|---|---|---|
| **CH** | 19% | 1'200 |
| **GR** | 18% | 295 |
| **VS** | 20% | 370 |
| **BE** | 22% | 165 |

***Table 1.2*** *- Cumulated amount of investments towards snowmaking up to 2005 for several Swiss cantons. Source of the percentages: SBS for Switzerland and Vikuna for the Valais canton.*

However, the increase in snowmaking investments has not occurred across the line as many companies still do not have recourse to artificial snow cover or only in very limited amounts. There might be several reasons for that. For instance, it might be that regional planning requirements are not fulfilled yet in some regions or that financing ability is insufficient. Technical unfeasibility can also occur: the water resources required to produce artificial snow or the

[15] Scott (2006, p.265) gives a comprehensive list of climate change adaptation options potentially available to the ski industry.

[16] Note first that these estimates are probably more precise for the cantons than for Switzerland. For Switzerland, Ecoplan/Sigmaplan (2007) formulates a much lower value for the cumulated amount of investments towards snowmaking facilities (i.e. 500 Mio CHF). Clearly, our estimates must be understood as upper bounds.

necessary conditions to produce it in a cost-effective way may be lacking. Indeed, there exist several mountain regions in Switzerland where the water resources necessary to produce artificial snow are lacking or, more generally, regions in which the water resources are not sufficient to expand snowmaking to larger parts of the ski resort. Storage lakes (reservoirs) are often built to solve these problems but are very costly to create and are subject to environmental protection issues[17]. Among other things, this latter example emphasizes the link between technical feasibility and financing ability since a technical solution exists but may be extremely costly to implement. Finally, temperature might as well be a limiting factor for the resorts situated in the lower regions. Low air temperature periods may be not long enough to insure a sufficient and cost-effective production of snow thereby preventing the companies from realizing any snowmaking investments.

The proportion of the overall area of prepared ski runs concerned with artificial snow cover will obviously continue to increase in the years to come. In Switzerland, the level of equipment is rather low compared to Austria or Italy where 54% resp. 68% of the overall area of ski slopes can be artificially snowed for instance (SBS 2006). Though the needs for snowmaking are not homogenous across regions in different countries, this clearly suggests, however, that future important snowmaking investments can take place in Switzerland. For the years 2005-2009, SBS indicates that the ski area operation companies foresee to invest around 274 Mio CHF annually. From this amount, 26% is planned to be invested in the ski runs (snowmaking, security, trails' preparation, etc.) and the catering trade. Hence, given the financing is found, 70 Mio would be invested annually in the ski runs and the catering trade. Assuming, on average, 50 Mio CHF of annual investments in artificial snow cover means that it is not less than 50 to 65 km of ski slopes that will be annually equipped[18]. This, in turn, represents an average annual rate of increase in the km of equipped slopes ranging roughly from 3 to 4.5% during the 2005-2009 periods. To our knowledge, no previsions are given for a time horizon above the year 2010.

As a matter of fact, ski lift operators have often emphasized the threats of climate change when they had to legitimate investment strategies in snowmaking. As noted by Bürki et al (2003): " Climate change and global warming, together with international competition, have been used as the key arguments for constructing artificial snowmaking facilities, as well as for extending existing ski runs and opening new ones in high-alpine regions (at above 3000 m)." A competitive environment could strongly motivates the recourse to artificial snow cover as well as it improves the comfort of the customers on the ski trails and allows the ski resort to position itself in relation to the competition using the snow-reliability argumentation. Indeed, demand oriented surveys emphasize the crucial importance of snow-reliability in the choice of destination made by winter tourists[19]. Not to forget that, on a regional scale, snowmaking is also useful to cope with local competitors.

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[17] According to Grischconsulta (2002), only about 30% of the Swiss ski area operation companies with snowmaking facilities are endowed with a reservoir. In reality, this figure might be even lower since small companies were not properly taken into account in the Grischconsulta's survey.

[18] Assuming the investments aim only at creating new installations. This is not a strong assumption given the average age of existing artificial snow cover equipment. Moreover, the value of 50 Mio matches up the indications that the average investment planned by the Grisons' companies in artificial snow cover use attains 15 Mio CHF annually between the 2003-2007 periods (Zegg and Gujan 2003).

[19] For instance, look at chapter 5 in Bürki (2000).

Of course, while climate change and international competition are the main arguments used to legitimate the recourse of the ski resorts towards artificial snow cover, this does not imply that they are the only motivations behind the choices towards artificial snow cover. The shock of successive winters with weak snowfalls at the end of the eighties and the beginning of the nineties could also explain the evolution encountered in the last decade towards snowmaking investments. This recurrent lack of snow had the consequence to create a worrying repetition of financially stressed seasons in the whole sector. While such periods of winters with little snow happened also earlier, it surely had a greater impact at this time because the sector got heavily industrialized in the meantime (Elsasser and Bürki 2002). Industrialization was accompanied by a tremendous increase in fixed costs making snow-poor winters even more problematic from a financial point of view. Hence, artificial snow cover use has become essential for lessening the adverse effects of snow poor periods. By extending the ski season, it also permits to cope with the huge dependency on key periods (Christmas and New Year vacations). The survey carried out by Grischconsulta in the Swiss ski area operation sector for the season 2001/02 (cf. Grischconsulta 2002) demonstrated the importance of these two points for ski area operators (i.e. snowmaking as a way to avoid losses of revenues and linearize the revenues). Confronted to a poor snow winter, 40% of the surveyed companies that experienced earnings losses in the 2001/02 winter season compared to the previous one stated that one reason for these losses was that the recourse to snowmaking was insufficient. In keeping with the second point, 53% of the surveyed Swiss companies have indicated that the start of the season depends heavily on the snowmaking installations.

## 1.4. Plan and content of the thesis

Chapter 2 begins by addressing the financing ability of Swiss cableway companies in order to understand why public authorities have helped financing so many investments projects in the cableway sector. In a second phase, it identifies what has been the authorities' role in the climate change adaptation process carried out by ski area operation companies by looking specifically at the public support provided to snowmaking projects. It also delineates how the authorities' support towards snowmaking could evolve in the years to come, by analyzing the latest developments in their support strategies. By carrying out a cantonal analysis, the aim is also to ascertain whether any differences exist in the degree of commitment of the different cantonal authorities towards the ski lift branch's investments in snowmaking. In the conclusive part, the results of studies based on the evolution of the Swiss ski areas' snow-reliability are confronted with the results obtained in the chapter with the aim to develop new insights for the vulnerability of companies located in different cantons. After the reading of chapter 2, the reader should therefore have a precise idea of the financial support provided for snowmaking projects in different regions of Switzerland. In the same manner, he should know what the support strategy of the authorities will be towards snowmaking projects planned in the short and mid-term. However, chapter 2 does not give any insight on the economic advisability of future snowmaking investments and therefore, does not tell the reader whether the public sector should continue subsidizing this kind of facility. These questions form the core of chapter 3.

More precisely, chapter 3 aims at analyzing the current impact of snowmaking facilities on the Swiss ski area operation companies' financial situation. This analysis has been made possible through the development of a relevant database and estimation of several statistical models of companies' operating results. The database nearly includes 90 companies and its originality lies in the collection of very different types of data including: quantitative information concerning transport and snowmaking facilities, size of the ski area, accommodation capacity in the hotel and para-hotel sectors, measures of the availability of natural snow during the winter season, vicinity to the densely populated regions, granted subsidies, organizational form, etc. Moreover, it provides data for the winter seasons 2003/04 and 2004/05. While some of the data were derived using datasets provided by different federal offices and organizations, much information still had to be collected through personal inquiries. For instance, it was necessary to ask the companies about their snowmaking investments. As regards the statistical analysis, it is made substantial by the research for an adequate model and by a thorough discussion of endogeneity problems. A linear model with normal error is assessed first and a procedure for model selection is used in order to derive a simple estimable model. In a second phase, omitted variables and measurement errors are tackled and potential endogeneity problems are raised. Search for consistent estimators motivates the use of both Instrumental Variables and Generalized Method of Moments estimation. Then, a third phase of the statistical analysis mainly aims at removing near collinearity from our data in order to improve the estimation results. Finally, a fourth phase makes the comparison between the estimation results obtained from the 2003/04 and 2004/05 winter seasons data. Throughout the different steps of the analysis, estimates of partial effects are central outputs and some of these are used to carry out particular kind of predictions. A global prediction is made and consists in determining what would have been the financial consequences at the sector level if all the Swiss ski area operation companies had invested in one additional kilometer of slope endowed with snowmaking facilities. While dealing clearly with the economic advisability of imminent snowmaking investments at the sector level, the global prediction also allows discussing the potential for climate change adaptation through snowmaking investments.

In chapter 4, the focus is not put anymore on snowmaking facilities and some of their related financial aspects. Chapter 4 therefore distinguishes itself from the first two chapters though climate change impacts and adaptation in the Swiss ski industry are obviously still the main themes. Using Data Envelopment Analysis (DEA), efficiency improvement potentials are estimated for a sample of 20 companies of the Valais canton. However, prior to assessing the degree of efficiency of these companies, a set of inputs and outputs has been derived. This set includes an input which measures the availability of natural snow. While not being so common in DEA analysis, this kind of natural resource related input is of primarily importance for our analysis. Inefficient companies are emphasized since they have a potential that could be potentially used to reduce the detrimental impacts of climate change. In particular, inefficient companies presenting a good financial situation are highlighted because they may represent a very interesting case in the perspective of climate change: as their healthy financial situation might be interpreted as a consequence of good snow conditions, efficiency improvements could therefore compensate for the adverse effects of climate change. Given predictions on the available amount of natural snow under climate change, DEA would theoretically allow defining whether potential efficiency improvements can compensate for the future deteriorating snow conditions. This latter analysis has been carried out in collaboration with Bastienne Uhlmann (a PhD student working at the faculty of climatic change and climate impacts from the University of Geneva) for two companies of the sample. Bastienne has provided me with data on the future amount of natural snow that may be available to these two companies.

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# 2. Contribution from the Swiss public sector to the financing of snowmaking investments

## 2.1 Introduction

In Switzerland, subsidies given to the winter tourism sector are motivated by the prominent role it plays in many remote mountain regions. Subsidizing winter tourism helps keeping a decentralized occupancy of the territory which has been the aim of the Swiss regional policy since several decades. In this context, the cableway sector has been a particularly important recipient of public subsidies due to its central role in the winter tourism sector. Indeed, the cableway sector is often perceived as the backbone of winter tourism. Supporting this sector allows indirectly supporting a set of other economic sector from the mountain regions including the accommodation sector, the catering sector, etc. One very important aspect of the support provided to the cableway sector is the fact public authorities help financing many investments projects. Economic impacts triggered by the supported investments are higher than those provided simply by granting operating subsidies. For instance, these investments are generally accompanied by substantial employment at the regional level. Another reason for subsidizing investments is the limited financing ability observed at the sector level. Problems encountered in financing investments are especially relevant for small and medium sized companies that have not yet begun any vertical or horizontal consolidation process. The causes that are mentioned to explain their situation are numerous: more demanding conditions for bank loans, a stagnant demand coupled with a tougher competition, the trend towards a decreasing natural snow cover, an inadequate accommodation supply in the ski resorts, higher responsibilities inducing higher costs, and their suboptimal structure.

Companies from the cableway sector have also begun to invest in snowmaking facilities. Such investments allow companies to be less vulnerable to snow variability thereby allowing them a priori to strengthen their financial situation. Moreover, securing snow cover on ski slopes does not only guarantee revenues for the ski area operation companies but guarantees revenues for all kind of other snow dependent economic activities. These elements provide motives for public support. On the other hand, such positive externalities need to be compared with the negative externalities associated to snowmaking facilities through their impacts on the environment and the landscape. The latter impacts are generally taken into account in the rules and principles set by regional development policies.

Before presenting the plan of the chapter, we will first clarify some points linked to our analysis of the financial support provided by the authorities to snowmaking projects. Then, we will also briefly describe the methodologies that we have employed in this chapter.

To begin with, we will give priority to the financial support provided at federal and cantonal levels for snowmaking projects. However, all along, we should not forget that the communes' commitment towards the sector should have ideally been taken into account, in order to have a comprehensive view of the authorities' support towards snowmaking[1]. Money from the communes flowing into the ski lift companies for their snowmaking projects was not taken into account for several reasons. On the one hand, it is obviously easier to focus on a limited number of cantons (in addition to the Confederation) than to deal with numerous communes. On the other hand, the support given at the communal level should be quantitatively smaller than the support provided at the cantonal and federal levels. Moreover, this support is sometimes not so easy to valuate and even to observe (e.g. the communes often stand as security for the loans granted by the Confederation). Throughout the analysis, we should also keep in mind that public authorities do not only interact with the ski lift sector through the implementation of direct support policies. Other important interactions are due to some legislations in force, namely in the fields of environmental and regional development. For instance, new constructions are submitted to a planning permission procedure. With regard to snowmaking projects, each cantonal authority has therefore set its own principles and planning permission procedure to put an end to a legal vagueness in the field that lasted until quite recently. In some cantons, these regional developments' restricting rules have also arisen following the undertakings of environmental protection associations, which represent another important player in the Swiss context. At the federal level, snowmaking facilities projects can also be subject to an environmental impact assessment study if the area concerned with artificial snow is greater than 5 hectares[2].

Obtaining some sound quantitative results in this chapter was not an easy task. For several reasons, financial support provided in one canton is not comparable with the financial support provided in another canton. Therefore, it was necessary to find a way to make comparable the support granted in different cantons. This was made possible by the choice of a discounting formula that has allowed computing a discounted flow of subsidies for each interest-free loan that was granted for snowmaking projects. Our aim in this chapter was to derive the overall amount of public subsidies that has been provided for snowmaking projects. However, information on the support provided to snowmaking facilities was only gathered for a set of seven cantons (including the most important ones for winter tourism). Therefore, extrapolation of the quantitative results that we obtained for this set of cantons was necessary in order to derive relevant values for Switzerland. This was simply done by applying a multiplying factor to our initial results. This multiplying factor is linked to the share of the reviewed cantons in the overall transport revenues generated at the sector level.

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[1] Communes are Swiss administrative districts that can span from villages to towns.

[2] OEIE: Ordonnance relative à l'étude de l'impact sur l'environnement.

The next part will depict some aspects of the Swiss ski lift companies' financial situation and financing possibilities whereas the following parts will deal with the authorities support towards snowmaking projects. More precisely, the third part will present general features of the support provided to the ski lift branch for their investments, with an emphasis on the link between the form of support and the institutional level and the conditions that a claimant must fulfill in order to receive support. This is a necessary preamble to the fourth part, which portrays the current state of support for snowmaking projects. The final part will draw some conclusions.

## 2.2 Financing possibilities in the Swiss ski lift sector

The adaptive capacity of a company is intimately related to its ability to finance new investments and withstand greater operating expenditures. This ability is especially important in the context of artificial snow cover use where both the investment costs and the induced operating costs are large (see chapter 3's introduction for more details). The financing ability of a given company depends on several factors as the amount of retained earnings, the market situation in the financing sector and the support given by the authorities. In this section, we concentrate on discussing the internal financing together with a particular source of external financing (i.e. bank loans) that is available to the companies. Limitations of these two sources of financing will be emphasized thereby providing motivation for focusing our attention on public support.

### 2.2.1 Self-financing

Self-financing is an important source of finance in the sector. For instance, during the 1998-2002 periods, the financing of the investments in Valais was done at 44% through cash flows (Zurschmitten and Gehrig 2004)[3]. This figure can be much smaller, however, as in the canton of Fribourg where self-financing has participated only to 20% of the investments' financing during the 1999-2002 periods[4]. Ideally, retentions should be sufficient to finance the operating expenditures and a large part of the investments[5]. Note however that for the years 2000 and 2001, only 20% of the firms that operate installations such as cable cars or funiculars distributed dividends to their shareholders[6]. Moreover, tax payments represent only 1% of the overall costs incurred by the cableway sector in 2001 (SBS 2002). Therefore, the amount of retentions generated at the sector level depends mainly on the revenues generated by the companies and also on the payments to security-holders (principal and interest) since both dividends and tax payments seem very limited. As regards the actual amount available for investments, it additionally depends on the way the company handles its operating costs. Central information on the elements that influence the actual amount available for investments is therefore given by a set of financial ratios as they allow assessing the financial structure and the

[3] This information is valid for the Valaisan companies operating cable cars and/or funiculars only.

[4] This estimation excludes two major investments made in the canton: the Rapido Sky of Charmey and the funicular of Moleson (Perruchoud-Massy and Délétroz 2004).

[5] Following the definition given by Tirole (2006), retentions are the difference between post-tax income and total payments to investors (shareholders and security-holders).

[6] This represents 41 firms distributing on average 13 Mio CHF in the year 2000 and 2001 (SBS 2002). Furthermore, using financial data provided on the cableway companies by SBS for the 2000-2005 periods, we find that, on average, 18.4% of the companies have allocated a part of their net incomes for dividends.

operating performance of companies. Summing up the financial analysis carried out in several studies, *figure 2.1* presents some aspects of the financial situation of companies located in the Bern, Valais and Grisons cantons.

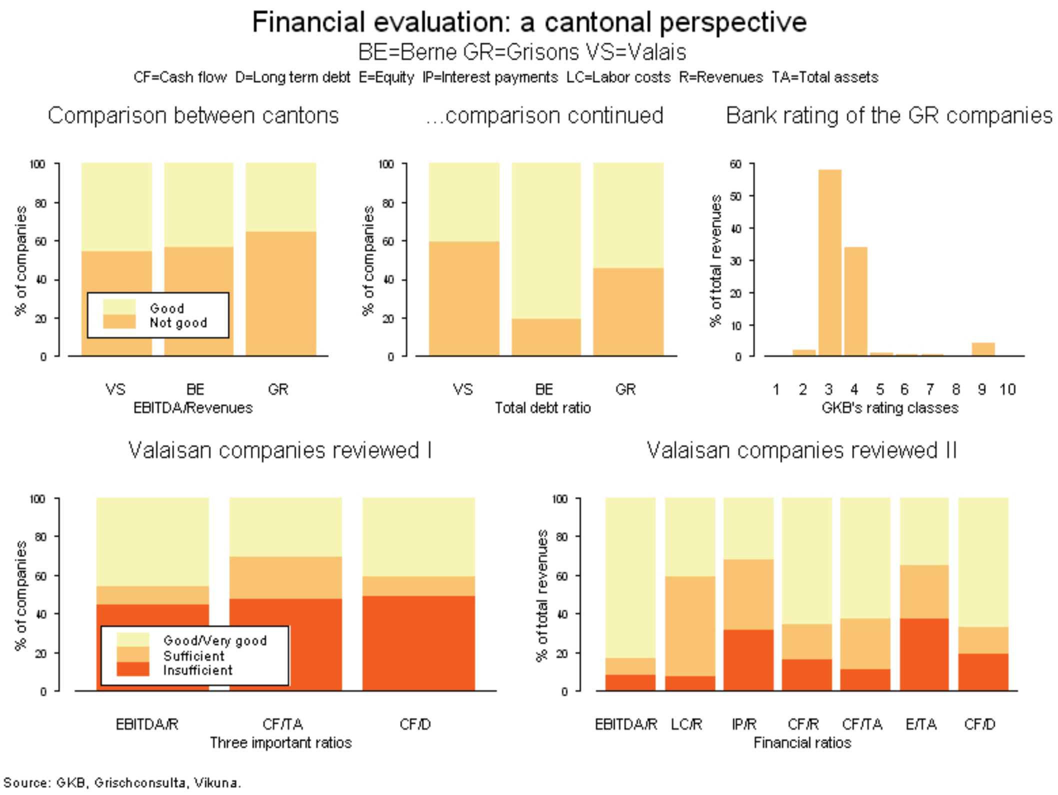


***Figure 2.1*** *- Some aspects of the financial situation of companies in the three most important cantons for winter tourism. Definition of ratios and thresholds are given in appendix 1.*

These data are based on the companies' activity reports from 2001 and 2002. Note that companies located in the Bern, Grisons and Valais cantons generate ¾ of the Swiss ski lift sector's revenues in 2002 and consequently can be used to assess the overall financial situation of the sector. The graphs of *figure 2.1* refer to several financial ratios. However, in the financial assessment of companies, the ratio EBITDA/Revenues is of the utmost importance and allows estimating whether a company operates its installations in a cost-effective way compared to the other companies. We can estimate that around 40% of the Swiss companies are rated as "Good to very good" with respect to this criterion (i.e. 40% of the companies display a ratio > 30%). Nonetheless, in Valais more than 80% of the revenues are generated by ski area operation companies showing a good EBITDA/Revenues ratio (45% of the companies) whereas in Grisons, 90% of the revenues are generated by companies benefiting from a good rating by the Graubündner Kantonalbank (GKB)[7]. These figures seem to indicate that healthy companies consist mainly of medium and large companies. Since the size of a given company is generally positively correlated with its altitude, these figures seem also to indicate that

[7] In this canton, only 35% of ski area operation companies have shown a good EBITDA/Revenues ratio in 2001 (Zegg and Gujan 2003). However, we must pay attention to the fact that banks' rating systems encompass qualitative and behavioral considerations beside the common quantitative analysis as emphasized in subsection 2.2.2.

healthy companies are mainly operating in medium and high locations. These results are not really a surprise. The financial difficulties of small ski lift companies are an old and widely recognized problem stemming often from abnormally high operating costs[8].

Another ratio available for the Bern, the Grisons and the Valais cantons is the total debt ratio. Because of the need to finance large investments in fixed assets, companies in the tourism sector generally display a large total debt ratio. As regards the Swiss ski area operation companies, we can estimate that 55% of them are rated as "Good to very good" (i.e. companies with a total debt ratio < 60%). Unlike the previous ratio, companies with a good rating are rather constituted of small and medium companies. For the year 2001, we note for instance that 44% of the companies generating 63% of the sector's transport revenues had a total debt ratio higher than 60%[9].

Summarizing the information above, we note that approximately 60% of the companies should experience difficulties in financing new investments through their cash flow because of insufficient operating performances. The figures suggest that these companies consist above all of small companies and also of some medium companies. Additionally, the financing ability of 45% of the companies should be affected (sometimes heavily) by interest payments and principal repayments as emphasized by their relatively high total debt ratio. In order to update their installations and invest in new facilities, these companies could therefore try to rely more heavily on some forms of external financing including bank loans and the financial support provided by public authorities.

### 2.2.2 External financing

In general, bank loans provide the bulk of external financing. For instance, during the 1998-2002 periods, 25% of the investments in Valais were financed through bank loans. Besides bank loans, LIM loans[10] account for 8%, leasing for 9% and the new issuing of shares account for 9% of the overall investments' financing (Zurschmitten and Gehrig 2004)[11]. Nonetheless, in cantons where many companies are in financial difficulties, the share of public support can increase substantially. In the canton of Fribourg, public authorities have financed 25% of the overall investments (including support from the communes) during the 1999-2002 periods whereas the share of bank loans has fallen to 20% (Perruchoud-Massy and Délétroz 2004)[12]. For the accounting year 2002/03, public authorities provided 10% of the overall debt capital put at the cableway sector's disposal (SBS 2004).

As shown in the previous paragraph, banks play a very important role for financing the tourism infrastructure. For the accounting year 2002/03, bank loans constituted 74% of the overall debt capital put at the cableway sector's disposal whereas public authorities provided 10% of that capital (SBS 2004). This predominant role could be explained by the

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[8] A more in-depth analysis of the operating performances at the sector level is provided in subsection 3.2.2 of chapter 3.

[9] For the year 2003, the figures are as follows: 37% of the companies generating 51% of the sector's transport revenues had a total debt ratio higher than 60% (SBS 2004).

[10] LIM loans are extensively presented in subsection 2.3.1.

[11] Idem as footnote 3.

[12] To cap it all, let's say that private loans account for 10%, leasing for 15% and the new issuing of shares for another 10%. Again, these figures exclude two major investments made in the canton: the Rapido Sky of Charmey and the funicular of Moleson (Perruchoud-Massy and Délétroz 2004).

fact the Swiss tourism sector is mainly constituted of small interrelated companies. Indeed, this situation does not allow direct investors and the financial market to fully recover the benefits from their investments (benefits of the investments are generally spread out across different companies) thereby making these investments less attractive.

As for any other borrower, interest rates faced by cableway companies depend on several elements including the collateral and the company's rating. Most of the time, collaterals are given by some fixed installations possessed by the company (base and upper stations, restaurants, administrative buildings, etc.) but it can as well be provided occasionally by the authorities. Therefore, the interest rate we are generally concerned with is the mortgage rate applied to industrial buildings. Of course, this time-varying mortgage rate depends additionally on whether it is a variable or a fixed rate. As regards the rates' differentiation that has arisen as a consequence of the rating systems' introduction, it was effective in the mid-nineties. Note that risk costs are especially large for small and medium companies in the tourism sector. Risk components for these companies are the following (Bieger 1999): risks in the real estate market (because of the use of real estate as collateral), cluster risks because of the interrelated businesses at the destination level, moral hazard risks, weather and other market risks (e.g. a given investment generally aims at developing only one activity in one destination). Risks are also increased by the presence of intangible assets (i.e. through investments in product and services development, market analysis, etc.) which cannot be sold in case of a company's closure. Interest rates faced by cableway companies are also made up of transaction and equity costs. Transaction costs (arising due to the loan request's examination, follow-up of the principal reimbursement, etc.) are relatively large in the tourism sector due to the presence of rather small companies. For their part, equity costs arise because of the banks' legal obligation to adjust equity capital to the level of granted loans. New orientations in the field link this adjustment with the risks associated to the loans (Basel II). In the light of the sector's financial situation presented in the previous section, it should be clear that the evolution towards risk-adjusted pricing and securitization of debt has made the access to bank loans more expensive for a majority of the sector's companies. In particular, it becomes very difficult for badly rated companies to obtain bank loans.

From the cableway sector viewpoint, there are mainly two families of banks operating on the capital market: large banks (Credit Suisse, UBS) and cantonal banks[13]. Because of their particular status, cantonal banks play a prominent role at the regional level and they each follow their own interest rates policy. Furthermore, they have developed their own rating system and risk-adjusted pricing policy[14]. For cableway companies, these cantonal differences can lead to some inequalities in the access to bank loans.

[13] In Valais, and for the 1998-2002 periods, 56% of the bank loans used to finance the investments was provided by large banks against 36% for the cantonal bank (Zurschmitten and Gehrig 2004).

[14] Despite their differences, it seems nonetheless that all rating systems developed by cantonal banks share the property to be based on some combination of quantitative (balance sheets, profit and loss accounts, financial ratios), qualitative (management, services, prospects) and behavioral criteria (use of the credit limits, terms of principals and interests payments, legal proceedings, etc.).

## 2.3 General features of the authorities' support towards the ski lift sector

### 2.3.1 The federalist framework at work

In the federalist framework that strongly characterizes Switzerland, support policies are carried out at federal, cantonal and communal levels. Consequently, authorities' involvement in the ski lift branch varies considerably from one region to another and the forms of support depend on the institutional level. The differences in support provided towards snowmaking projects in several cantons will be discussed below in subsection 2.4.3. In the next paragraph, we therefore concentrate on presenting the different forms of support and explaining which forms are used at each of the three institutional levels.

#### *2.3.1.1 Forms taken by the authorities' support*

The support can take numerous forms. Financially, it can take the form of a subsidy, an interest-free loan, a loan's guarantee, a tax relief, debts forgiveness to facilitate financial strengthening or a share in the company's capital. In the context of the ski lift branch, financial support has four main purposes: 1/ to enable investments important for the company's viability, 2/ to reduce expenses created by new and essential investments or by normal operations, 3/ to allow the financial strengthening of some companies, and 4/ to foster the sector's restructuring. Clearly, financial support granted to promote investments is by far the most substantial and will be at the centre of this chapter[15]. Non financial support is more concerned with the environment in which the companies are evolving, in other words, the general conditions. It must be emphasized that favorable general conditions are often thought to be more important for the ski lift sector than the implementation of a direct support policy. In order to realize why, suffice is to mention that the general conditions encompass the following fields of particular interest for ski lift companies: regional development, administrative procedures, transport, tourism accommodation and promotion, vacation planning, tax systems, conditions on the labor and electricity markets, water resources management, etc.

#### *2.3.1.2 Forms and limits of financial support at federal, cantonal and communal levels*

At the cantonal and federal levels, the most important legal instrument is the LIM law. LIM is the French abbreviation for the law regarding investment support in mountain regions. From 1974 to 2004 (at the latest), nearly 250 projects from the cableway branch were financed with the help of LIM contributions. For these projects, the overall authorities' support (i.e. all subsidies and interest-free loans provided at all institutional levels) amounts to 360 million CHF. These projects required a total investment of CHF 900 million[16].

The LIM law has been the cornerstone of the Swiss regional policy. The Confederation has created a federal fund to support investments in mountain regions and uses it in order to grant loans. Actually, both the tasks of fixing the amount of the federal loans and of granting them are delegated to the cantons (art. 8 al. 1 LIM). The cantons also have

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[15] A subsection of chapter 3 will also deal with public and third-party contributions in the cableway sector. Nonetheless, the focus in chapter 3 will be put on the financial support impacting directly the operating results.

[16] All these figures are given by the Seco (2004 reproduced in SBS 2004). It is interesting to note that the cantons and the Confederation have provided 90% of the total 360 Mio CHF. However, the figures do not disclose any information regarding the financing of these 250 projects through increased shareholdings in the companies by communes or other public institutions.

the responsibility to verify that the guarantees given for the federal LIM loan are sufficient (art. 12 al. 1 LIM). To make sure that the cantons will carry out this task, the LIM law further stipulates that the canton must take on half of the loss in case the beneficiary of a federal LIM loan does not reimburse it (art. 12 al. 2 LIM). The support from the federal fund is restricted in two main ways. On the one hand, a ceiling is fixed on the maximum amount of federal LIM loans that can be granted in every relevant canton during a four years' period. On the other hand, not all the mountain regions can benefit from the federal LIM loans. The appendix to the LIM law enumerates the mountain regions that can be eligible for LIM contributions. In the following, we will simply refer to these regions as the LIM regions.

LIM loans are granted at attractive rates or even at zero rates (art. 9 LIM). Furthermore, they must be repaid within 30 years at most and the canton can decide to defer the first payment for at most five years (art. 10 al. 1 LIM). A restriction applied to these loans is that the return on investment for the shareholders should not be greater than the interest rate paid on the LIM loan. Usually, this means that the debtor must refrain from paying dividends until the maturity of the loan, since interest-free loans are the rule. In the loan agreement, debtors commit themselves to respect this clause[17]. An important feature of the LIM law is that, in order for the federal government to grant loans, the canton must participate in the financing of the project in at least the same proportion as the federal government (art. 5 LIM). Some freedom is available to cantons as to the way to meet this requirement, since they are responsible for the enforcement of the LIM law (art. 22 LIM). Sometimes, the equivalent contribution of the canton consists exclusively of loans. In some cases, a cantonal subsidy is granted as long as the federal loan is not fully reimbursed and it must be equal to the interests not recovered by the Confederation on the amount of the residual loan (the so-called "Zinskostenbeiträge")[18]. However, when the cantonal subsidy is distributed only once – with the effect of strongly reducing administrative costs – the cantons use a table provided by the Seco (State secretariat for economic affairs) in order to determine the minimal sum it has to pay. This table defines the equivalent subsidy of the federal LIM loan (i.e. the present value of the flow of subsidies associated to the federal LIM loan) as a function of the amount and the term of the federal LIM loan, using a market's mortgage rate. The formula used to compute the values found in the table is the following:

$$B_{pv} = P\left[1 - \left[\frac{(1+r)^n - 1}{rn(1+r)^n}\right]\right] \quad (2.1)$$

Where:

P = amount of the federal LIM loan

r = mortgage rate

[17] This restriction has some detractors. They emphasize the fact that the restriction could delay numerous projects because shareholders are generally not ready renouncing the dividends.

[18] For instance, a "Zinskostenbeiträge" was granted by the Saint-Gall canton in 2002 for a project coupling the renewal of an installation to an investment in snowmaking facilities. In this case, the variable mortgage rate for first rank security applied by the cantonal bank is used as the interest rate to be applied on the residual loan. Might this rate falls below 3.5%, the 3.5% rate would be used instead (this is what has actually occurred).

n = term of the federal LIM loan

The formula is derived for a straight line depreciation of the federal LIM loan and a discounting rate equal to the mortgage rate. For several years, the mortgage rate used in the formula has been equal to 3.5%. It is sometimes changed according to the market and was noticeably higher in the late eighties/beginning of the nineties (i.e. when mortgage rates were at their highest).

At the cantonal level, other legal instruments (such as cantonal tourism equipment funds) are sometimes available in order to encourage investments in mountain regions. These funds allow cantonal support to increase beyond what is required under the LIM law for a project benefiting from a federal loan. It also allows the canton to support projects in some mountain regions that cannot take advantage of a LIM contribution. Subsidies and sometimes loans can also be granted through these instruments. When concluding this discussion about the forms of financial support provided by federal and cantonal levels to the ski lift branch, it is important to emphasize that the Confederation only grants LIM loans, whereas the cantons can grant loans and subsidies and can even stand as guarantor for a federal loan[19]. Looking more specifically at support for snowmaking, it is worth noting that the Confederation has fixed no particular ceiling to support provided to these types of projects. However, federal guidelines were published in 1991 that limit the support towards snowmaking facilities in some situations: snowmaking facilities located at an altitude below 1300-1500 m should not, in general, be financially supported by the Confederation.

As for communes, they supply companies with subsidies and loans' guarantees. Moreover, communes themselves can be recipients of LIM loans granted by the federal and cantonal authorities (art.4 LIM). Nonetheless, a distinguishing feature of the financial support provided by communes is that it seems to have also taken the form of an important shareholding in companies. For the financial year 2002/03, average shareholding of communes in the cableway sector was 20% (SBS 2004). The highest values are reached in cantons with the companies' worst financial situation.

### 2.3.2 Recent evolution of the authorities' support

At times, the institutional framework changes, as illustrated by the moratorium on the federal LIM loans launched by the Seco at the end of 2002. The objective of the moratorium was to put an end to the so-called "sprinkler principle" in the ski lift sector[20]. It intended to compel cantons to (re)define their strategies towards the branch. Following the Seco's decision, in-depth analyses of the sector were carried out in most of the relevant cantons. They gave rise to reports which detailed proposals for future strategies[21]. These reports were meant for the decision makers at the political level, and were the bases on which the new cantonal strategies were built – at times they even composed parts of the strategies.

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[19] Actually, as already mentioned, the LIM law already establishes the canton as the guarantor of half of the federal loan, since it has to reimburse half of it to the Confederation in case the debtor does not repay it.

[20] A first letter devised by the Seco launched the moratorium at the end of 2002 and asked the relevant cantons to develop a strategy for their ski lift branch. One year later, a second letter clarified the requirements in order to lift the moratorium.

[21] The references of these reports are given in the bibliography for the following cantons: Grisons (Grischconsulta's report), Valais (Vikuna's report), Vaud (Furger's report) and Fribourg (HEVs's report).

#### *2.3.2.1 The new cantonal strategies*

The new cantonal strategies define the criteria that both the claimant and his investment project must satisfy in order to be granted financial support from the federal LIM fund. These new strategies differ, since the role of the ski lift branch in mountain regions, the companies' financial situation (i.e. the origins of their financial difficulties, the severity of the problem and the type of companies concerned), the location of the ski areas with respect to each other, etc. change from one canton to the other. As we will see in subsection 3.1, support to investments through the LIM law (federal loan and its cantonal counterpart) accounts for the major part of overall financial support yet provided to snowmaking projects at cantonal and federal levels. Therefore, it is of some interest to describe more precisely these new strategies[22]. For six cantons, the following table displays some of the conditions that must be respected in order for the claimant to be granted a federal LIM loan:

[22] Moreover, these strategies are generally also used as a guideline to appreciate the requests for the cantonal support that is not attached to the LIM law.

| Conditions... | ...placed on the... | Bern | Fribourg | Grisons | Saint-Gall | Valais | Vaud |
|---|---|---|---|---|---|---|---|
| Writing up a business plan | ...claimant | ● | ● | ● | ● | - | - |
| Professionalism of the board of directors and/or of management | | ● | - | ● | - | ● | - |
| Company's size | | ● | - | ● | - | - | ● |
| Specific location[23] | | - | ● | - | ● | - | - |
| Integration in a destination's/regional marketing | | ● | - | ● | ● | - | - |
| Following a strategy aimed at improving the operating margin (within the firm) | | - | ● | - | - | - | - |
| Involved in a vertical reconfiguration process | | ● | - | ● | ● | - | - |
| Involved in a horizontal reconfiguration process | | ● | ● | ● | ● | ● | ● |
| Financial health after investment | ...project | ● | ●[24] | ● | ● | ● | - |
| Required % of self-financing vs maximum % of support[25] | | - / - | - / - | var. / max 35%[26] | 40%/ - | -/ max 50% | - / var.[27] |
| Required guarantee from the commune(s) | | - | ● | ● | - | - | ● |
| Integration in a global investment strategy (at the ski area or connected ski areas' levels) | | ● | ● | ● | ● | - | ● |

***Table 2.1*** *- Example of conditions that the claimant and his investment project must satisfy according to the new cantonal strategies.*

The fact that production structures are suboptimal in the branch – a widely shared opinion among specialists – is reflected in the fact that all of the six cantons link the acceptance of the company's request to the proceeding of cooperation or merging strategies (horizontal reconfiguration in order to exhaust the "economies of scale")[28]. Such strategies also guarantee a trend towards more professionalism in the company, which is otherwise somewhat difficult and sensitive to assess[29]. On the other hand, the reviewed cantons do not systematically refer to vertical reconfiguration as a condition (exploitation of the "economies of scope"). This is an interesting and striking feature since a recent study (Laesser et al. 2004) tends to prove that, among diverse conceivable business reconfiguration

[23] In addition to the fact that the company must be located in a LIM region.

[24] Only required for snowmaking equipment.

[25] In this context, the term of self-financing not only means retained earnings but retained earnings and the new issuing of shares.

[26] The required percentage of self-financing depends both on the financial situation and the size of the company. The figure of 35% concerns the federal LIM loan (no cantonal LIM loans are granted in Grisons).

[27] The involvement of authorities in a project's financing depends on the financing ability of the claimant.

[28] This is not the only possibility for cantonal authorities to give incentives to companies located on their territory to merge or cooperate more closely. For instance, the canton of Valais has set other incentive measures in order to encourage the structures' adaptations in the sector. These are: the financing of cooperation/merging studies, tax relief in case of merging, and a higher participation by the authorities in the financing of projects that leads to a tighter cooperation between companies. Very importantly, the banks, through more stringent loan policies, also provide very strong incentives to companies to adapt and optimize their structures.

[29] In Valais, the institution in charge of evaluating the request for a LIM loan systematically asks for the curriculum vitae (or the professional experience) of the board of directors' members. The central elements that are taken into account when assessing the professionalism of the board of directors are: 1/ the number of persons in the board of directors, 2/ the education and experience of each member of the board together with their relative complementarity, and 3/ their local, regional or international origin.

measures, it is vertical reconfiguration – ranging from cooperation to integration on a destination level – that should lead to the best results in terms of cash flow increase and therefore in terms of viability enhancement in the cableway sector[30].

Another recurrent criterion is that the company must play an important role at regional scale in order to be supported (linked to the company's size or the specific location criteria in *table 2.1*). An exception to this principle can nevertheless be made if it is proven that a small company plays an important role in the renewal of the ski lift sector's customers. In general, it is admitted in the new cantonal strategies that transport infrastructure must be maintained in mountain regions that rely heavily on winter tourism even though snow conditions are not secure anymore in these regions. As a result, cantonal strategies do not generally set the present or future snow-reliability of the ski area operated by the claimant as a requirement in order to be granted the authorities' support. On the contrary, the poor and/or deteriorating snow conditions[31] are commonly used to motivate authorities' support towards snowmaking projects, with the noteworthy exception of the Saint-Gall canton that has a priori excluded two companies from being supported for any type of projects promoting skiing activities, because they already operate ski areas that are not snow-reliable enough[32]. Another common feature regarding snowmaking is that authorities only deal with snowmaking investments that are compatible with companies' strategies contained in their business plans and that aim at securing snow conditions on the busiest ski runs. This last feature translates the economic importance of projects that aim at securing snow cover during the winter season on the busiest ski runs. Such an economic importance is also taken into account in regional development policies, which generally allow the competent authorities to give the planning permission for such projects, given that a set of requirements is fulfilled. This example sheds light on the (unsurprisingly) existing consistency between the new cantonal strategies and the principles set in the regional development policies. Obviously, only projects that respect the principles and procedures set in the regional development are those that can be financially supported. Respecting the regional development's principles is therefore more or less explicitly stated in the new cantonal strategies. In the framework of *table 2.1*, these principles can be seen to add some additional criteria, mainly regarding the nature of investment projects, even though they apply to all investment projects carried out by the ski lift branch (and not only to those projects co-financed by the authorities). These requirements placed on projects by regional development laws imply that the claimant must justify the project from an operational perspective, demonstrate that snowmaking facilities will be appropriately located in a regional development perspective (respect of land-use maps and concepts) and must prove that environmental impacts are limited.

Finally, it is sometimes required that federal LIM loans be guaranteed by the communes, as shown in *table 2.1*. This criterion directly follows from article 12 of the LIM law which stipulates that the cantons make sure that the guarantees

[30] This is even more the case if horizontal reconfiguration measures confine themselves to cooperation.

[31] It must be noted, however, that the notion of "poor snow conditions" is sometimes more relative than absolute. For instance, in the canton of Bern, one argument to financially support snowmaking investments is that snow conditions are less satisfactory than in the competing cantons of Grisons and Valais.

[32] For the Valais, the Vikuna report states that ski lift companies without snow-reliable ski areas should not be financially supported (Zurschmitten and Gehrig 2004). The cantonal guidelines then do not explicitly name snow reliability as a necessary condition to be fulfilled in order to receive the LIM support.

given for the federal LIM loans are sufficient. For a given canton, the fact to rely on the communes in order to secure the federal LIM loan seems to depend on several factors: the financial health of the communes, the general level of requirements for granting LIM loans, the difficulty for the canton to obtain guarantees of same rank than other creditors (banks), the will of cantonal authorities to strongly involve local authorities in the local development and/or to involve them in the process of supporting investments.

#### *2.3.2.2 Consequences of the new cantonal strategies on authorities' support*

What these observations bring out is that cantons are not operating a selection between "viable" and "non viable" companies in order to concentrate their support on viable ones. Although very small companies (transport revenues<0.1 Mio CHF) are not supported, this is not due to their financial situation but rather to their very limited economic impact. For the same reasons, small companies (0.1 Mio CHF<transport revenues<1 Mio CHF) are not supported or (as it occurs more often) are subject to more restrictive conditions than those faced by large companies[33]. For instance, the new cantonal strategy of the Bern canton states explicitly that companies generating (total) revenues of less than 1 Mio CHF cannot be supported for their snowmaking projects. Even those companies recognized to be endowed with particularly unfavorable snow conditions and therefore hardly "viable" are not automatically excluded from the set of potential beneficiaries[34].

Furthermore, the use of financial ratios as a criterion must be interpreted with caution. In the majority of cantons, it is true that the claimant must satisfy a set of financial requirements, but these requirements can be accommodated depending on the company and region's global situation and future prospects.

Cantons have rather used financial reliance of the branch on authorities' support as an instrument to induce changes within the societies and the branch. By resorting to such an approach, authorities aim at improving the financial situation and competitiveness of the whole sector in order to ensure its presence in mountain regions. With such improvements, the reimbursement of granted loans also becomes easier. Of course, this orientation of new cantonal strategies is not very surprising given the purpose of the LIM law: to create favorable conditions for economic development and to increase competitiveness of mountain regions, to maintain a decentralized occupancy of the territory, to insure the sustainable development of mountain regions, etc.

### 2.3.3 Future evolution of the authorities' support

A new federal policy, regarding the issues at stake for regional development, is announced for 2008. The new federal regional policy aims at increasing the competitiveness of some specific areas, thereby indirectly contributing both to the protection and creation of jobs in these areas and to the balanced development of Swiss regions and cantons. In

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[33] Looking at the distribution of company sizes in the sector, it is worth noting that, under the new cantonal strategies, a large proportion of companies from the cableway branch are concerned with either exclusion from support or faced with additional criteria applied to the claimant's request. However, this does not automatically mean that these companies were supported before the Seco's moratorium (refer to the analysis of the companies that have been supported for their snowmaking projects carried out in subsection 2.4.4).

[34] However, in some situations, support they can ask for might only concern very innovative and promising projects aimed at developing new activities (i.e. projects that allow them getting out of the skiing business).

response to this future orientation, some cantons have decided to revise their legislation dealing with themes like economic promotion and regional development.

One strategy included in this new regional policy is to promote programs and projects that reinforce the value added chain within mountain and rural areas. Since ski area operation companies are at the root of tourism development and play a central role in the value added chain of many mountain areas, it is foreseeable that they will also be supported under this new federal framework. Because the emphasis is clearly made on supporting those projects that reinforce the value added chain, we can state that the new regional policy will be in concordance with new cantonal principles for the granting of support to ski area operation companies. For that matter, it is expected that those principles will remain unchanged under the new federal regional policy. Financially speaking, projects will still be financed by the Confederation, through the LIM fund, and by cantons. The principles enforced under the LIM law will still be applied, namely the equivalence principle.

## 2.4 Description of the authorities' support towards snowmaking

Before presenting the figures of support towards snowmaking projects, one digression is needed. Actually, one can argue that the ability of companies to finance their snowmaking projects in the past did not strictly depend on the amount of money directly granted to snowmaking projects, but rather on the overall amount of money granted by the authorities to such companies. As we will see, the amount of federal money that has been granted at sector level to finance investments in transport infrastructure is much higher than the amount of federal money granted for snowmaking projects (approximately in a 80%/20% proportion for the last 10 years). In this case, is it really relevant to look exclusively at support provided for snowmaking projects? What should be emphasized here is that investments made in transport infrastructure are obviously much more important than those made in snowmaking facilities over the last 10 years (i.e. indicating that the average percentage of public financing is probably not so high for the transport infrastructures)[35]. So we cannot assert that authorities, through their assistance to transport infrastructure, have indirectly financed snowmaking facilities. And, at the company level, we should not forget that those that needed public money to finance their transport installations are generally the same that needed support from the authorities to finance their snowmaking facilities. For these reasons, hereafter we concentrate on authorities' financial support to snowmaking projects only.

### 2.4.1 Current state of support

According to Grischconsulta (2002), about 70% of ski area operation companies endowed with snowmaking facilities during the winter season 2001/02 had benefited from or were benefiting from authorities' support towards artificial snow cover use (the concept of support being understood here in very broad terms). One has to note, however, that only 13% of companies endowed at this date with snowmaking facilities had taken advantage of at least one lump sum monetary assistance, generally granted to help finance snowmaking equipment, while only 4% had benefited or were

[35] Indeed, a ceiling is sometimes fixed to the percentage of public financing in the projects carried out by the cableways companies (as shown in *table 2.1* for the new cantonal strategies).

benefiting of at least one regular financial support to operate their snowmaking facilities. Therefore, it must be clear that most of the companies simply took advantage of the favorable general conditions set up by authorities towards snowmaking investments (administrative facilities, rights on some water resources, etc.), whereas only a few of them have received financial support. Another important feature revealed by this study was that 78% of the ski area operation companies that have been financially supported when investing in snowmaking facilities have received support at the communal level. Of course, this does not tell us anything about the amount that was obtained through the communal channel nor whether this support was more important in some regions than others. However, it clearly demonstrates one more time the interest and commitment of the communes for the ski lift branch and the complementarity of the communal support with respect to the cantonal and federal supports.

The current state of cumulated direct support in the field of artificial snow cover investments at cantonal and federal levels are given for seven cantons in *table 2.2*.

| | Nbr of beneficiaries[36]/ Nbr of projects | Federal LIM loans (Mio CHF) | Cantonal support through the LIM law (Mio CHF) | | Other cantonal support (Mio CHF) | |
|---|---|---|---|---|---|---|
| | | | Loans | Subsidies | Loans | Subsidies |
| Bern[37] | 3 / 3 | 0.77 | 0.77 | - | - | - |
| Fribourg[38] | 3 / 3 | 1.6 | - | - | 0.49 | |
| Grisons | 8/ 11 | 4.71 | - | 0.83 | - | 0.18 |
| Saint-Gall[39] | 2 / 2 | 1.7 | - | 0.33 | - | - |
| Ticino[40] | 1 / 1 | 0.53 | - | 0.53 | - | 0.53 |
| Valais | 10[41] / 12 | 4.87 | 6 | - | - | - |
| Vaud[42] | 2 / 2 | 3.9 | 0.2 | - | 4.3 | - |
| **Total** | **29 / 34** | **18.08** | **6.97** | **1.69** | **-** | **-** |

***Table 2.2*** *- Cumulated direct support at federal and cantonal levels for snowmaking projects in several Swiss cantons (state at the end of 2006). All loans are interest-free.*

*Table 2.2* illustrates some very important features of the legislative backgrounds that were previously presented. For instance, the diverse mechanisms of cantonal counterparts to federal LIM loans are visible. When the equivalent contribution is exclusively composed of cantonal LIM loans (as is the case in the Bern and Valais cantons), then *table 2.2* shows that the amount of these loans is greater or equal to the amount of the LIM loans granted at federal level

36 In general, these are the ski lift companies themselves. Other possible entities are communes.

37 In accordance with the new cantonal strategy, support for snowmaking facilities in this canton is granted when this investment is included in a larger project aimed at modernizing the company's ski lifts. Since 2004, this has happened only three times and no snowmaking projects were supported before. Overall support granted to these three projects (LIM loans) amounts to 10.6 Mio CHF distributed between the three beneficiaries. The only available fact is that support is primarily devoted to transport infrastructure. Hence, the amount displayed for LIM loans is an estimate.

38 The cantonal support of 0.49 Mio CHF incorporates both an interest-free loan and the amount of two subsidies aimed at decreasing the burden linked to interest payments. The latter have duration of 6 resp. 12 years. Two companies benefit from these subsidies that were not entirely paid at the end of 2006. In this canton, we also know that two companies have benefited from communal subsidies that amount to 0.37 Mio CHF.

39 The row values are estimates. One of the two projects that were supported in the Saint-Gall canton includes both the renewal of a chairlift and the extension of the artificial snow cover use. Nearly half of the project's costs were devoted to renew the chairlift. Therefore, as a crude estimate, half of the support allocated to this project was considered granted to snowmaking facilities.

40 Moreover, cantonal authorities stand as security for the entire federal LIM loan granted to the beneficiary.

41 The number of beneficiaries could be 11 instead of 10. This uncertainty has arisen since two projects have been supported in one or possibly two different companies that have since merged with other companies to form one relatively "big" company. Information given at the cantonal level for these two projects does not allow removing this uncertainty.

42 Besides a very high level of financial involvement in the supported projects (see *table 2.4*), one reason for the fact support in the canton of Vaud is large is that additional investments are also supported within snowmaking projects (snow cats, shelters and improvement of existing installations).

and that no other cantonal support is provided. *Table 2.2* further shows that when the canton does not grant cantonal LIM loans, then it can provide an amount of support at least equivalent to that allocated by the Confederation, by making use of subsidies in the context of the LIM law (Grisons, Saint-Gall, Ticino). Finally, a canton can also contribute to the financing of a given project through its tourism equipment fund (Vaud, Fribourg, Grisons, Ticino). Taking the Ticino canton as an example, *table 2.2* shows that on top of support provided through the LIM law, there is also cantonal support coming from the cantonal equipment fund. This extended support is also visible in *table 2.4* (i.e. among the reviewed cantons, Ticino is the one that finances the highest percentage of supported projects). Globally, the LIM law is by far the major channel through which financial support is being provided to snowmaking projects at cantonal and federal levels. A cantonal tourism law can also be a complementary channel for financial support – or even an alternative channel for those projects falling outside the scope of the LIM law, as was observed for two cases in the Fribourg and Grisons cantons.

*Table 2.2* provides a rather good overview of the nation-wide support towards snowmaking at cantonal and federal levels, as the ski lift companies located in the listed cantons generate nearly 85% of the Swiss ski lift branch's total earnings in 2002. Since the mid-seventies, we can estimate the value of cumulated interest-free loans granted for snowmaking at federal and cantonal levels in Switzerland to lie around 35 Mio CHF (including 20 Mio of federal LIM loans). Subsidies granted at cantonal level and already paid to the companies at the end of 2006 are more modest and can be estimated to represent 3.5 Mio CHF[43].

Making use of the 20 Mio CHF estimate in conjunction with values of cumulated LIM loan payments made to the ski lift sector at federal level, we can deduce that roughly 15% of overall amount of LIM loans provided by the Confederation for investments in the ski lift branch has been devoted to artificial snow cover projects[44]. Nevertheless, one has to keep in mind that 15% being the estimate of the proportion of the overall amount of federal loans devoted to snowmaking since the LIM law was launched in the mid-seventies, it would surely have been higher if, for instance, we had restricted ourselves to the last decade. Indeed, our information indicates that snowmaking projects have begun to be supported only starting the mid-nineties onward. However, this proportion does not increase sharply and raises around 20% when we consider LIM loan payments from the mid-nineties only. The reason for this is that LIM loan payments have precisely increased sharply since the mid-nineties, this trend having stopped with the Seco moratorium at the end of 2002. These results have to be compared with the evolution of snowmaking investments in Switzerland. *Figure 2.2* shows how the resort to snowmaking increased since 1990 in Switzerland.

[43] The estimates in this paragraph were computed by applying the multiplying factor $(0.85)^{-1}$ to *table 2.2* totals.

[44] The values of cumulated LIM loan payments at federal level were found in Mordasini (2004).

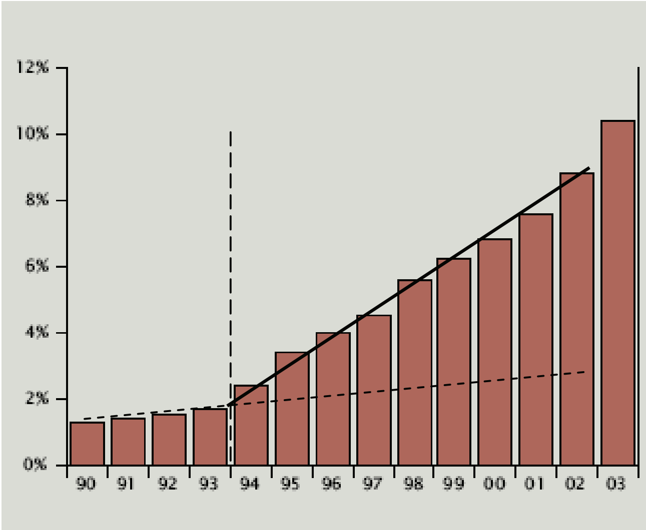


***Figure 2.2*** - *Artificial snow cover concerns an increasing part of the overall area of prepared ski trails in Switzerland. Source: SBS (2004).*

One can observe that the proportion of the overall area of prepared ski trails concerned with artificial snow has increased at a steeper rate since the mid-nineties. This means that yearly investments in snowmaking have suddenly sensibly increased. To some extent, this development was made possible by public support. At least, the State has adapted its support in order to take into account massive needs for investments in snowmaking at the sector level. This fact has surely contributed to the very strong increase in the amount of federal LIM loans granted during the 1995-2002 period.

Another way to look at support is to note that at most 35 companies have taken advantage of the authorities' financial support towards snowmaking. Furthermore, the percentage of investment financed by authorities in the supported projects is relatively high, with a value of 34% on average (without the communal level). Let us also emphasize the fact that the projects that have received support have generated a global investment of around 110 Mio CHF, which only represents roughly 10% of the cumulated amount of investments towards snowmaking in Switzerland. To make another comparison, we could also mention that 110 Mio CHF was roughly the amount of money invested by ski area operation companies in the Grisons canton for snowmaking facilities during the 1994/95 to 1998/99 winter seasons (Zegg 2000). Last but not least, we must be aware that the figures in *table 2.2* regarding authorities' support will rapidly increase, at least in some cantons. This last point is suggested by the yet limited overall number of supported projects and the fact that regional development requirements have only been reached in some regions.

### 2.4.2 Equivalent subsidies of the cantonal and federal support

Interest-free loans are a very important instrument used by authorities to foster investments towards snowmaking. Therefore, it is essential to deduce the amount of subsidies which are hidden behind these repayable loans. Actually, an interest-free loan provides a flow of subsidies to its beneficiary. At each period, the subsidy is equal to the interests not recovered by the creditor on his loan. Our aim in this subsection is therefore to compute the discounted value of the flow of subsidies related to each one of the granted interest-free loans and “Zinskostenbeiträge”. Adding these discounted values to the other subsidies would result in an overall assessment of the (equivalent) subsidies granted at cantonal and federal levels for snowmaking projects.

One possibility to estimate the equivalent subsidy of a given interest-free loan is to use the simple discounting formula given in equation 2.1. It is simple both because the depreciation of the loan is taken to be linear and because the discounting rate and mortgage rate are considered to be equal and constant. In order to use it, we need to know the value and time length of the interest-free loan. Moreover, we need to determine the mortgage rate. The latter information is obviously more difficult to obtain than the former. As previously emphasized, the Seco currently uses a 3.5% interest rate when using the discounting formula as a way to derive the equivalent cantonal contribution to a federal LIM loan. Nonetheless, this interest rate was noticeably higher when market rates were at their peak values during the very beginning of the nineties, meaning that the interest rate used in the formula is modified when significant changes occur on the market for mortgage loans. We also remember from footnote 6 that the canton of Saint-Gall chooses the variable mortgage rate for first rank security applied by the cantonal bank when determining the “Zinskostenbeitrag” at each period. This way of determining the cantonal subsidy at each period emphasizes even more the fact that it is important to take into account market rates actually available to the beneficiary of a federal LIM loan. In the context of the VAT treatment of interest-free loans, the same logic is applied to determine the subsidy associated to them[45]. The rate that is chosen to compute the (annual) subsidy related to an interest-free loan is the variable mortgage rate for first rank security asked by the bank with whom the beneficiary of the interest-free loan keeps steady business relations, or by which he is a mortgage debtor. Taken altogether, these elements motivate us to use, in the discounting formula of subsection 2.3.1.2, the variable mortgage rate for first rank security applied by the cantonal bank during the year the loan was granted (mean value).

In the discussion of the previous paragraph, the interest rate that is considered is always the one that applies to a company with the best score in a given credit rating system. Since the differentiated rates were introduced in Swiss banks around the mid-nineties and nearly all of the loans that we are considering were granted since this period, we consider logical to take into account the credit scores of the beneficiaries when assessing the equivalent subsidies related to interest-free loans. Of course, no knowledge on the credit score of a given company can be obtained from banks. This is the reason why, instead, we will try to use the credit score assigned to the majority of ski lift companies by the cantonal bank (at the time the loan was granted) to derive the mortgage rate(s) for each relevant canton. However, it happens that even this information is sometimes considered confidential and is not communicated by all cantonal banks. In this case, we simply add a risk premium of 0.5% to the basic level of the mortgage rate.

*Table 2.3* provides the values of equivalent subsidies for interest-free loans and the “Zinskostenbeiträge”, along with the assessment of overall (equivalent) subsidies granted at cantonal and federal level for snowmaking projects in six different cantons.

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[45] Information concerning the VAT treatment of interest-free loans is given in a brochure edited by the Swiss federal tax administration (cf. chif. 1.2.3.5 of AFC (2008)).

| | a) LIM loans federal | a) LIM loans cantonal | b) Other cantonal loans | c) Zinskostenbeiträge - LIM canton – | b) LIM subsidies - canton – | e) Other cantonal subsidies | Total a+b+c+d+e (Mio CHF) |
|---|---|---|---|---|---|---|---|
| Bern | 0.22 | 0.22 | | | | | 0.44 |
| Fribourg | 0.45 | | 0.04 | | | 1.02 | 1.51 |
| Grisons | 0.93 | | | | 0.83 | 0.18 | 1.94 |
| Saint-Gall | 0.68 | | | 0.50 | 0.24 | | 1.42 |
| Ticino | 0.22 | | | | 0.53 | 0.53 | 1.28 |
| Valais | 1.60 | 1.91 | | | | | 3.51 |
| **Total** | **4.10** | **2.13** | **0.04** | **0.5** | **1.6** | **1.73** | **10.10** |

***Table 2.3*** - *Equivalent subsidies computed for interest-free loans and "Zinskostenbeiträge" in six different cantons. The column "Total" gives the estimate of the overall (equivalent) subsidy granted for snowmaking projects in these cantons (state at the end of 2006).*

At the end of 2006, we can estimate the cumulated value of the equivalent subsidies associated to the interest-free loans and "Zinskostenbeiträge" granted for snowmaking projects at federal and cantonal levels in Switzerland to lie around 8.5 Mio CHF. The cumulated value of the other subsidies is estimated to be equal to 4 Mio CHF. Therefore, the overall equivalent subsidy granted in Switzerland for snowmaking projects is approximately equal to 12.5 Mio CHF[46]. When focusing on the last column of *table 2.3*, we clearly distinguish three different types of cantons. In concordance with the previous results, Bern is the reviewed canton where the financial support is the smallest. However, this conclusion is somewhat surprising given the share of the Bernese cableway companies in the sector's total revenue and the fact that the Bernese ski resorts are told to have worse snow conditions than ski resorts located in the Valais and Grisons cantons. A second group is formed of several cantons: Fribourg, Grisons, Saint-Gall and Ticino. In this group, the overall equivalent subsidy ranges from 1.28 to 1.94 Mio CHF. Finally, the canton of Valais clearly distinguishes itself from the first two groups. By far, it displays the highest overall equivalent subsidy. The financial support granted in Valais is approximately 2.5-fold that granted in the cantons of Fribourg, Saint-Gall and Ticino and 8-fold that granted in the canton of Bern. Moreover, this value is 81% higher than the overall equivalent subsidy of the Grisons canton. We would not expect such a difference between the cantons of Grisons and Valais by simply looking at the figures of *table 2.2*. This result has emerged mainly because of lower duration of the loans in Grisons compared to the Valais[47]. The following figure sums up all the previous results and discussion in a more attractive way.

[46] The estimates in this paragraph were computed by applying the multiplying factor $(0.80)^{-1}$ to *table 2.3* totals. As the ski lift companies located in the listed cantons of *table 2.3* generate 80% of the Swiss ski lift branch's total earnings in 2002, we use this multiplying factor in order to extrapolate values of the equivalent subsidies for Switzerland.

[47] In general, duration of the LIM loans granted for snowmaking projects is 15 years in Valais versus 10 years in Grisons.

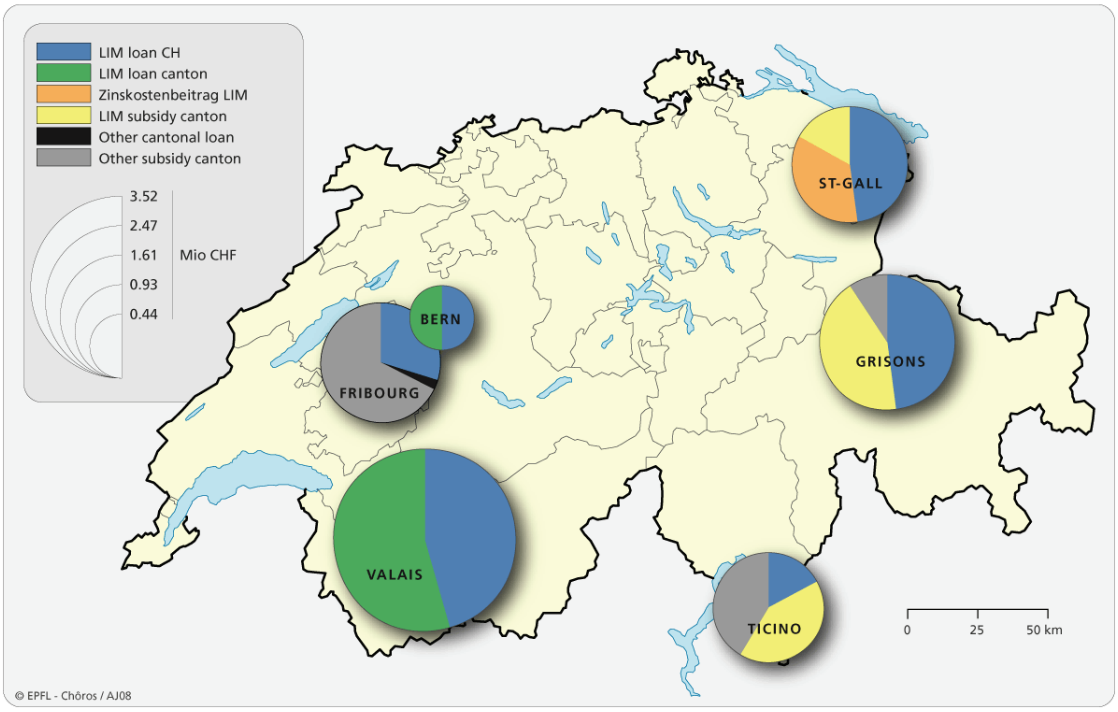


***Figure 2.3*** *- Equivalent subsidies given for different sorts of financial support in six different cantons.*

There are several shortcomings to the method we have chosen to use in order to compute the equivalent subsidies. On the one hand, we do not know the effective depreciation scheme applied to LIM loans and it may not necessarily be linear. On the other hand, our method does not allow taking into account the cases in which the first reimbursement is deferred. For this reason, we tend to underestimate the equivalent subsidy for two of the three supported projects in the canton of Bern because of the two and four years' deferments of the first payments associated to the granted loans. Finally, the mortgage rate is considered to be constant with the consequence that the subsidy at each period only varies because of the loan depreciation. This is obviously not what occurs in reality. Not only do conditions on the monetary markets that determine interest rates change, but the score of a given company in a credit rating system may also change. This could be the case, for instance, when a company that benefits from a LIM loan merges with one or several other companies. Another possible way for the mortgage rate to vary is when the risk-adjusted pricing applied by the bank changes during the loan's duration (e.g. gradual introduction of risk-adjusted rates or changes in the pricing due to a new rating system).

### 2.4.3 Comparison between cantons

As shown in *table 2.2*, financial support varies from one canton to another with respect both to the amount and the form of support. Some cantons grant interest-free loans while others grant direct subsidies, some of them do both. This fact prevents making direct comparisons between the financial supports provided in different cantons. Even in the case of two cantons granting only interest-free loans, direct comparison still remains misleading. For instance, the standard duration of LIM loans and the requested guarantees may generally not be the same from one canton to another[48]. In the same way, not all subsidies are directly comparable since some are paid in one lump sum to the company, whereas others are paid over longer periods. These are the reasons why we attempted to derive in the previous subsection an equivalent subsidy to the support given in each canton. Our comparison between cantons is then partly based on these computed equivalent subsidies. Thanks to these figures, we have already shown that the canton of Valais has provided by far the most important amount of financial support to snowmaking projects. Up to now, we have therefore been thinking in absolute terms but we can wonder whether statements such as "the financial support granted in one canton is x-fold that granted in another" helps to uncover possible differences in cantonal authorities' commitment towards the ski lift sector. What we would like to emphasize here is that the comparison between cantons has more sense if we place support in its cantonal context. *Table 2.4* provides such an analysis by looking at the degree of involvement of the cantonal and federal authorities in the investments towards snowmaking made in each of the seven cantons mentioned in *table 2.2*.

| | Ratio of number of beneficiaries to number of companies with snowmaking facilities | % of the authorities' financing in the supported projects[49] | Ratio of induced investments to total investments | % of the total cumulated public aid to artificial snow cover investment |
|---|---|---|---|---|
| Bern | *13%* | *12%* | *7%* | *3.5%* |
| Fribourg | *75%* | *32.4%* | *95%* | *12%* |
| Grisons | *23%* | *23%/28%*[50] | *9%* | *15.4%* |
| Saint-Gall | *50%* | *30%* | *26%* | *11.2%* |
| Ticino | *33%* | *74.8%* | *36.5%* | *10.1%* |
| Valais | *25%* | *38.7%* | *8%* | *27.8%* |
| Vaud | *33%* | *80%* | *?* | *?* |

***Table 2.4*** *- For seven cantons, the first column indicates the proportion of companies endowed with snowmaking facilities that have received a support for this sort of equipment. The second and third columns display support towards snowmaking related to the overall costs of supported projects and to the overall investments in snowmaking for the same cantons. The last column shows how the total cumulated public aid to artificial snow cover investment (i.e. the overall (equivalent) subsidy granted in Switzerland) is distributed among the reviewed cantons. All percentages in all columns are referring to the state at the end of 2006.*

*Table 2.4* aims at showing how the dependence to public support changes from one canton to another when it comes to snowmaking projects. The discussion will focus as much as possible on cantons by decreasing order of dependence.

In the Fribourg canton, the presence of snowmaking equipment depends nearly completely on the authorities' support. The importance of support is visible, as the only company that was not supported when investing in snowmaking facilities has invested a negligible amount compared to the others. Furthermore, companies that have been supported

[48] As mentioned earlier, the canton can stand as guarantor for the entire federal loan which can be viewed to create another flow of subsidies in favor of the ski lift company. In this work, we will however not take into account this kind of subsidy, partly because in practice it is more common that communes stand surety for the federal interest-free loans.

[49] In this column, the financing of the snowmaking projects through authorities' support does not take into account subsidies in the form of "Zinskostenbeiträge".

[50] The first percentage is given for all the projects. The second percentage is given only for supported projects in the LIM regions (i.e. for the supported projects that also benefit from federal LIM loans).

have only invested once in snowmaking facilities, thereby being totally dependent on support provided by authorities for their investments in snowmaking.

In the Vaud canton, until recently ski areas were barely equipped to produce snow, but the situation has changed due to several large investments (Leysin, Les Diablerets-Meilleret). Further investments will soon take place in another ski resort (Villars) and adequate land-use maps and concepts are currently being drawn in other important ski resorts of the canton. In *table 2.4*, the commitment of cantonal authorities is visible from the fact that they have contributed a very high proportion of the money needed to finance the supported projects. This situation is expected to continue, since the principle of a variable intervention rate is included in the new cantonal strategy. It allows supporting companies with the worst financing ability, through more means. For these reasons, we can assert that the authorities' support plays a crucial role in this canton as well. This is also true for the Ticino canton that seems to share the same features as the canton of Vaud regarding support allocated to snowmaking projects.

In the Valais, although induced investments only represent a modest part of global investments for snowmaking, 25% of companies currently endowed with snowmaking facilities have benefited from authorities' support since the mid-nineties. This means that the authorities' support has sensibly helped companies to begin or carry on their investments towards snowmaking in a period characterized, at the sector level, by a decreasing financing ability. These observations can also be applied to the canton of Grisons, the only difference being that participation in supported projects (when computed as in column 2 of *table 2.4*) is clearly smaller than in the Valais. This difference is due to the previously mentioned nature of cantonal counterparts to federal LIM loan: the canton of Valais has granted 6 Mio CHF of interest-free loans which must be paid back by companies, whereas the canton of Grisons has given a bit more than 1 Mio CHF worth of subsidies to supported companies.

Compared to the cantons reviewed above, the canton of Saint-Gall is halfway between the two extremes, without clear-cut characteristics – namely because snowmaking investments concern two very different regions within the Saint-Gall canton that have very different financing ability[51]. As a consequence, its pattern of support shares some aspects of support provided to the sector in the cantons of Grisons and Valais, as well as some characteristics that make it similar to support provided in the cantons of Vaud and Ticino.

Bern comes in at the tail end of all cantons, for different reasons. In the first place, there are a limited number of projects that can be supported since the rule is that no support is allocated to snowmaking projects alone[52]. A priori, this rule can exclude many small and medium sized companies from being supported. It seems that this is what actually occurred in reality, since transport revenues generated by the "smallest" company among the three beneficiaries listed in *table 2.2* amount to approximately 8 Mio CHF. The fact that only "big" companies have yet taken advantage of the authorities' support for their snowmaking projects could probably explain the small percentage of

[51] The Pizol and Flumserberg ski areas on the one side and the Obertoggenburg ski areas on the other side. The two supported projects were located in the latter region.

[52] In theory, this is not exactly true. The new cantonal strategy allows supporting pure snowmaking projects when no greater investments for transport infrastructure are foreseen in the midterm.

authorities' financing in supported projects because of their strong financing ability. Even more probable is the fact that the percentage of authorities' financing in supported projects was relatively small due to the very large amounts of the investments. Whatever the reasons, this small percentage is not linked directly to a restrictive rule concerning the maximum percentage the support can represent in the overall investment (such a rule does not exist, as shown in *table 2.1*), but is rather linked indirectly to the restrictive support framework regarding snowmaking projects. In the previous subsection, we have discussed the fact that Bern is clearly the reviewed canton with the smallest support for snowmaking. From *table 2.4*, it also becomes clear that it is the canton where investments towards snowmaking are least dependent on support provided at federal and cantonal levels. Indeed, snowmaking investments realized in the canton of Bern are not smaller (in relative terms) than those that were realized in some other cantons of interest (cf. table 1.2).

How could we explain differences in the policies carried out by the reviewed cantons towards snowmaking investments? Since the Seco moratorium, we note first that policies carried out by the different cantons are quite similar in spirit. However, differences in the new cantonal strategies exist and could potentially rise from many factors including the economic importance of the winter tourism, the financial situation of the cableway companies, the companies' shareholding, etc.

### 2.4.4 Analysis of the beneficiaries

We will make this analysis according to the company's size[53]. Our aim is to identify the classes of company size that have benefited the most from federal and cantonal support for their snowmaking projects. We could then try to determine if the role of the authorities in the adaptation process carried out by ski lift companies is different from one class to another. *Figure 2.4* and *figure 2.5* sum up some useful information.

[53] As in the general introduction to the thesis, the size of a company will be determined by looking at the amount of its transport revenues. Moreover, the accounting year used to derive the amount of transport revenues for a given company will normally correspond to the year in which the company has received the authorities' financial support.

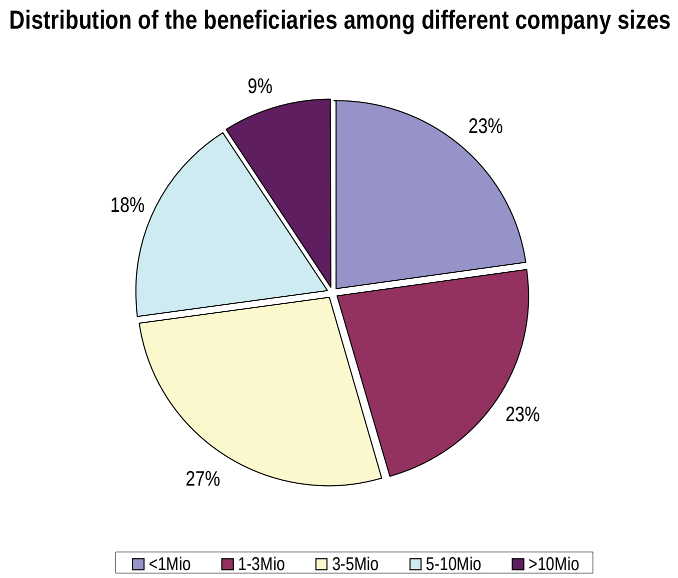


***Figure 2.4*** *- Distribution of beneficiaries of federal and/or cantonal support among different company sizes. The sample is constituted of 22 companies.*

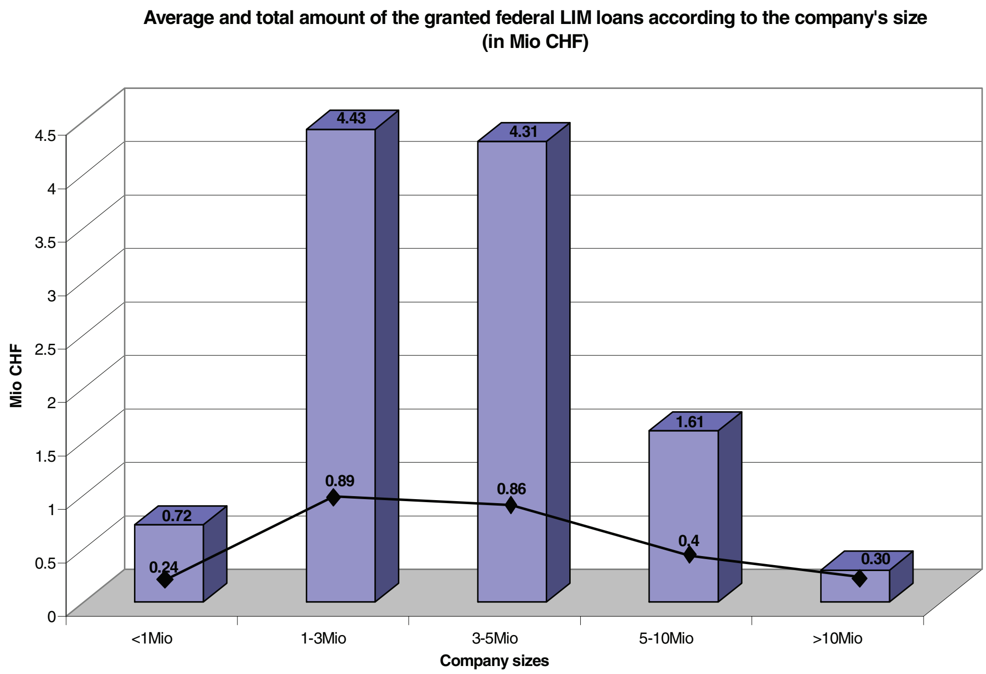


***Figure 2.5*** *- Distribution of federal LIM loans among different company sizes. The sample is constituted of 18 companies.*

Looking at *figure 2.4*, a question we can immediately ask is whether the pattern of support follows the pattern of sizes in the ski lift branch[54]. In other words, is the distribution of beneficiaries among different company sizes representative of the distribution of the sector's companies among the same classes? The answer clearly is no: statistics given by SBS show that 77% of companies in the cableway branch have generated transport revenues smaller than 1 Mio CHF in 2001. However, only one fourth of the beneficiaries are part of this class (23% to be exact). In the same way, SBS indicates that 7% of companies from the cableway sector have generated transport revenues higher than 5 Mio CHF in 2001. The latter class represents 27% of beneficiaries, from which 9% is attributable to companies with transport revenues above 10 Mio CHF. 50% of beneficiaries are therefore companies with transport revenues ranging from 1 to 5 Mio CHF, although companies of that size represent less than 20% of the total number of companies[55]. However, one has to note that the companies with transport revenues smaller than 1 Mio CHF only have accounted for 14% of overall transport revenues generated at the sector level, while companies with revenues higher than 5 Mio CHF have accounted for 60% of overall transport revenues generated at the sector level in 2001. In other words, the companies that generate most of the sector's revenues have taken a greater advantage of support granted towards snowmaking.

To complete this analysis, we need to look more precisely at the amount of money actually granted according to the company size, since both the investment value and the authorities' part in financing investment change from one supported project to another. *Figure 2.5* presents how federal LIM loans granted to 18 companies are distributed among different company sizes. At first glance, the major elements displayed in *figure 2.4* are also present in *figure 2.5*. For instance, both figures display the very small support provided to companies with transport revenues >10 Mio CHF. As shown in *figure 2.4*, there are very few companies of this class that are supported for their snowmaking projects. This fact must be linked to their good financing ability both in terms of self-financing (cash-flow) and access to bank loans and is also probably due to the restricting aspect of LIM loan on the payments of dividends. *Figure 2.5* then confirms that the amount of federal loans granted to this class of companies has been limited. Note however that the limited amount of federal loans display in *figure 2.5* is also due to the nature of the supported project[56]: the latter concerned both transport and snowmaking facilities but the support was primarily devoted to the transport facilities[57]. Despite their similarities, there are also some differences between *figures 2.4* and *2.5*. One thing that becomes clear when looking at *figure 2.5* is the very small amount of money granted to companies with <1Mio though companies of this class represent 23% of the beneficiaries according to *figure 2.4*. Probably due to their limited economic importance and reimbursement capacity, the small companies that received support for their snowmaking projects were only granted very small amounts of money. Finally, the average amount of federal LIM loan

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[54] The discussion in this paragraph makes use of the statistics provided by SBS for the cableway sector (SBS 2002). To be more precise, it uses information of the first figure displayed in the general introduction.

[55] Note that *figure 2.4* is obviously only concerned by ski area operation companies. Therefore, the differences in the percentages could be a little bit different from those presented if we were comparing our results to the distribution of size among the subset of companies operating a ski area. The latter information was not available.

[56] In our sample of 18 companies (used to construct *figure 2.5*), only one company has transport revenues higher than 10 Mio CHF.

[57] Indeed, the project took place in the canton of Bern. The main condition set in the support strategy of this canton towards snowmaking projects is presented in footnote 37.

given to a beneficiary decreases as one moves from the 1-3 Mio CHF class to the 5-10 Mio CHF class of companies. As shown in *figure 2.5*, this feature is particularly visible when we compare the average amount of the federal LIM loans granted to beneficiaries in the 3-5 Mio CHF class (i.e. 0.86 Mio CHF) with the average amount granted to the beneficiaries of the 5-10 Mio CHF class (i.e. 0.4 Mio CHF). This might reflect the poorer financing ability of companies as they become smaller and/or the trivial fact that their snowmaking investments were higher.

Given the preceding facts, can we deduce that the role of authorities in the adaptation process has been more important for some types of companies than others? This is what *figures 2.4* and *2.5* seem to indicate. Both from the number of supported companies and the amount of granted loans' standpoint, ski lift companies with total revenues between 1 to 5 Mio CHF has benefited above all from the public support. This is logical in the sense that we expect companies of this class to have only limited external and self-financing possibilities (i.e. we expect that bank loans do not allow financing completely what self-financing does not cover). Moreover, they generally suffer from a high level of costs that drive their financial results down. With interest-free loans, these companies take advantage of a reasonable increase in their interest charges. Finally, many of these companies aim at developing their ski area before paying dividends to their shareholders, which tends to make the "no dividends rule" less dissuasive.

This analysis of the beneficiaries also allows us to discern some continuity in the ski lift sector's support strategies across time. This continuity is particularly visible in the fact that small companies were only supported in a limited way, even before the new cantonal strategies. Finally, the fact the sector's largest companies did not rely on the authorities' support for their snowmaking investments seems to indicate that the cantons have not chosen the wrong path with their new support strategies (i.e. by promoting the adoption of cooperation or merging strategies or the creation of operating companies).

## 2.5 Main results

Limited self-financing ability and access to bank loans have made public support an important source of finance in the cableway sector. In this context, restrictions placed on the types of potential beneficiaries are of some importance. However, very few classes of companies are automatically excluded from financial support granted by cantonal and federal authorities to the ski lift branch. Even the small companies (companies with transport revenues between 0.1 and 1 Mio CHF) can be recipient to the authorities' support towards snowmaking, although only under very restrictive conditions and for small amounts. Taking the figures given by SBS for the Swiss cableway branch (SBS 2002) and the results of subsection 2.4.4, we can observe that:

- The smallest companies account for around 23% of support beneficiaries (noting on top of that that granted loans were small), whereas they represent 77% of the total number of companies (but only 14% of the sector's revenues).

- Up to now, the bulk of companies having benefited from support for their snowmaking projects were companies with transport revenues ranging between 1 to 5 Mio CHF. These companies represent 16% of the total number of companies and 26% of the sector's revenues.

- Due to their good financing ability and also probably to the very restrictive aspects that support (federal LIM loans) puts on the return to shareholders, large companies were not really concerned by this support.

With new cantonal strategies for the ski lift sector recently developed in each relevant canton, authorities now use the financial reliance of the ski lift sector on their support as an instrument to induce change in the companies' structure (thus acting similarly as all the other sector's lenders). These incentives and conditions set by the sector's financial backers are expected to have a positive effect namely on the midterm operating margins of the companies, which in turn will improve their financing ability. Concerning snow conditions, it is worth emphasizing that cantonal strategies do not generally set the present or future snow-reliability of the ski area operated by the claimant as a requirement in order to be granted authorities' support. On the contrary, insufficient and deteriorating snow conditions are commonly used under the new cantonal strategies to motivate the authorities' support towards snowmaking projects.

Quantitatively speaking, the major findings on support provided for snowmaking facilities in Switzerland are that[58]:

- The cumulated sum of granted interest-free loans can be estimated to be equal to 35 Mio CHF including 20 Mio CHF of federal LIM loans and 8 Mio CHF of cantonal LIM loans. Subsidies granted at cantonal level and already paid to the companies at the end of 2006 are more modest and can be estimated to represent 3.5 Mio CHF. The overall equivalent subsidy granted in Switzerland for snowmaking projects is approximately equal to 12.5 Mio CHF.

- Interest-free loan is the major form of financial support provided to snowmaking projects. The equivalent subsidy of interest-free loans granted at cantonal and federal levels as computed in subsection 1.3.2 is equal to 7.8 Mio CHF. The latter figure is higher than the equivalent subsidy of both lump sum and spread subsidies granted at cantonal and federal levels which is equal to 4.7 Mio CHF.

- The equivalent subsidy of support provided through the LIM law is equal to 10.4 Mio CHF. The support provided to snowmaking projects through the cantonal tourism laws is comparatively small.

- Among the reviewed cantons, the canton of Valais displays the highest overall equivalent subsidy (i.e. 3.51 Mio CHF). Based on these overall equivalent subsidies, we can state that the financial support granted in Valais is approximately 2.5-fold that granted in the cantons of Fribourg, Saint-Gall and Ticino

[58] State at the end of the year 2006.

and 8-fold that granted in the canton of Bern. Moreover, this value is 81% higher than the overall equivalent subsidy of the Grisons canton. This last result has emerged mainly because of lower duration of the federal LIM loans granted in Grisons compared to the Valais.

- As mentioned above, 20 Mio CHF of federal LIM loans have been granted for such projects. They represent 20% of the federal LIM loan payments allocated to the cableway sector since the mid-nineties. This last point is emblematic of a reallocation of a non negligible part of federal support devoted to the mountain regions' development for snowmaking facilities.

- Support has only begun in the mid-nineties and concerns at most 35 companies. These represent 12% of all cableway companies that operate at least one ski trail, and 23% of all companies operating a ski area located in the Alps with at least 3 transport installations and 5 km of ski trails' length[59].

- Supported projects only represent a small fraction (roughly 10%) of all snowmaking investments in Switzerland, which puts reliance on authorities' support into perspective. The average public financing of supported projects lies around 34% (without the communal level).

- However, the fraction of supported projects to total projects in terms of investments could be large in some cantons, such as the canton of Fribourg (95%), Ticino (36.5%) or Saint-Gall (26%). If computed from the mid-nineties, this fraction could also be higher than it is in *table 2.4* for cantons such as the Valais and Grisons, since support figures are important (18 or 19 beneficiaries and 23 supported projects for these two cantons only).

- As shown by the preceding figures, reliance on public support is very distinct from one canton to another and from one period to the other. Furthermore, financial support provided to a given project generally changes from one canton to another with respect to the following aspects: the form and characteristics of financial support, the maximum authorities' share in project financing, the required percentage of self-financing, etc.

Taking all former elements into account, the cantons in which ski area operation companies are most dependent on authorities' support for their snowmaking investments (see subsection 2.4.3) are the cantons of Fribourg, Vaud, Ticino and (to a lesser extent) Saint-Gall. The Valais and Grisons cantons are less dependent, at least when support is compared to investments undertaken since the mid-seventies. Bern is clearly the canton with the smallest support for

[59] The percentages were computed on the basis of the number of companies registered in the 2006 list of members of the umbrella organization *Seilbahnen Schweiz* (SBS). The 23% figure seems more relevant than the 12% figure since the former is the percentage of the companies that could possibly plan a snowmaking project because of their economic importance.

snowmaking, and the canton where the cableway sector is the least dependent on authorities' support for its snowmaking investments.

## 2.6 Conclusion

Due to the shock of successive winters with weak snowfalls, a change of attitude from many ski area operation companies might have occurred towards snowmaking at the beginning of the nineties. Besides renewing the transport facilities, securing the snow cover has then probably been seen as another necessary condition for operating a ski area with profit. Many investment projects should have been planned at this time thereby strongly increasing the needs for financing. Along with a diminishing financing capacity, these new needs could explain the huge increase in the granted federal LIM loans that has been observed during the nineties and that has motivated the moratorium on the federal support launched by the Seco. As a result of these trends, 20% of the federal LIM loans that were granted to the ski area operation sector during this period were devoted to snowmaking projects. This means that the role played by public authorities in the adaptation process carried out at the sector level is non negligible. Nonetheless, the smallest and the largest companies of the sector were only marginal beneficiaries of that support. Above all, public support has benefited to medium sized companies (i.e. companies with transport revenues between 1 to 5 Mio CHF). Accordingly, the public support has played an important role for the adaptive process carried out by this class of companies. Does it mean that companies in the other classes of companies have not invested in snowmaking facilities? As will be shown in the next chapter when giving some figures based on a sample of 87 Swiss companies, small companies have not invested significantly in snowmaking facilities. They have not yet begun to adapt. One reason for this situation is that they have had very limited access to authorities' support. On the contrary, the largest companies have already invested large amounts in these facilities and display an average level of investments above the Swiss mean of 19% provided by SBS for the year 2005 (SBS 2006). These investments were financed nearly in the total absence of cantonal and federal financing. Therefore, the adaptation process carried out by these companies does not depend at all on the financial support provided by the cantonal and federal authorities.

The features of public support are also interesting when compared to the snow-reliability's assessment of Swiss ski areas in the future. As mentioned in the first chapter, such studies have been undertaken in Switzerland by different authors (Abegg 1996; Bürki 2000) and recently by the OECD (Abegg et al 2007). They emphasize the fact that the only regions that will not suffer too greatly from climate change are the Grisons and Valais cantons. In the other regions, predictions are rather pessimistic. With a 2ºC increase scenario in 2050, we remind the reader of the future percentage of snow-reliable ski areas: this percentage will probably diminish from 100% to 53% in the western foothills of the Alps (Fribourg and Vaud), from 100% to 50% in Ticino and from 96% to 62% in the "Berner-Oberland" (cf. Abegg et al 2007)[60]. One can argue that adaptation to climate change is easier when the authorities' support towards snowmaking is higher, thereby indicating that the latter reduces the vulnerability of ski lift companies to climate change. What we can observe by confronting the results of the snow-reliability's studies to the results presented in this paper, is that

[60] Results of the studies on the evolution of snow-reliable ski areas are presented in a more extensive way in the general introduction to the thesis.

generally the companies most at risk are located in cantons in which support is the most developed in relative terms (with the exception of Bern). By taking into account the institutional elements and not only the natural ones, does this really mean that the vulnerability of these companies is smaller than it seems? Looking at the support's level is obviously paradoxical when it comes to the adaptive capacity. On the one hand, a high level of support means that public authorities are concerned by companies' development and that they are ready to support them strongly to improve their adaptation to changing economic and natural environments, in other words to secure their viability. On the other hand, a high level of support means an otherwise low level of financing ability, on which depends the companies' adaptive capacity and viability. Indeed, the cantons in which support is most developed in relative terms are generally those that have to deal with the cableway sector's worst financial situation.

When looking at the institutional elements, it would be furthermore dangerous to limit ourselves to the support side of interactions between the State and ski lift branch, because it could lead to an erroneous understanding of the global policy carried out by authorities towards snowmaking facilities. For instance, in the Fribourg canton, the purpose of the regional development policy towards snowmaking as it is stated nowadays, is to severely limit the recourse to this kind of installation, even though the presence of snowmaking facilities in this canton has only been made possible via the authorities' support. There is nothing illogical here: the cantonal authorities simply consider that it is worth supporting snowmaking facilities up to a certain level for economic reasons but that it is also worthwhile avoiding a widespread and intensive use of the same facilities, for environmental and landscape preservation purposes. Given the restrictive principles contained in the cantonal regional development policies, we can ask whether they will impede adaptation measures in the medium and long term. Answering this question would give a more comprehensive view as regards the effect of authorities' policies on the vulnerability of jeopardized companies. If the answer to this question is yes, we could further ask whether regional development policies will be relaxed when the needs for more adaptation will occur. As suggested by the high reliance of jeopardized companies on authorities' support, relaxing the planning permission's policy to allow new investments would probably not be very meaningful if the authorities' support for snowmaking were not increased at the same time. Therefore, another crucial question to be asked is up to which point public authorities will financially support the ski area operation sector in its adaptation process.

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# 3. Do snowmaking investments improve the financial situation of the ski area operation companies in the perspective of climate change?

## 3.1 Introduction

Measures set up to enable the companies to maintain skiing activities on the resorts they run despite climate change can be of various types and range from investments in security to those in artificial snow, via an enhancement in the preparation process of the slopes as well as their maintenance. Producing artificial snow is often considered to be the adaptation measure par excellence to deteriorating snow conditions. It is an established fact that snowmaking is the most widespread climate change adaptation option currently in use by the Swiss ski industry. It requires massive investments (from CHF 0.75 Mio to 1 Mio per km of slope), usually financed through an important contribution of foreign capital. Artificial snow thus creates heavy new depreciation and financial costs for the company. Annual operating costs can also be weighty (current values generally range from CHF 0.05 to 0.075 Mio per km of slope) and are variable across different situations as they depend not only on the type of snowmaking facilities (degree of automatism for instance) but also on the use that is made of it (before season use namely), on the natural resources availability (snow of course but also free access to some water resources) and on the prices for the different factors of production necessary to run the equipment[1]. For instance, annual operating costs can reach values up to CHF 0.09 Mio per km of slope if snowmaking facilities are used to open a ski slope with the only contribution of artificial snow cover in a before season setting. Finally, climate change and a possible increase in the price of energy could generate a future increase in the related costs. Climate change particularly supposes that more artificial snow will need to be produced, with the problems in water supply that this entails[2]. We already observe that current investments in big artificial snow projects are already very expensive for that reason. In the framework of climate change and the efforts needed to counter its impacts and make ski lift companies durable, the question that arises is whether artificial snow is an adaptation measure that increases companies' profitability, or that decreases it. This underlies another important question: should governments subsidize this kind of facility? This chapter aims at answering these two questions.

[1] For instance, costs associated to snowmaking investments are given in Furger (2002).

[2] With respect to energy costs, Scott (2006, p.269) emphasizes the fact that climate change impact is two-fold. Climate change will lead to a greater consumption of energy due to a greater volume of snow to be produced but also because snow will need to be made (on average) at warmer temperature.

When focusing on a particular economic sector, economists generally try first to gain information on the technology under study by estimating either a production function or a cost function. In the case of the ski area operation sector, choosing a cost function would be preferable for econometric investigation since factor prices and produced quantities of good and services would probably be exogenous in this structural equation. Accordingly, we have tried to estimate such cost function at an early stage of our work. Even when considering a limited number of production factors (capital, labour and energy), we were however not able to make such estimations due to a lack of sufficiently detailed and recent data for the sector's companies. In particular, information on energy consumption and costs was lacking. An alternative then consists in estimating a model which is not directly obtained from an economic model. Following this way, we have estimated, using available databases, a statistical model of companies' operating results. Though not derived directly from economic theory, we have tried to develop firm economic foundations when adding regressors to our model. However, the structural equation so obtained was not directly estimable. We only arrived at an estimable model after having combined assumptions about other variables with algebraic manipulations. By focusing on the operating results (i.e. on companies' EBITDA), we have access to a measure of a company's performance devoid of interference with its depreciation policy or the banking and credit conditions it is confronted with, which vary from one canton to another - taxes varying even between the communes (which are the smallest territorial division in Switzerland). Therefore, EBITDA can be used to compare the companies' performance with greater ease. Regarding our research focus, the estimable model we have derived is advantageous as it allows assessing the impacts of snowmaking investments on companies' financial situation[3]. Eventually, estimations were carried out for the financial years 2003/04 and 2004/05 in order to allow comparison of the estimation results obtained for two different winter seasons.

After having defined beforehand the notion of EBITDA, the next section will briefly present the operating performance of the Swiss ski lift companies. The following section will focus on the various elements that influence the operating results of a ski lift company. They will be differentiated according to whether they are observed or not. For the whole of the observed elements, predictors and terms will be suggested and used in the statistical model of EBITDA that will be estimated in section 4. Previously, section 3 will have described our sample of companies, as well as the source and characteristics of the collected data. Section 5 provides a conclusion.

## 3.2 Understanding the operating results of the sector's companies

### 3.2.1 Definition and accounting aspects of EBITDA

EBITDA are the earnings before interest, taxes, depreciation and amortization. This earnings measure is calculated on the basis of the profit and loss account of a company, as the difference between its operating revenues and costs. All the elements that can be defined as extraordinary costs or revenues should not be taken into account in the calculation

[3] At this point, it is worth noting that cash flow (and indexes based on the cash flow) rather than EBITDA was used in a study (Laesser et al 2004) in order to assess the impacts of reconfiguration measures on the viability of the cable car companies. This choice was based on the results of a previous study (Bieger et al 2000) that develop a set of financial indicators mainly based on cash flow indexes whose aim is to determine the competitiveness and survivability of cable car companies. In these studies, cash flow equals the EBDA (Earnings Before Depreciation and Amortization). In this work, we will stick to this definition of cash flow.

of the EBITDA. Since companies in the ski area operation sector have large amounts of fixed assets, this earnings measure is of particular interest. Indeed, it essentially gives the income available to the company for interest payments and investments. Furthermore, it has the advantage of not being directly influenced neither by the depreciation practices, the banking rate policies and the organization of the company's external financing nor by the cantonal and communal tax rates. As the EBITDA is calculated on the basis of revenues and costs, it is nevertheless influenced by certain accounting operations that companies can resort to (transitional assets and liabilities, provisions for/recovery of certain provisions). Not only is each and every company's reality specific explaining the differences in these accounting entries but practices and accounting periods, as well as policies, vary greatly from one company to another. All these elements can complicate the process of explaining a company's operating results, one example being the creation and release of provisions. One must be aware that there are several reasons for which a ski lift company can form provisions, and that certain entries, instead of crediting a liability and transitional account, can also lead to create a provision. When the closing does not take place on the 31st of December (the majority of cases), provisions can be set up for the staff's holidays, for the thirteenth month or even, in the case of healthy companies, for the bonuses. The companies that close their accounts during the winter season can also create a provision, given the revenues received in advance (such as yearly pass sales). Similarly, certain maintenance works for which a bill has not yet arrived can be passed to provisions instead of transitional liabilities. There are also provisions for future litigation or, for companies that effectively own buildings, provisions for building renovations[4].

Finally, in the case of a disaster, the set up of a provision enables to take into account the loss risks that were not covered by the insurance (e.g. excesses) in the financial year's results. In Switzerland, all these provisions can be deducted for tax purposes from the net profits if they are justified for commercial use. Also worthwhile to point out is the fact that the sector's companies do not really create provisions for fiscal reasons as soon as many of them are in difficult financial positions. As for the release of a provision or a provision's balance that has no longer any reason to be, it can be realized by crediting the account "extraordinary revenues", but in practice it is possible that a cost account (account that enters in the operating costs) be credited instead.

It is also interesting to note that the EBITDA can depend on the way the company deals with its leasings in its accounts. Sometimes the annual installments linked to certain "light" investments (snow groomer vehicles for example) bought during a leasing are considered as operating costs. For bigger investments (transport facilities, artificial snowmakers), the object financed with the leasing is usually considered as a fixed asset. Therefore, costs associated to these investments do not impact the EBITDA's value. However, in the case of "light" investments, it seems that the fact of considering the annual installments as operating costs only has a slight impact on the EBITDA. Finally, specific accounting practices that also have to be considered arise due to the structure in which certain companies are

[4] Provisions to renovate technical facilities are not common.

integrated. For example, the rules chosen to allocate common revenues and costs between the different companies of a group will also influence the EBITDA of each of these companies[5].

### 3.2.2 Operating performances: current situation and analysis

In a few items[6]:

- Labour costs represent a very important part of the sector's operating costs (52.2% on average for 2000-2005)[7]. For the financial year of 2003, only 39% of companies had a ratio labour costs/total of revenues under 35%, albeit the winter season was a good one (i.e. the generated revenues were important). This result points out one of the branch's meaningful problems: a structure that is too cost-intensive, explained among other things by too many facilities and the sub-optimal size of many companies.

- The former ratio, as well as operating ratios such as the ratio cash flow/total of revenues also highlights certain companies' insufficient revenue generation. In 2003, 34.1% of companies presented a ratio cash-flow/total of revenues inferior to 20%.

- A classification of companies on the basis of their performance shows that, on average, for the period 2002-2003, 7.9% of companies have excellent operating results, with nonetheless a lag in investments. This group is mainly made up of big companies. Then 23.4% of companies (mostly small and medium-sized) have rather good operating results, but non-harnessed labour costs and also insufficient investments. Another 40.2% of companies have good operating results, probably helped by important investments that were recently undertaken. However, these investments increase the debt rate of these companies, which are generally mid-size or big companies. The last 28.5% of companies do not fulfil any of the financial indicators used to estimate the companies' performance. These are small companies usually located at low to medium altitude, with financial results highly variable from one winter season to another depending on snow conditions.

- The operating performance of the sector's companies varies greatly from one region to another. The Valais, Grisons and Berner Oberland are among the most privileged regions.

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[5] See section below dealing with cooperation between companies.

[6] All the percentages hereafter are taken from the same study (Bieger and Laesser 2005) apart when specified differently.

[7] Percentage calculated with financial data supplied by SBS.

### 3.2.3 Observed variables which would determine the operating results

The aim of this subsection is to present a set of variables that will be tested in the statistical models of EBITDA developed in section 3.4. For each of these variables, we will also try to predict what their effects on the EBITDA might be.

#### *3.2.3.1 Mean and weighted transport passenger flow*

A trend observed in Switzerland is the decreasing number of ski lifts, partly replaced by chair lifts as suggested in *figure 3.1*.

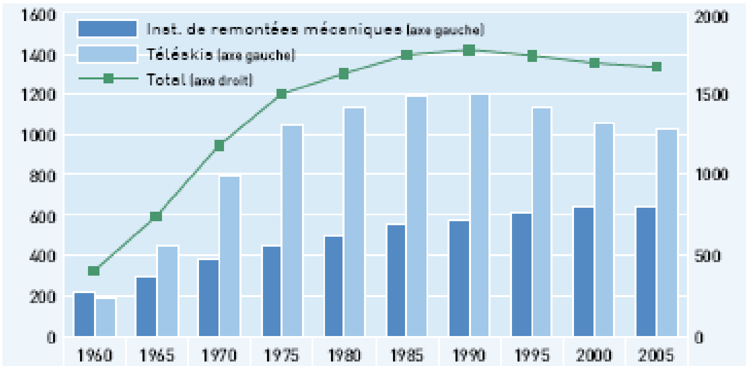


***Figure 3.1*** *- Number of total transport facilities (Total), cableways (Inst. de remontées mécaniques – left axis) and ski lifts (Téléskis – right axis) benefiting from federal concessions since 1960 (FOT 2005 reproduced in SBS 2006).*

However, the total transport capacity has increased during the last decades. While the total number of transport facilities decreased by 6% between 1991 and 1999 (-14% for ski lifts), the total transport capacity has followed an opposite trend with a 3% increase (FOSD 2001).

By getting rid of under-used ski lifts, the aim of the company is to rationalize the operating of its resort. By replacing one or several ski lifts by chair lifts, the company modernizes its supply (comfort, speed) while presumably reducing its operating costs (less staff employed because less facilities and no need to cover the uphill track with snow). At the scale of a company, the consequences of this trend are thus at first sight positive ones (less costs, more appeal and thus more revenues). This hypothesis is supported by the results of a study realized in Switzerland on the sector of ski lifts (cf. Bieger and Laesser 2005). Through an analysis using a correlation model, the authors of this study show, among other things, that the value of the tangible assets is positively correlated to operating margin, while it is negatively correlated to the ratio labour costs/total revenues. They have thus demonstrated that companies that agreed to important investments tend to have better operating results, notably thanks to their reduced labor costs. This result can also be interpreted by saying that a linear function of the value of a company's tangible assets can help us predict its operating margin.

At the level of companies, the intensity of the phenomenon described above can be measured by using the mean transport passenger flow, as it generally implies an increase of the total transport passenger flow and a simultaneous decrease in the number of facilities[8]. As far as appeal is concerned, it might be worthwhile to ask oneself which portion of the company's supply was modernized. If we consider that the difference in level between the start and finish stations of a facility is an indicator of its importance for a ski resort's operations, we could then use these data to compute the weighted transport passenger flow (WTPF).

#### *3.2.3.2 Total length of marked slopes in km*

Bigger companies have larger values of the EBITDA. Due to this scale effect, we expect that the EBITDA increases with the size of the ski area. Moreover, the very important initial investments that must be made in order to operate a ski area suggest that economies of scale must exist at the company's level. Companies that operate a vast ski area have most likely been able to take advantage of all or part of these economies of scale, which should result in a lower average cost with notably a more favorable ratio of labour costs to developed services. We thus expect the profitability of a company to increase with the size of the ski area, which is referred to in this study as the number of km of prepared slopes (Slopes).

#### *3.2.3.3 Resort lodging*

About 75% of the 24 million skier-days generated by the Swiss population in 2001 were made by people lodging in the ski resorts, while the remaining 25% was the making of "excursionists"[9]. Ski consumption is thus mainly the activity of people residing in the ski resorts. We can even go slightly further by admitting that in many cases, people residing in a resort are the core business of this resort's ski lifts. For example, the Compagnie des Alpes (CDA) indicates that in the resorts where it operates, 85% (on average) of ski lifts' clients reside in the resort itself[10].

The capacity and type of lodging of a resort are thus crucial. In certain cases, it is also critical to know whether this supply is only open to winter sportsmen and sportswomen, or whether it must also satisfy other guest flows, notably during tourist peaks of the winter season (for example Davos with the World Economic Forum). The need to consider the lodging supply as a whole has led certain parties involved in tourism to differentiate the professional supply that generally corresponds to "warm beds" (hotels, holiday villages, tourism residencies, furnished apartments, chalets) from the private lodging supply, mainly made up of "cold beds" (individual owners with secondary houses can indeed rent out their lodging on an occasional basis, without generally having to resort to a commercial circuit). As a professional bed is on average two times more effective for a resort's activity than a private bed, the allocation of the winter sports' touristic supply between these two types of beds is fundamental for the commercial performance of a resort. At our level of concern, certain data are put forward showing that a professional bed yields about 60% more skier-days than a private one. But this is not yet a differentiated effect on the turnover of the ski lift companies. At the turnover level, other elements are determinant, such as the commercial expenses paid by ski lift companies to the

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[8] For a given transport facility, the transport passenger flow gives the number of people that can be transported during one hour in one direction.

[9] The data of the Swiss population's skier-days are available in (Bieger and Laesser 2005). Important to point out is the fact that more than 90% of these skier-days were consumed in Switzerland. We have not come across data regarding the number of skier-days consumed in Switzerland by a foreign clientele. Nevertheless we can assume that an important proportion of these was the making of people residing in the resort.

[10] The data regarding the CDA are available in (Symposium international du tourisme 2005, 79-86). It is also the same source that is used for the data on the impact of different types of beds used in this subsection.

intermediate ticket retailers in the framework of the "professional ski days" (a practice which is however scarce in Switzerland).

To sum up, what we can bear in mind from the former paragraph is that the total number of beds in a resort is not a good indicator of this resort's activity, due to the crucial difference between the numbers of overnight stays produced by different types of beds. Although to a lesser extent, the total number of beds is not significant for the ski consumption either (i.e the difference still remains important between the different bed-types). This reasoning leads us to distinguish between different types of beds in our model, in order to analyze the effect of "identical" bed-types on companies' financial results. As our data do not enable us to establish this distinction between professional and private beds, we will operate the distinction between hotel beds (hbeds) and para-hotel beds (phbeds)[11].

#### *3.2.3.4 Location variable/potential commuting*

As already said, one quarter of the skier-days generated by the Swiss population in 2001 was the making of "excursionists"[12]. Overall, one-day excursions are thus a significant source of income for the ski-lift sector. Further, as the distribution of these skier-days is very uneven between the different regions of Switzerland, the part of "excursionists" in the whole of skier-days of a ski lift company can be very important in certain cases. As this distribution depends a lot on the distance to the big population basins, i.e. the agglomerations of Zurich, Bern, Geneva and Lausanne, Central Switzerland, the Alps of Vaud, Fribourg and the Bernese Oberland were thus privileged destinations of "excursionists" in 2001 (these regions cumulated 60% of skier-days generated by this category of clients). In order to take into account the advantage in terms of clientele generated by the proximity to the densely populated regions, we can introduce one or several explanatory variables. The first possibility is to introduce a continuous variable which is simply equal to the time that it takes to go by car from the (nearest) big population basin to a given ski area (dist). Another possibility is to use binary variables. This latter solution seems more preferable than the former since the effect on EBITDA of moving away from the densely populated regions is probably not a linear one. In this case, threshold levels need to be chosen. We have not found in the literature at our disposal any indications on such thresholds. Therefore, we will set these values using our own knowledge which leads to creating two binary variables. The first one takes a unitary value whenever a company's ski area is accessible by car in 90 to 120 minutes from the nearest big population basin (dist1) while the other takes a unitary value whenever more than two hours are needed to reach the ski area from the nearest densely populated region (dist2).

#### *3.2.3.5 Availability of natural snow*

The quantity of snowfall and its timing strongly influence a company's profitability. Having snow early in the season and then abundantly after that is a critical element (among other things to operate the facilities during activity peaks). The variability of the snow blanket during the season encourages distinguishing between days when the height of natural

[11] The para-hotel sector generally comprises: rented holiday houses and apartments, youth hostels, group accommodations and camping sites. The variable phbeds will take into account the lodging supply of those different types of establishments, apart from camping sites. Also, the variable phbeds will not incorporate the beds in the mountain huts (accounted in the group accommodations) since we are only considering the lodging supply in the resorts.

[12] The data presented in this paragraph is again taken from (Bieger and Laesser 2005).

snow reaches a certain threshold, and days when it does not. A height of 30 cm is usually believed to be the minimum threshold at which skiing can take place (Bürki 2000). In practice, this threshold is specific to each ski resort, according to its characteristics (ground texture, inclination, presence of stones and others)[13]. By using the snow height of certain meteorological stations and the threshold of 30 cm, we can define the number of days during which the natural snow cover was theoretically sufficient to allow for skiing activities, for our sample's companies. For the reason mentioned above and also because this value does not take into account neither the slope grooming nor artificial snowmaking or meteorological conditions, this value does not have the objective of predicting the exact number of days during which a company was able to run these facilities. Rather, it can indicate information regarding the availability of natural snow[14]. We must also define the period for which we will calculate the number of days with sufficient snow cover. For a given company, the period to consider must be embedded in the financial period required to calculate its profitability in 2004 and 2005. For this reason, we will systematically consider the periods 1st-31st December and 1st January-15th April inside the accounting period. In the end, our approach leads to create a variable that gives the number of days, inside the period 1st December-15th April, during which the natural snow cover was theoretically sufficient (i.e. >= 30 cm) for skiing practice (without taking the grooming into consideration).

As far as profitability is concerned, we also notice that revenue and cost flows are not constant throughout the operating season. There are activity peaks, i.e. periods during which an important part of the turnover is generated. A lack of snow during these periods thus has much more acute effects, even though there can be compensation effects from one period to another in case of bad conditions during a key period. These arguments prompt to operate a distinction between, on the one hand, natural snow available during these key periods, and on the other hand, natural snow available at other times of the season, and lead to create two distinct variables (Cdays and NCdays). In order to build these, the periods of high activity must be defined for each one of the sample's companies. In this case, the trends are well-known and correspond to school holiday periods (Christmas-New Year's, February-March holidays, Easter holidays) as well as weekends in January and February. Generally, end of the year holidays and those of February-March tend to be more popular than Easter holidays (notably due to the fewer number of "excursionists" starting mid-March). The Christmas clientele is also more of the family-type (i.e. less sporty than that of February-March), and less centered on skiing. At the company level, the clientele's distribution in the season depends more precisely on a certain number of factors such as the ski resort's characteristics (altitude, exposure), the operating season (in particular: late closing in the season), and the origins (from which depends the school holiday periods) and type of clientele ("excursionists" versus "visitors"). The way the school holidays of different cantons overlap plays a specific role. In the 2005 activity reports of a certain number of Grisons ski lift companies, the unfavorable layout of holidays and bank holidays and the concentration of sports' holidays during three specific weeks are put forward to explain the decrease in revenues noticed during the 2004/05 financial year, compared to the former one. The importance of the school holidays' configuration for the ski lift sector is so important that, sometimes, the latter has put

[13] The calculation of this threshold for each resort of our sample was not possible due to a lack of data required to be able to apply a method enabling to determine these values.

[14] Also important to recall is the fact meteorological stations used for these calculations are rarely located on ski resorts.

pressure on several cantons so as to have them coordinate their calendars, mainly in order to dissociate their February holidays.

Hereafter, we will focus on the holidays of the end of the year and of February/March, as well as the weekends of January/February, due to their preponderant role in the turnover. Also, we have assumed that the activity peak during the end of the year holidays does not include December 24, 25 and 26. For a number of regions and cantons, we have thus defined periods of high activity on the basis of the school holiday periods of the majority of the clientele's cantons of origin (cf. appendices 2 and 3)[15]. At the company level, we have also taken into account its size and its clientele type when determining the periods of high activity. In certain cases, the activity peaks of a small company or a company whose clients are essentially "excursionists" will thus be exclusively determined on the basis of the school holidays of the regional clientele.

#### *3.2.3.6 Use of artificial snow*

Artificial snow enables to guarantee a snow cover and thus the running of the ski resort, which is a revenue guarantee for the company. On the other hand, artificial snow also creates operating costs, notably for water and electrical use as well as labour. These operating costs are generally underestimated as the costs linked to the preparation of the ski slopes with the produced snow are not taken into account. In our model, we represent the intensity of investment in artificial snow by the number of km of slopes covered in artificial snow (artkm). We have also added a quadratic term as it is plausible that the benefits of these investments will decrease as the investments increase. From an operational standpoint, it seems logical that companies should first want to ensure the snow cover of their resort's main supply (main slopes, those leading back to the station, and connecting slopes) before eventually extending it to the rest of the resort (and they might as well be driven to this by the planning regulations and creditors' conditions).

#### *3.2.3.7 Integrated structures and cooperation within the industry*

The Swiss ski lift sector's companies are currently undergoing a restructuring process. In this framework, they are developing several initiatives, ranging from limited and specific collaborations for the purchase of material or the employment of technical staff for example, to much larger collaborations, groupings of management and administration and even mergers. The mergers have in fact led to the creation of the sector's largest companies (Zermatt Bergbahnen AG, Bergbahnen Destination Gstaad AG, CMA, Davos Klosters Bergbahnen AG, etc.). All these initiatives and changes in structure should have had a positive influence, albeit variable in the profit intensity of the companies undertaking them, so it is worth looking at whether they could be introduced in the model one way or another.

First of all, these evolutions all aim at an enhanced cost management and the measures used in this context should normally quickly display their positive effects on profitability. In this first phase, the partner companies therefore seek first and foremost to exhaust synergies (e.g. to get rid of some posts and to benefit from advantageous prices on

[15] The method used to determine the periods of high activity is valid notably when the percentage of foreign clientele is limited. An additional uncertainty exists on the method's validity when this percentage rises, as is the case in certain regions of the Grisons, where German tourists are numerous. In some resorts of this region, they are responsible for 25%-50% of registered overnight stays during the winter season, for the whole of the hotel and para-hotel sectors.

material bought in common). This stricter cost management helps to release more means for investments and thus to increase, on the medium run, the ski resort's appeal. Presumably, this heightened appeal has also a beneficial effect on the companies' profitability through revenues increase. Cost reduction and ski resort's appeal can be reinforced even more when the companies' integration is such that it allows optimizing the transport capacity and leading a concerted planning of investments for several ski resorts. Other strategies, wishing to create a stronger and better profiled tourism destination by grouping the marketing of the companies involved in the same unit, also have a positive impact on the companies' profitability, through the increased activity of the ski resorts they should spark off. *Table 3.1* is an attempt to represent the various integration degrees that can be encountered between companies of the sector.

| Degree of integration | Description |
|---|---|
| Merger | From a judicial point of view, there is only one company left, thus one sole management and administration. |
| Group /Takeovers | Different companies are linked to a parent company.<br>Generally the parent company or one of its subsidiaries is in charge of the operational and strategic management and aggregates the administration of all or part of the group's companies. |
| Operating company | The companies abandon their operations to a third-party company which they own.<br>There is only one operational and strategic management and one administration. |
| Collaboration | Fields of cooperation include: product purchasing, staff, technical equipment, common tariffs and ticket systems, marketing and client satisfaction, training, etc. These cooperations can be cumulated or undertaken separately.<br>Collaboration can be the making of two or more companies (for example through an umbrella organization). |

***Table 3.1*** *- Presentation of the different forms of horizontal integration encountered in the Swiss cableway sector.*

Important to recall is the fact that all the initiatives undertaken by the companies in this restructuring process do not have the same reach, notably in their effects on profitability. This aspect is emphasized in *table 3.2* taken from Laesser et al (2004) which outlines the potential impacts on cash flow of possible forms of reconfiguration including the horizontal one.

| Form of reconfiguration | Potential impact on | | |
|---|---|---|---|
| | ***Revenues*** | ***Costs*** | ***Cash flow*** |
| Horizontal | Moderate and little likely increase<br>Only a small part of the value chain is concerned with the reconfiguration | Slight cost reduction because of synergies with regard to overhead<br>Economies of scale with regard to sourcing<br>High impact if reconfiguration incorporates capacity optimization | Very likely increase in cases of capacity optimization<br>Without capacity optimization: poor increase, because of moderate revenues increase and only moderate cost reductions |
| Vertical | Increase – absorption of a greater part of the value chain | Increase because of non-concentration on core-competencies, coordination costs<br>Highly dependent on productivity of industries envisioned for vertical reconfiguration | In the long run significant increase, because of integrated product development and great revenues increase |
| Lateral | Increase because of potential business expansion in fields of high revenues and low costs – but in these fields the competition is high | Potential increase due to transaction costs, coordination costs, complexity costs (learning effort) | Unclear; medium increase only in optimal case because of high costs |

***Table 3.2*** *- Overview of the impacts of possible forms of reconfiguration. Source: Laesser et al (2004).*

As regards horizontal integration, the results displayed in *table 3.2* state that only mergers or takeovers at a minimally regional level could have a significant impact on cash flow through transport capacity optimization. Otherwise, the potential for cost reduction and revenues increase (and thus the potential for cash flow increase) through synergy effects is estimated to be actually very limited. This opinion is confirmed by the results of another study (Bieger et al 2004) which presents the cooperation gains for different levels of cooperation. The following figures are based on a budget planning agreed by two collaborating Swiss medium sized ski lift companies:

| | Synergies |
|---|---|
| Joint financing (cash pool) | + 13% |
| Coordinated investments | + 13% |
| Joint operation including coordinated opening | + 15% |
| Joint sales – coordinated prices | + 10% |
| Joint buying | + 3% |
| Joint marketing | + 5% |

***Table 3.3*** *- Cooperation gains expressed in percentages of cash flow generated before cooperation. Source: Bieger et al (2004).*

Two remarks with respect to these figures: on the one hand, the most effective synergies are also those that are the most difficult to reach by cooperation processes. Other forms of reconfiguration (e.g. a merger) could then be a much faster and safer way to take advantage of the synergies available at deeper cooperation levels (cf. Bieger et al 2004). On the other hand, some of these synergies (joint financing, coordinated investments) mainly permit diminishing the financial costs through increased self-financing thereby not really influencing the EBITDA. Here, we must recall that we focus on the companies' operating results but that restructuring does not only impact operating revenues and costs. Indeed, strongly integrated structures have additional advantages, also in terms of conditions set by banks. A merger, for instance, can reduce the financial costs, due to reevaluations of ratings and credit lines. If it is controlling in other companies, a company that originates from such a merger can then allow its subsidiaries to benefit from more profitable credit conditions. Generally speaking, the organization of the ski lift companies' banking and financing is not something that is taken into consideration in this chapter.

Another point to emphasize is the fact that all the initiatives undertaken by the companies in the restructuring process are not automatically observable for the researcher. Contrary to a number of collaborations, the groupings of management and administrations are very visible[16]. More specifically, this means we could observe whether in our sample, companies share their management or administration with other companies, either through an operating company, through a parent company or through one of the subsidiaries in the context of a group. As mentioned in the previous paragraphs, these forms of horizontal integration additionally offer a wide range of synergies to be harnessed and the possibility to optimize the transport capacity. We will focus our discussion on these cases only by looking at the advisability of adding a binary variable to our model that would take a unitary value when a company does not have its proper management and administration or when it controls that of other companies.

Actually, there are some practical reasons for thinking that the effect of such variable will not be significant in our model. The concrete cases have shown that this way of taking into account horizontal integration suffers from at least two drawbacks. The first is that certain of these structures were very recent during the financial years of 2003/04, so all possible synergies and improvement potentials were perhaps not totally tapped into at the time. Typically, capacity optimization is expected to arise rather in the mid-run or even in the long-run. The second drawback resides in the existence of common revenues and costs that might affect the results of the integrated companies in some arbitrary

[16] The groupings of management and administrations are visible in the sense that these events are well documented on the companies' websites.

way. In practice, differing rules are used to allocate the common expenses between the companies (e.g. according to the turnover or to a constant coefficient that depends on the number of facilities and on the slopes' length, etc.), whereas direct costs are covered by each company separately. The same distinction applies between common and direct revenues. In particular, the revenues linked to passes that allow their holder the access to different ski resorts are also divided between the companies, following a rule that varies from one case to another (e.g. according to each resort's activity, or to a constant coefficient, etc.). Obviously, these rules do not reflect the exact effective share of revenues and costs corresponding to each company. In this respect, they can superficially modify a company's results. If these modifications are of the same magnitude as the effects of the reconfiguration strategies on the EBITDA then it is possible that hardly any systematic effect could be detected.

#### *3.2.3.8 Public and third-party contributions*

There are several ways in which the public and third-party can support the ski lift companies. Because we are concerned in this chapter with the companies' operating results, we will concentrate hereafter solely on the support that impacts directly the operating results. This support either aims at increasing the operating revenues or at decreasing the operating costs. The latter form of support includes the payments of certain bills or the fact to put staff at disposal for instance, but remains most of the time unobservable for the researcher. This is the reason why we will focus our discussion below on the money received by the companies for their operations.

In fact, certain companies get money directly from public authorities, for different underlying motives, and for one or the other of its activities (transport, catering, etc.). Two main types of public financing exist regarding the operating of transport facilities: indemnities and subsidies. The notion of indemnity applies to money spent by cantons and the Confederation for transport services that have a public service character. Subsidies, for their part, are only paid for by communes. For example it can be the money one or several communes allocate a company because transport facilities are open to their schools, or as a way of participating to reinforce the company's liquid assets.

The fact a company receives indemnities means that it does not operate transport facilities for touristic purposes only, as its facilities can also be used by the local population. This suggests a lesser dependency on the winter season and on the snow cover conditions and therefore stable income for the company, but also, most probably, a low profitability of the facility allowing for this public service, even after payment of the indemnities. As mentioned above, the fact a company receives subsidies can indicate this is to compensate for the fact its facilities are used by school classes. Such a case guarantees a clientele basis and income for the company. In the other mentioned example, the subsidy is there to directly alleviate a company's difficult financial situation. We realize that all these elements thus influence, albeit perhaps only weakly, the operating results of a company. In the following, we will not take the communal subsidies into account when we will calculate the EBITDA of our sample's companies. Arguments will be developed in section 3.3 to only retain, in the calculation of the EBITDA, the indemnity payments. We will therefore add to our model a binary variable (grant) that takes a unitary value when a given company has received indemnity payments[17].

Other types of income can be allocated to ski lift companies, without entering either category previously defined. It is for example quite common in this sector for a company to receive an operating compensation (or for the company to take advantage of third-party services) in return of which it continues to run certain facilities that it has no reason to. The ski lift companies' interlocutors are in this case corporations, interest groups or tourism offices (communes). They compensate the company, not with the aim of making the operating of targeted facilities profitable, but to prevent them from costing the company too much money. In other words, the money the company receives does not generally allow making these facilities' operating a profitable one, but they do guarantee the financial participation of all involved parties. In this respect, these agreements prevent the company from optimizing the ski resort's operating, as they force it to keep unadapted structures in place, and in the end withdraw certain opportunities it has to enhance its profitability. These supportive schemes are not considered in our model, in the absence of sufficient data regarding these elements and considering their relatively secondary importance.

### 3.2.4 Other (non observed) variables

It is relatively easy to deduct a certain number of additional variables upon which a company's operating results depend. We have not yet presented these as they are not systematically observed and/or are difficult to quantify, and they will therefore be included in the error of the different regression models we will address in section 3.4. Below, we quickly present these variables and postpone to later the discussion regarding econometric problems (omitted variable bias) that their presence in the error might trigger.

1. Professionalism
   It influences the quality of decisions taken at the level of a company's management, which influence the company's profitability.
2. Meteorological conditions
   During the winter season and particularly during weekends, bad weather and meteorological conditions (e.g. conditions that tend to be too cold) can divert potential clients away from ski lifts.
3. Privileged situation and landscapes
   Certain companies benefit from a remarkable landscape or viewpoint, accessible via their facilities. This specifically allows these companies to generate important revenues during the summer season.
4. Investments undertaken to develop the summer season
   Sled slope, adventure path, etc.

[17] We do not choose to add a binary variable because the amount of indemnity payments is unknown (these values are given by SBS). We make this choice because we think it is the best way to account for all the effects on the ski area operation companies' financial situation of operating non tourism transport facilities.

5. Conditions of access to the ski resort
   The circumstances making the access to the ski resort more difficult (closed roads, broken down connecting facilities) have a negative impact on its activity, and on the financial results of the company that runs it.

6. Public policies and measures
   Some measures taken at the local level by public authorities could influence the financial results of ski area operation companies. A striking example of such a measure is when owners of second homes are compelled to buy transmissible season passes to the companies. In addition to the direct revenues for ski area operation companies, another indirect effect could arise because owners of second homes should be more open to rent their second homes in order to compensate for the cost of the season pass (i.e. indirect effect through increase in ski areas' frequentation).

We also note that snow conditions in competing and/or lower located resorts play a role on a resort's profitability. These conditions do not really constitute non-observed variables as we have some measurements of available natural snow for the companies of our sample. In this case, the econometric problem will be different (non respect of the hypothesis of "strictly exogenous regressors"). More generally, econometric problems can arise because of the spatial correlation or spatial dependence between our cross section units. Indeed, we cannot state that our sample is a random one because outcomes from adjacent observations are likely to be correlated.

## 3.3 Data collection and sample representativeness

### 3.3.1 Data collection

Sources and specificities of all the data that are employed to estimate the models developed in this chapter are communicated below. Data were collected for the winter seasons 2003/04 and 2004/05 since one of the initial ideas was to estimate some statistical models for two winter seasons in order to analyze the robustness of the estimation results. However, we have to note that data availability changes from one year to another. For instance, data availability on lodging supply has changed between 2003 and 2005. The 2004 data are more comprehensive. Accordingly, estimation results presented in this chapter will be mainly based on the 2003/04 data.

- In terms of financial data, as we only had a limited number of company activity reports, we have mostly used data provided by SBS to determine the EBITDA of our sample's companies. However, we have privileged the information resulting directly from the companies' result accounts when we had these. These data are indeed more disaggregated than those of the SBS and enable us to calculate precisely our variable of interest. Several comments must be made with respect to the data coming from SBS, as well as the way the EBITDA values were derived from these. The major drawback of this database is the fact it does not directly give the value of operating revenues. Instead, it indicates a value of the revenues generated by transport services, one for the subsidies or indemnities the company received in the framework of its transport activities[18] and one for all the other revenues. This last value includes operating revenues as well as financial ones, with no way of distinguishing one from the other. Consequently, we proceeded to calculate the operating revenues in the following way: we first added the value of "other revenues" to that of revenues generated by the transport services, in spite of the presence of financial revenues. This seems acceptable as the latter are generally negligible, at least as far as small and medium-sized companies are concerned, and thus do not contribute much to the "other revenues" register[19]. Then, to this first sub-total, we added the cantonal and federal indemnities, when these existed, for the corresponding financial year. On the other hand, we have not taken into consideration communal subsidies in the calculation of the operating revenues[20]. This choice was made for two reasons. In the first place, the subsidies that are granted to the companies are generally not linked to any services provided directly by them and therefore tend to artificially improve the operating results. As a result, these subsidies tend to diminish the operating results' variability which is not a desirable feature. The second reason is also based on some econometric considerations. Indeed, indemnities are linked to transport services that have public services' characteristics, and not to the financial situation of the company as communal subsidies generally are. In a model of companies' performance, this helps to avoid any simultaneity problem between an explanatory variable that would express the presence of a public contribution, and the dependent variable.

- Data on ski slopes' length and snowmaking were mainly collected by phone calls or by sending e-mails to the ski lift companies. In a small number of cases, these data had to be completed using the information taken from the Swiss tourism online database and the Ski ADAC Guides. For information on the characteristics of the transport facilities and the skiing area, use was made of the ITT statistics (FOSD 2001). SBS provides also technical information on the transport facilities. These two sources of information have also helped to verify and crosscheck the information available on different websites (ski resort websites, ski lift companies' websites, Swiss Tourism and Bergfex online databases).

- The data on lodging supply comes from the Federal Statistical Office (FSO). Nevertheless, several differences exist between the data available for 2003 and that for 2005. Between the two years, the survey method changed, starting January 2005, using a new statistical method (HESTA). As a consequence, the types of establishments for which data are available are not the same. In 2003, data was available for the hotel sector (hotels and clinics) and the para-hotel sector (rented holiday houses and apartments, camping and caravan sites, group accommodations and youth hostels)[21]. The type of lodging "holiday houses and

[18] Information about the public aid that companies have possibly received in other fields of activity is not provided by SBS.

[19] Financial revenues can be quite important in some of the sector's big companies. However, we generally dispose of their activity reports, which solves the problem.

[20] However, it is possible that the operating revenues thus calculated include the communal subsidies paid for others than transport facilities.

[21] The 2003 data on the para-hotel sector are in fact valid for the touristic year of 2003, which runs from November 2002 to October 2003. All the other data are available for the civil years of 2003 and 2005.

apartments" also includes Bed and Breakfast establishments, as they were covered by the survey[22]. In 2005, we have data for the hotel sector[23]. The para-hotel sector was not yet part of the new statistics, apart from the youth hostels and camping sites which had signed up to the federal register of companies and establishments. The variable phbeds does not therefore cover the same sort of establishments in 2003 and 2005. Whereas in 2003, it covers the lodging supply of rented holiday houses and apartments, group accommodations and youth hostels, in 2005 only the lodging supply of youth hostels is covered. One must also be aware that the former and new statistics on lodging supply in the hotel sector can only be partially compared, as in these two surveys, the definition of the population is different. For both years the hbeds variable does not include beds from the clinics. Another difference between these data comes from the fact the 2003 data only refer to "inventoried" beds, while that of 2005 allows to differentiate them from "available" beds. The distinction between "inventoried" and "available" beds stems from the fact some of the commercial facilities that must take part in the survey might be closed for certain periods of time. For our research, we have used the data on the number of "inventoried" beds. They reflect quite precisely the effective lodging supply during the peak touristic activity of winter sports' resorts. Finally, data on the number of beds in 153 mountain huts in 2002 was provided by the Club Alpin Suisse and was used to correct the data given by the FSO on the group accommodations supply.

- The available data on the natural snow sum up to the snow heights measured on a daily basis in the measure stations spread throughout the Swiss territory, for the years that interest us. The values have two sources: the first is that of MeteoSwiss, which has several automatic stations measuring this parameter. The second, more often used here, is that of the Swiss Federal Institute for Snow and Avalanche Research (SLF), whose automatic and manual network for snow height measures in Switzerland is extremely dense. In principle, the data providing from these two sources are collected in similar conditions, and so can be used in equivalent ways. A measure station was assigned to each ski resort, according to its proximity and altitude. We then calculated the number of days for which snow height was higher or equivalent to 30 cm, for the periods of interest within the accounting years 2004 and 2005. It is important to bear in mind the fact that with this method, we use one value of snow height to describe the daily snow conditions of a resort, and that this value was not automatically measured on the site itself. For that matter, a correction was made to the values of snow height disclosed by the stations not located on the territory of a ski resort. The correction is based on the difference in level between the measure station and the ski area[24]. Another potential limit is due to the fact that the slopes grooming is not accounted for in the measured snow height. When snow is plentiful, plowing reduces the snow height but in the long run, it

[22] As they were not identified separately, it is not possible to assess the extent of this type of service's coverage.

[23] All the companies that are part of the hotel sector as defined by the federal register of companies and establishments (hotels, clinics and restaurants with rooms) must be part of the new statistics.

[24] The method has been developed by Bastienne Uhlmann which is a PhD student at the faculty of climatic change and climate impacts from the University of Geneva. For all the measure stations of the MeteoSwiss network, she has first calculated the difference in the mean snow height during the winter season attributable to the difference in level between the station and the associated ski area. Uncovered for the stations of the MeteoSwiss network, the relation between these two differences was then used to predict the change in the mean snow height for the stations of the SLF network.

particularly prevents it from melting. We have nonetheless assumed that most ski resorts, if not all, plow their slopes, rendering the data provided by the meteorological stations sufficient and useful for our research.

- Data on housings and buildings are provided by the FSO. A dedicated survey is carried out as part of the federal census and deals with inhabited and inhabitable housings and buildings. As the last federal census took place in 2000, the available data on housings and buildings are not more recent than 2000. Characteristics of the housings that are recorded by the survey include the way it is occupied (permanently/temporarily/non occupied) as well as the number of rooms. The status of the occupants (renter/owner/etc.) is also given when the housing is permanently occupied. On the contrary, the status is not given in the two other possible cases as the federal census does not link any household to the temporarily and non occupied housings. In the framework of the general instrumental variables regression model that will be studied in subsection 3.4.2, data on the temporarily occupied housings are especially important since they will be used to compute the instrumental variables estimator. Their interest lies in the fact that all holiday houses and apartments should be included in this statistic. Therefore, we expect values describing the number of temporarily occupied housings to be positively correlated with the number of beds in the rented holiday houses and apartments. In the tourist regions, the FSO thinks that the values given for the temporarily occupied housings at the communal level are generally reliable. In certain rare cases, it however emphasizes the fact that these values seem to be strangely small compared to the values given for the non occupied housings. In these cases, the FSO supposes that part of the latter housings was actually temporarily occupied. When preparing data for the statistical analysis, we will pay attention to these features and make corrections whenever necessary and possible.

- Information related to the legal procedures carried out by environmentalist groups was gathered in two ways. On the one hand, databases containing information on the most recent procedures were directly provided by Pro Natura and WWF (these two associations are by far the most active environmentalist groups in the Swiss alpine regions). On the other hand, we went to their national division and threw ourselves into their archives in order to obtain information on the older ones. Only oppositions that delay investments in snowmaking and transport facilities during the 2003/04 winter season are taken into account.

- As regards information on the presence of natural objects of great worth inside or in the vicinity of ski areas, use was made of some existing federal inventories that put emphasis on biotopes and habitats protection. More precisely, we make use of the inventories that list different kinds of marshes (two inventories in the OBM and OHM) and the breeding sites of batrachians which are important at the national level[25].

### 3.3.2 Choice of sample

We consider only companies that operate a ski area. This being said, these are noticeably heterogeneous, in particular as far as their strategies are concerned. Some will focus on transport activities and slopes while others will broaden their scope to include catering and hotel activities, among other things. These differentiated strategies also lead to a change in the nature of the EBITDA. Indeed, in case of diversified activities, the latter will summarize the operating results not only of the transport activity but of several activities.

Ideally, we would have liked to calculate the EBITDA only for the "transport and slope" activities of each company. But the available data rarely enabled to do so. To make the best of this situation, we only consider companies with a ratio transport revenues/total revenues>2/3, i.e. we focus on companies that continue to concentrate on transport activities. By doing so, it is possible that we favor companies of a certain region at the expense of others to constitute our sample, as the above-mentioned strategies change from one region or one canton to another. For this reason, it is interesting to present the distribution of the sample's companies by big region of winter sports, in order to concentrate more particularly on this aspect of the sample's representativeness. *Figure 3.2* shows the companies' location in the Swiss Alps whereas *figure 3.3* presents some characteristics of the 2004 sample[26].

[25] OBM=Ordonnance sur la protection des bas-marais d'importance nationale ; OHM=Ordonnance sur la protection des hauts-marais et des marais de transition d'importance nationale ; PPS=Inventaire des prairies et pâturages secs de Suisse ; IBat=Inventaire des sites de reproduction de batraciens d'importance nationale.

[26] We do not present the data collected for 2005. As their characteristics are almost identical to those of 2004, the comments made for the 2004 sample thus also apply to that of 2005.

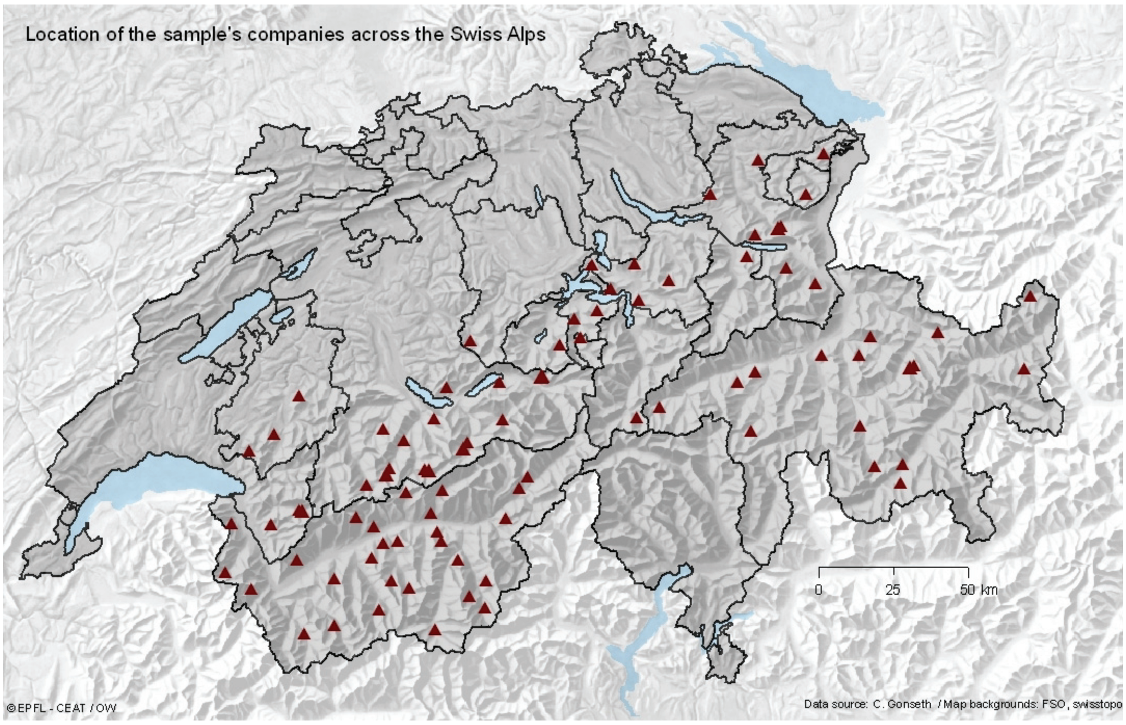


***Figure 3.2*** *- Location of the 2004 sample's companies across the Swiss Alps.*

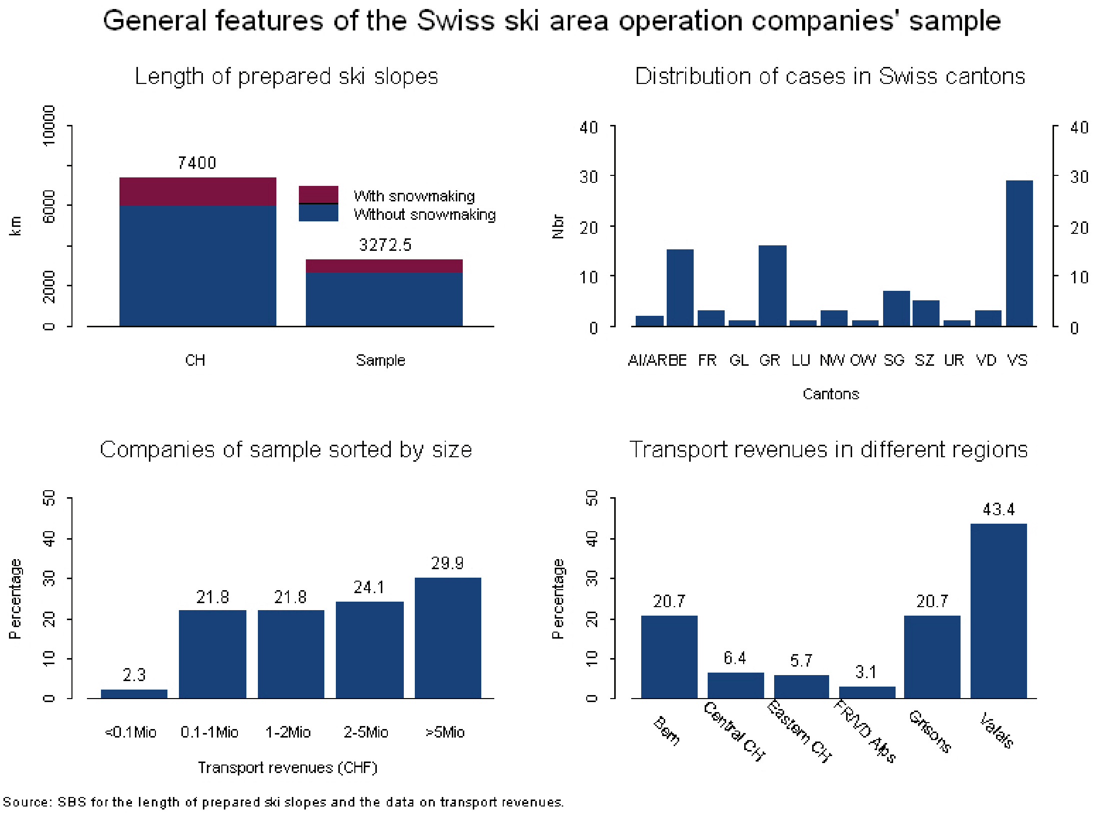


***Figure 3.3*** *- Description of the sample of 87 cases used for the statistical analysis.*

First we observe that our sample is relatively large, as it represents nearly 45% of the sector's total supply in terms of prepared slopes (upper left hand-side graph of *figure 3.3*). We note from both figures that the 87 cases of our sample are mostly located in the cantons of Valais, Grisons, and Bern. The lower right hand-side graph of *figure 3.3* indicates how the transport revenues of our sample's companies are distributed in six distinct regions. As we expected, these figures do not reflect exactly the distribution of total transport revenues observed at the level of the ski area operation sector. In particular, companies from the Grisons canton and central Switzerland are under-represented. For example, at the sector level, the Grisons constitute 28% of total transport revenues during the 2004/05 accounting year (cf. SBS 2006) while in our sample it only reaches 20.7%. On the contrary, the Valais and Bernese parts are higher in our sample (respectively 43.4% and 20.7%) than they are in reality for the sector (33% and 14% during the 2004/05 accounting year). For the Bernese canton, this is probably because companies in this canton have until now followed a strategy that favors concentration on their natural activities, namely transport of goods and people (cf. Grischconsulta 2003). Finally, the lower left hand-side diagram of *figure 3.3* shows that very small companies are almost non-existent in our sample (generally, these companies operate one or two ski lifts). The next two classes of companies are represented in a similar proportion (i.e. one fifth of the sample's companies for each class) while classes of larger companies represent 24.1% respectively 29.9% of the sample's companies.

*Figure 3.4* shows the size of the ski area while *figure 3.5* shows the recourse to artificial snow cover for each company included in our 2004 sample. *Figure 3.6* is different from *figure 3.5* since it presents the resort to artificial snow operated by our sample's companies, categorized in five different-sized classes. More precisely, *figure 3.6* outlines the average share of technical snow used for their slopes, by companies of a given category.

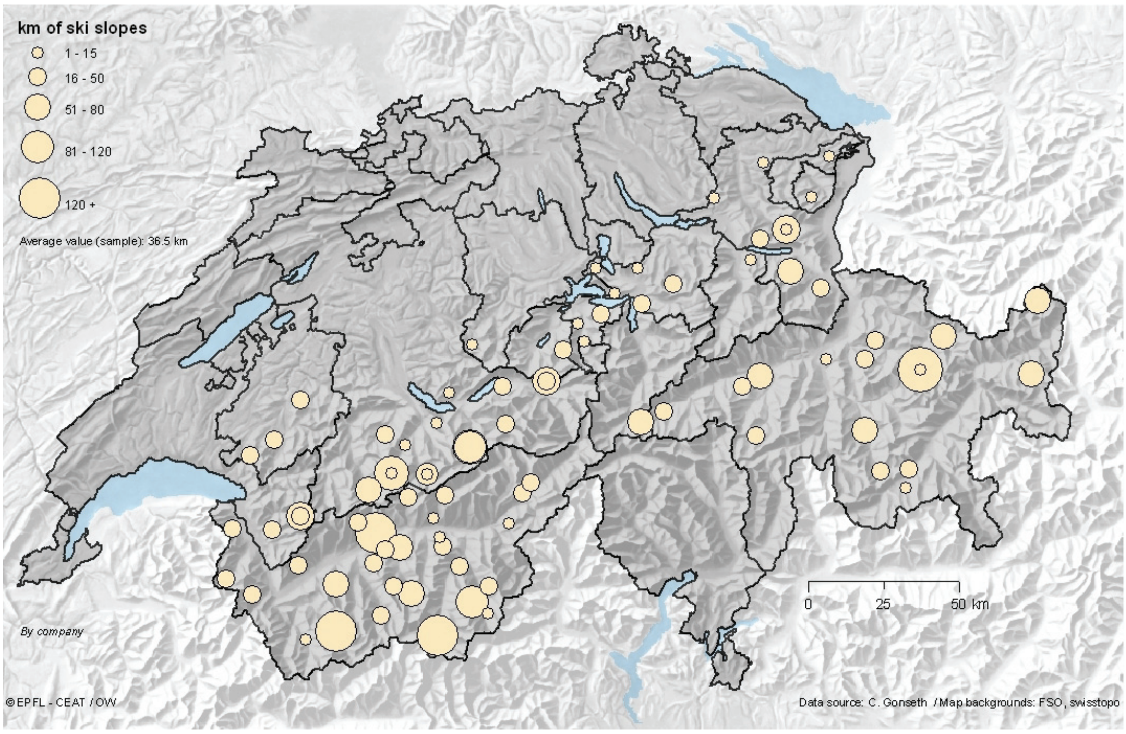


***Figure 3.4*** *- Overall kilometers of prepared ski slopes operated by each of our sample's companies. One circle is included in another circle when two ski area operation companies are located in the same commune.*

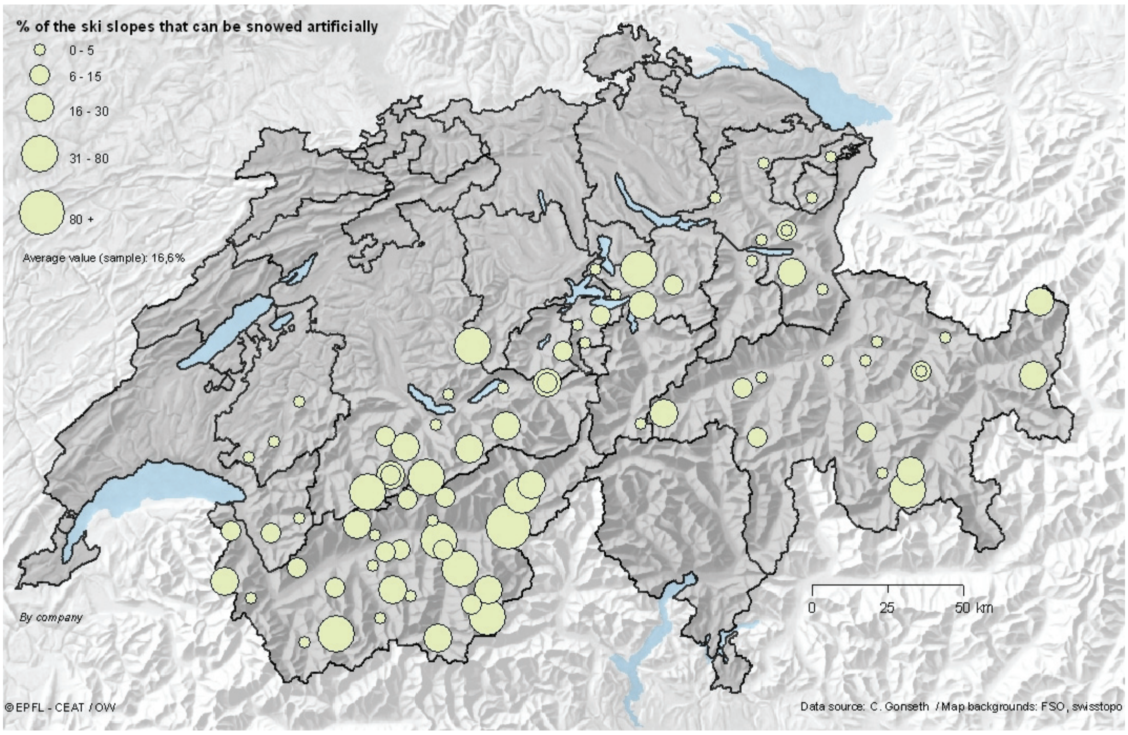


***Figure 3.5*** *- Percentage of the ski slopes that can be snowed artificially for each of our sample's companies. One circle is included in another circle when two ski area operation companies are located in the same commune.*

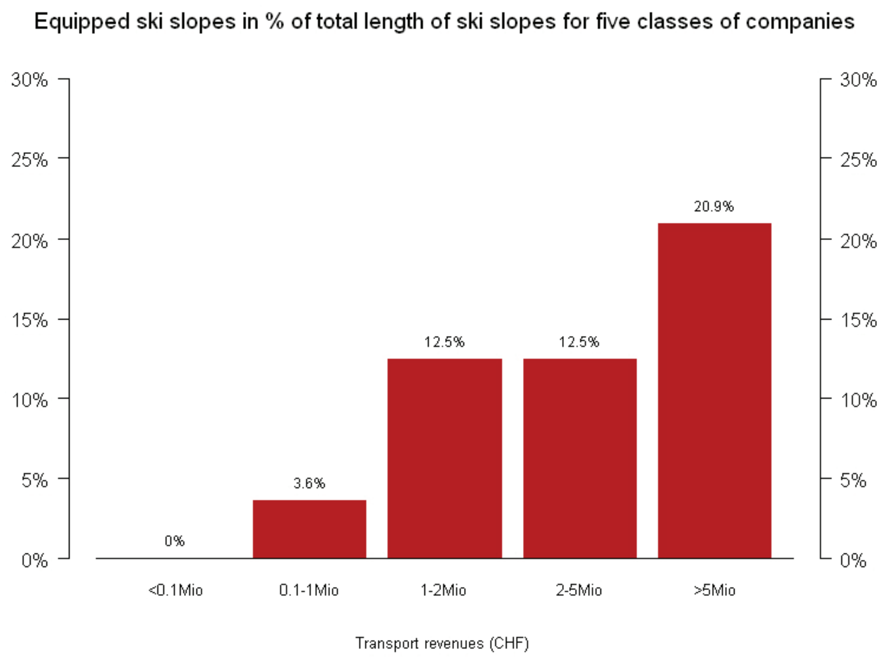


***Figure 3.6*** *- Snowmaking investments intensity for the companies of the sample.*

Our data accurately highlights that the proportion of artificial snow increases on average with the companies' size. This is not a surprising result, and reflects at least two aspects of the ski area operation sector: the increase of a company's financial capacity along with its size, and above a certain size, its struggle in a competitive market. For means of comparison, SBS indicates that, for the year 2003, a little bit more than 10% of the total slopes' area (more or less 10% of the slopes length) can be artificially snowed in Switzerland (SBS 2004).

## 3.4 Statistical results[27]

### 3.4.1 A normal linear model

In this subsection, our aim is to estimate a multiple linear regression model of EBITDA under some classical assumptions. Estimation of this model will serve us as a starting point before elaborating insights on more realistic models and more sophisticated techniques. For companies of similar size, EBITDA values are typically relative. Moreover large values of EBITDA are likely to vary more than small ones. Along with the statistics describing the sample of EBITDA, these elements motivate the transformation of the dependent variable with the natural logarithm. We also use the same transformation for some of the explanatory variables with a distribution skewed to the right. Some of the plots showing the transformed response versus each of the transformed predictors (cf. appendix 5) indicate that we must cope with a nonconstant variance function. For this reason, we estimate the model using weighted least squares with $w_j=\log(Slopes_j)$[28]. We expect that these weights give a good indication on the relative precisions of the $y_j$. Prior to present the results for 2004, *table 3.4* will remind the reader of the variables that we will initially include in the regression model. Descriptive statistics for some of these variables as well as for EBITDA are provided in *table 3.5*.

[27] Appendix 4 gives a brief overview of the statistical theory used in the following pages. For the normal linear model, the steps of the regression, the plots, the formulas and computations leading to the main results are documented in appendix 5.

[28] One case of our sample has Slopes=1km. The weight associated to this case will be zero with the consequence that it will be ignored in the fitting.

| Variables | Definition | Subsection |
|---|---|---|
| WTPF | Weighted transport passenger flow (persons/hour) | 3.2.3.1 |
| Slopes | Total length of marked slopes (km) | 3.2.3.2 |
| hbeds - phbeds | Number of beds in the hotel and para-hotel sectors | 3.2.3.3 |
| dist1 – dist2 | Ski area located by car at 90-120 minutes resp. at more than 120 minutes from the nearest big population basin. | 3.2.3.4 |
| Cdays - NCdays | Number of days during peak and non peak periods with a sufficient snow cover for skiing activities (snow height>30 cm) | 3.2.3.5 |
| artkm | Total length of slopes covered in artificial snow (km) | 3.2.3.6 |
| org - grant | Presence of an integrated structure – Presence of indemnity payments | 3.2.3.7-3.2.3.8 |

***Table 3.4*** *- Summary of the explanatory variables that will be included in the initial regression model.*

| **Variables** | **Location** | | **Scale** | | | | **Shape** |
|---|---|---|---|---|---|---|---|
| | **Average** | **Median** | **Sample minimum** | **Sample maximum** | **Sample standard deviation** | **Interquartile range** | **Standardized sample skewness**[29] |
| EBITDA (Mio CHF) | 2.5 | 0.96 | -0.29 | 25 | 4.4 | 2.4 | 3.22 |
| WTPF (persons/hour) | 954 | 911 | 235 | 1835 | 319 | 409.5 | 0.21 |
| Slopes (km) | 38 | 30 | 1 | 195 | 35 | 36 | 1.99 |
| hbeds | 768 | 478 | 0 | 6512 | 968 | 731 | 3.07 |
| phbeds | 2444 | 1373 | 62 | 14692 | 2852 | 2341.5 | 2.20 |
| Cdays[30] | 44 | 46 | 6 | 61 | 14 | 13 | -1.00 |
| NCdays[31] | 81 | 85 | 10 | 164 | 31 | 36.5 | -0.02 |
| artkm (km) | 6 | 3 | 0 | 56 | 10 | 7.8 | 2.92 |
| dist (min) | 85 | 83 | 28 | 187 | 31 | 41.5 | 0.68 |
| Altm (m) | 2293 | 2270 | 1040 | 3900 | 558 | 750 | 0.11 |

***Table 3.5*** *- Descriptive statistics for EBITDA and for some of the explanatory variables.*

[29] We will quote Davison (2003, p.18) in order to explain how to interpret the standardized sample skewness (noted as $g_1$ by Davison): "If the data are perfectly symmetric, $g_1=0$, while if they have a heavy upper tail, $g_1>0$, and conversely".

[30] The statistics displayed on this row are based on a sample of 84 rather than 87 companies. This is due to the fact that data on the availability of natural snow were lacking for three companies.

[31] Idem as footnote 1.

| Variables | Full model Est (SE) | Backward Est (SE) |
|---|---|---|
| Dependent variable: log(EBITDA) | | |
| Explanatory variables: | | |
| Intercept | 4.0078* | 3.2859 |
| | (2.5028) | (1.9841) |
| log(WTPF) | 0.6447 | 0.9123*** |
| | (0.4241) | (0.3277) |
| log(Slopes) | 0.4588** | 0.5266*** |
| | (0.2114) | (0.1581) |
| log(hbeds) | 0.2696** | 0.3669*** |
| | (0.1153) | (0.0742) |
| log(phbeds) | 0.2183* | |
| | (0.1300) | |
| dist1 | -0.2838 | -0.3708* |
| | (0.2673) | (0.2018) |
| dist2 | -0.5230* | -0.5114** |
| | (0.2965) | (0.2197) |
| Cdays | -0.0022 | |
| | (0.0105) | |
| NCdays | 0.0039 | |
| | (0.0043) | |
| artkm | 0.1211*** | 0.1107*** |
| | (0.0301) | (0.0230) |
| $artkm^2$ | -0.0018*** | -0.0016*** |
| | (0.0006) | (0.0004) |
| grant | 0.5668 | |
| | (0.4419) | |
| org | -0.2409 | |
| | (0.3581) | |
| Nbr of obs | 79 | 81 |
| $R^2$ | 0.7817 | 0.8258 |

***Table 3.6*** *- Parameter estimates and standard errors for the full linear model and the model fitted by backward elimination. Individual coefficients are statistically significant at the *10% level, **5% level or ***1% significance level.*

We use backward elimination in order to select the most relevant explanatory variables from our full model[32]. Using this procedure, we are left with a model in which the EBITDA increases with the modernity of the transport facilities (as summarized by the variable WTPF), the size of the ski area, the number of beds in the hotel industry, the proximity to a big population basin and the investments in snowmaking[33]. More precisely, the partial effect on the EBITDA of the latter

[32] Backward elimination starts from our initial model and then successively drops a term so as to minimize the Akaike's information criterion (AIC) at each step. It stops when no term can be removed without increasing the AIC.

[33] Examination of the diagnostic plots for the first model chosen by backward elimination underlines the presence of an outlier which, after verification, has an abnormal value of the EBITDA. Therefore, *table 3.6* presents the model fitted by backward elimination when this case has been removed from the sample.

variable is positive but tends to decrease as the level of investments becomes higher and can even be negative at some point. When there is no snowmaking, the fact to equip one kilometer with snowmaking facilities induces an 11.1% change in the EBITDA. When the initial recourse to snowmaking is equal to 10, 20, 30, 40 km, the partial effect shrinks to 7.9%, 4.7%, 1.5%, -1.7%. However, these figures are point estimates. 95% confidence intervals for the true value of the partial effects have been computed in appendix 5 at different values of the variable artkm (i.e. 0, 10, 20, 30 and 40 km). These confidence intervals show clear evidence that the partial effect is positive up to 20 km. Evaluated at 30 km, it is not excluded that the true value of the partial effect be slightly negative. At 40 km, the true value of the partial effect can also be positive according to the confidence interval.

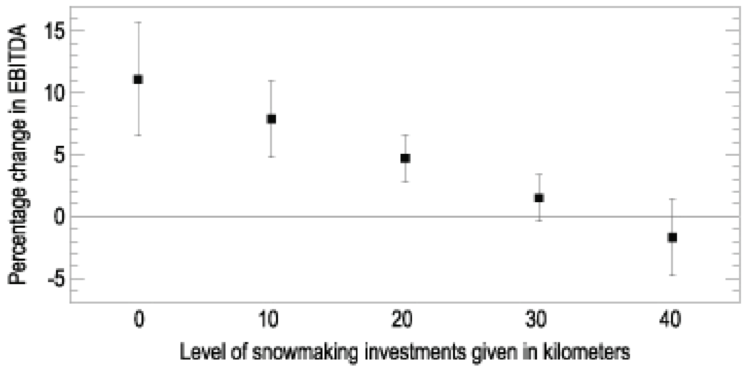


***Figure 3.7*** *- 95% confidence intervals of the partial effect of artkm computed at different initial levels of snowmaking investments (i.e. for different initial values of artkm).*

As regards the variables related to the natural snow conditions, they were not found to be significant. A priori, this is a strange result but some reasons can be put forward to explain it. Since we use a cross section sample, it is questionable whether the snow conditions vary sufficiently to affect values of the dependent variable. Furthermore, our measures of the snow conditions are not accurate ones even if corrections were made to them. Finally, it is possible that coefficients' estimation suffers from an omitted variables bias since variables given the number of days with theoretically sufficient natural snow cover for skiing might well be negatively correlated with air temperature and length of the sunny period. We know for instance that very cold weather deters people from skiing.

With the results obtained, we can try to give some insights on some broader questions. For instance, what could we say about the global financial consequences if all the companies of our sample were to equip one additional km of ski slope with snowmaking facilities? By analysing this problem, we would like to discuss what the potential was during the financial year 2003/04 for EBITDA, cash flow and net income improvements through snowmaking investments. In order to answer the question, we have basically analysed, for each sample's company, the effect of additional investments in snowmaking on the conditional mean function of EBITDA and then have compared this estimated effect with the value

Moreover, information on the availability of natural snow was lacking for three companies of our sample. Added to the outlier deletion, this explains why the number of observations is equal to 81 in the model fitted by backward elimination.

of other costs linked to the investments (i.e. financial and depreciation costs). Details of the method that was used are given in appendix 5 whereas the results are shown in *table 3.7*.

| EBITDA enhancing | Cash flow enhancing | Net income enhancing |
|---|---|---|
| 97.5% | 86.4% | 61.7% |

***Table 3.7*** *- Figures giving the percentage of our sample's companies for which additional snowmaking investments would have increased 1/the EBITDA, 2/the cash flow and 3/the net income.*

According to these figures, these additional investments in snowmaking will worsen the EBITDA of only 2.5% and the cash flow of only 13.6% of the sample's companies. This percentage increases up to 38.3% when being concerned by the net income. In other words, this means that 38.3% of the companies would worsen their net profits if they were to equip one additional kilometer of slope with snowmaking facilities. Of course, this result seems to draw some economical limits to the common view that adaptation to climate change will be primarily carried out through investments in snowmaking facilities. However, we might be aware that these figures would be different with a different sample thereby not giving definite values but rather clues.

A troubling aspect of this model is that four cases had to be omitted from the regression because they display negative EBITDA which is incompatible with the natural logarithm transformation. In this case, the cause of the deletion is not independent of the values themselves and that may create some statistical problems. In order to analyze the effects of these deletions on the value and the standard error of the estimates, we have reintroduced gradually these four cases in our sample by adding at each step a positive offset to the values of the dependent variable. This analysis shows clear evidence that the EBITDA increases with the first kilometer of investment in snowmaking facilities. Considering all the confidence intervals, this increase ranges approximately from 5% to 20% of the EBITDA. Furthermore, the point estimates are all lying in the range between 11% and 14%. As regards the parameter $\beta_7$, we can see that the upper limit of all the confidence intervals is always negative. This is again evidence that the net operating gains of snowmaking investments decrease as the level of snowmaking investments increases. The point estimates vary from a value of -0.0022 to a value of -0.0016.

### 3.4.2 Instrumental variables and generalized method of moments estimation

We need to make a preliminary remark to this new subsection. One of the things that were brought out in the previous subsection is the fact the sample is made up of very heterogeneous companies. This can be observed in the very high leverage of certain cases and in the fact that certain companies display a negative value of the EBITDA. By focusing our attention on a subset of the sample, we would be able to make a more rigorous analysis. This is the reason why we will concentrate below on companies that operate more than 15 kilometers of ski slopes. In this subset, only one company has a negative EBITDA.

#### *3.4.2.1 Measurement errors in the para-hotel sector's lodging supply variable*

In the previous subsection, the variable phbeds has not been kept in the final model. However, we still think that the number of beds in the para-hotel sector has a systematic impact on the ski area operation companies' EBITDA.

Keeping this variable in the systematic part of the model would also allow discussing potentially differentiated impacts on EBITDA of the beds in the hotel and para-hotel sectors[34]. This could be of some policy relevance when considering the types of beds that it is worth promoting in ski resorts. As discussed in appendix 5, the data used to derive the phbeds variable are far from being accurate ones. Instead of removing the variable from the model, a more satisfying thought process would therefore be to keep the term linked to the para-hotel beds and to describe explicitly the error linked to the measurement of the para-hotel sector's accommodation capacity. We will discuss this possibility and its consequences in the next paragraphs.

In subsection 3.2.3.3, we have defined the variable phbeds as the number of beds in the rented holiday houses and apartments, youth hostels and group accommodations (without taking into account the beds in the mountain huts). In order to build this variable, we use data provided by the FSO for the tourism year 2003 which runs from November 2002 to October 2003. As emphasized in subsection 3.3.1, these data sometimes incorporate beds from the Bed and Breakfast establishments in the amount of the holiday houses and apartments' beds. When putting in perspective the variable's formal definition with the available data, we need to recognize that the definition of phbeds is somewhat imprecise. At this point, we need to redefine the variable that influences the companies' EBITDA generated during the 2003/04 accounting year. We will do it by defining the variable as the number of beds available during the winter season 2003/04 in the rented holiday houses and apartments, youth hostels, Bed and Breakfast establishments and group accommodations (without taking into account the beds in the mountain huts). This (unobserved) variable will be written phbeds*. This definition allows us to write the following equation for the model:

$$\begin{aligned}&\log EBITDA_j = \beta_0 + \beta_1 \log WTPF_j + \beta_2 \log Slopes_j + \beta_3 \log hbeds_j + \beta_4 \log phbeds_j^* \\ &\beta_5 dist1_j + \beta_6 dist2_j + \beta_7 artkm_j + \beta_8 artkm_j^2 + \varepsilon_j\end{aligned} \quad (3.1)$$

To be more precise, we have in mind the following conditional mean function:

$$\begin{aligned}&E(\log EBITDA_j | x_j^*) = \beta_0 + \beta_1 \log WTPF_j + \beta_2 \log Slopes_j + \beta_3 \log hbeds_j \\ &+ \beta_4 \log phbeds_j^* + \beta_5 dist1_j + \beta_6 dist2_j + \beta_7 artkm_j + \beta_8 artkm_j^2\end{aligned} \quad (3.2)$$

---

[34] This is not the only way to test for such differences. For instance, one can sum the beds in the hotel and para-hotel sectors in order to remain with only one variable measuring the overall lodging capacity in a given ski resort and compute the percentage of hotel beds from this total. Regression carried out with these two variables also allows discussing potentially differentiated impacts on EBITDA of beds in the hotel and para-hotel sectors. Using these variables instead of hbeds and phbeds has an advantage and a drawback. The advantage is that we are potentially avoiding complication in the estimation process due to the high correlation between beds in the hotel and para-hotel sectors (cf. *table A 5.2* of appendix 5). On the other hand, we are mixing accurate data with data containing measurement errors by aggregating the variables hbeds and phbeds in only one variable. In this chapter, the steps that we will carry out are the following: we will first try to estimate a mean function which includes both hbeds and phbeds. By doing so, we will see the measurement errors in the phbeds variable as a source of endogeneity that leads to underestimate the effect of phbeds. Estimation techniques other than OLS will then be chosen in order to cope with endogenous explanatory variables. After having completed this part of the analysis, we will return to OLS and estimate a mean function with the overall lodging capacity and the percentage of beds in the hotel sector replacing the hbeds and phbeds variables.

Where

$$x_j^{*T} = (1, \log WTPF_j, \log Slopes_j, \log hbeds_j, \log phbeds_j^*, dist1_j, dist2_j, artkm_j, artkm_j^2)$$

Instead of phbeds*, we observe however a measure of phbeds* which is an inaccurate one. The observed measure of phbeds* is the variable phbeds. The relationship between the two variables can be stated as follows.

$$phbeds_j = phbeds_j^* + e_j \quad (3.3)$$

Where $e_j$ is a measurement error.

By replacing $phbeds^*_j$ by $phbeds_j$-$e_j$ in equation 3.1, we will somehow modify the error and form a composite error which will depend on the measurement error $e_j$. A central problem is then to determine whether the composite error and $phbeds_j$ are correlated (i.e. determining whether $phbeds_j$ is endogenous). The following condition must be fulfilled in order to rewrite equation 3.2 with $logphbeds_j$ instead of $logphbeds^*_j$:

$$E\left(e_j \middle| x_j\right) = 0 \quad (3.4)$$

Where

$$x_j^{T} = (1, \log WTPF_j, \log Slopes_j, \log hbeds_j, \log phbeds_j, dist1_j, dist2_j, artkm_j, artkm_j^2)$$

Among other things, this implies that $e_j$ and $phbeds_j$ are uncorrelated. However, this is not the case under the classical errors-in-variables (CEV) assumption which states that (cf. Wooldridge 2001, p.74):

$$\mathrm{cov}(phbeds_j^*, e_j) = 0 \quad (3.5)$$

Due to equation 3.3, the CEV assumption then implies that $e_j$ and $phbeds_j$ must be correlated:

$$\mathrm{cov}(phbeds_j, e_j) = \sigma_e^2 \quad (3.6)$$

Without further insights on the way the data were collected and/or on the factors influencing phbeds* in different ski resorts, the CEV assumption seems a reasonable assumption in our case thereby expecting the variable phbeds to be endogenous. Theoretically, this has a direct consequence on the estimated ordinary least squares (OLS) regression coefficients. In particular, if $\beta_4$ is positive (as expected) then its OLS estimate will tend to underestimate it. Moreover, the attenuation bias will be important if phbeds* is strongly collinear with the other explanatory variables. By testing the null hypothesis $H_0$: $\beta_4$=0, the probability of Type II error will therefore be higher. In the next subsection, we have estimated the estimable version of equation 3.1 (i.e. by replacing phbeds* with phbeds in equation 3.1). The results seem to agree with the theoretical insights that were just presented. Indeed, the estimated effect on the EBITDA of a one percentage increase in the hotel sector's number of beds was nearly four times that of a one percentage increase in the para-hotel sector's number of beds. Intuitively, we would not have expected such a huge difference. These results seem to indicate that the variable phbeds is not found to be significant because of measurement errors.

As a matter of fact, measurement error in the phbeds variable will not be the only source of endogeneity in our model. Omitted variables bias and simultaneity problems will also arise. The former source of endogeneity will be treated in the next subsection and a solution will be proposed to alleviate or, at least, mitigate the impacts of omission of certain variables. The way to cope with simultaneity problems and measurement error will be treated in following subsections.

#### *3.4.2.2 Proxy variable, additional dummy variables and interaction terms*

By looking at the model of log(EBITDA) presented in the previous subsection, we can see that the natural snow conditions related variables are omitted. Therefore, the effects of these conditions are included in the error term. In this case, estimations can be contaminated with what is generally referred to as an "omitted variables bias" in the literature: omitting natural snow conditions will lead to inconsistent estimator if one or several explanatory variables included in the model are correlated with these conditions. Typically, we expect the location and resort lodging related variables to be potentially correlated with natural snow conditions. A way to cope with this problem is to add a proxy variable for these conditions in the model. In our setting, we will add a variable that gives the maximum altitude of the ski area (Altm).

| Variables | Initial model Est (SE) | Model with proxy Est (SE) |
|---|---|---|
| Dependent variable: log(EBITDA) | | |
| Explanatory variables: | | |
| Intercept | 0.1166 | -1.5149 |
| | (2.0980) | (2.3310) |
| log(WTPF) | 1.0535*** | 1.3320*** |
| | (0.3465) | (0.3834) |
| log(Slopes) | 1.0184*** | 0.7534*** |
| | (0.2384) | (0.2677) |
| log(hbeds) | 0.3369*** | 0.3383*** |
| | (0.0835) | (0.0779) |
| log(phbeds) | 0.0829 | 0.0130 |
| | (0.1118) | (0.1191) |
| dist1 | -0.5748*** | -0.6001*** |
| | (0.1725) | (0.1523) |
| dist2 | -0.3616 | -0.6919* |
| | (0.2824) | (0.3892) |
| artkm | 0.0926*** | 0.0989*** |
| | (0.0236) | (0.0217) |
| $artkm^2$ | -0.0016*** | -0.0016*** |
| | (0.0004) | (0.0004) |
| Altm | - | 0.0005** |
| | | (0.0002) |
| Nbr of obs | 59 | 59 |
| $R^2$ | 0.8542 | 0.8659 |

***Table 3.8*** *- Parameter estimates and standard errors for OLS regressions carried out with and without the proxy variable. *p≤0.1, **p≤0.05, ***p≤0.01. White standard errors are reported. Regressions done with EViews6.*

Though it is an imperfect proxy because snow conditions do not depend exclusively on altitude, adding the Altm variable clearly helps mitigate the omitted variables bias as shown in *table 3.8*[35]. The effect of adding the proxy variable is most visible by looking at the estimated coefficients for the variables dist1 and dist2. As can be verified by looking at *figure 3.8*, remote ski resorts are also generally those located in the highest regions. Therefore, we expect these two variables to be partially positively correlated with natural snow conditions. By adding the proxy variable, it is therefore logical to see the negative effects of both dist1 and dist2 increasing.

[35] Actually, including a proxy variable can theoretically mitigate bias as well as reduce asymptotic variances (Wooldridge 2001, p.64).

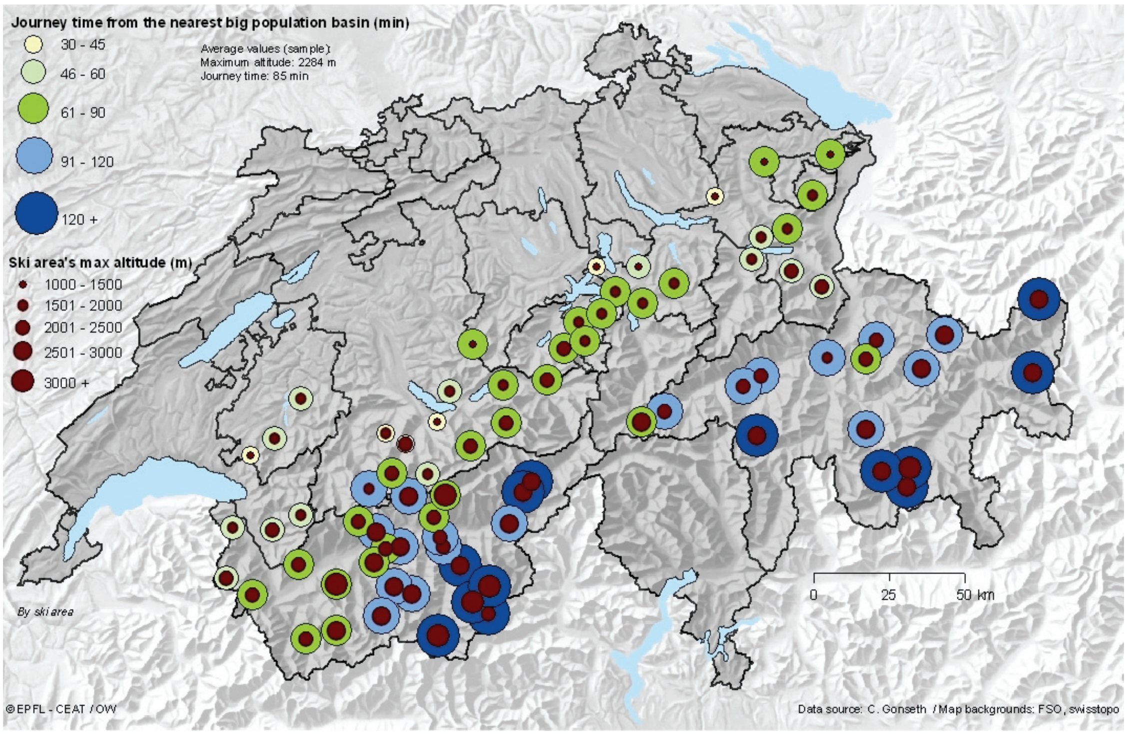


***Figure 3.8*** *- Maximum altitude and accessibility of the ski areas included in the 2004 sample.*

As a next step, we have tried to introduce in our model additional dummy variables indicating things such as the location of companies in different ski regions or cantons and the exposure to the sun of the ski areas. Our aim is also to use these dummy variables in order to build interaction terms with the variables artkm and $artkm^2$ (i.e. we would like to test whether the partial effect of snowmaking investments depends on the level of these dummy variables). Except for one dummy variable, these variables were however not found to have a significant effect on the EBITDA once the already determined explanatory variables were taken into account. Exception concerns the dummy variable OICH indicating whether a given company is located in the central/eastern part of Switzerland or not. A positive effect is associated to this dummy variable. A priori, this might seems a strange result since dummies indicating location in other ski regions like the Valais or the Grisons were not found to be significant. However, some explanations can be put forward. On the one hand, ski areas located in the central/eastern part of Switzerland account for nearly one third of all the skier-days from "excursionists" generated by the Swiss population in 2001. This is due mainly to the proximity to Zurich and its agglomeration. On the other hand, these skier-days might also be less scattered between different ski areas than is the case in other ski regions.

As shown in *table 3.9*, introducing this dummy variable has the effect to change estimates of the coefficients related to dist1 and dist2. More precisely, these estimates decrease in absolute terms. This arises because companies of our sample located in the central/eastern part of Switzerland are quickly reachable by car from the center of Zürich (i.e. dist1 and dist2 take the value zero for these companies). In the absence of the dummy OICH in our model, partial effects of variables dist1 and dist2 therefore capture the effect on the EBITDA of both an increase in the distance to the densely populated regions and a change in the ski region.

| Variables | Model with proxy<br>Est<br>(SE) | Model with proxy and dummy<br>Est<br>(SE) |
|---|---|---|
| Dependent variable: log(EBITDA) | | |
| Explanatory variables: | | |
| Intercept | -1.5149 | -1.8216 |
| | (2.1243) | (1.9019) |
| log(WTPF) | 1.3320*** | 1.3152*** |
| | (0.3494) | (0.3070) |
| log(Slopes) | 0.7534*** | 0.6575*** |
| | (0.2440) | (0.2354) |
| log(hbeds) | 0.3383*** | 0.2511*** |
| | (0.0710) | (0.0678) |
| log(phbeds) | 0.0130 | 0.1291 |
| | (0.1085) | (0.1060) |
| dist1 | -0.6001*** | -0.4627*** |
| | (0.1388) | (0.1499) |
| dist2 | -0.6919* | -0.5870* |
| | (0.3547) | (0.3368) |
| artkm | 0.0989*** | 0.1057*** |
| | (0.0198) | (0.0191) |
| $artkm^2$ | -0.0016*** | -0.0017*** |
| | (0.0004) | (0.0003) |
| Altm | 0.0005** | 0.0006*** |
| | (0.0002) | (0.0002) |
| OICH | - | 0.6565*** |
| | | (0.1600) |
| Nbr of obs | 59 | 59 |
| $R^2$ | 0.8659 | 0.8849 |

***Table 3.9 -*** *Parameter estimates and standard errors for OLS regressions carried out with and without the dummy OICH. *p≤0.1, **p≤0.05, ***p≤0.01. White standard errors are reported. Regressions done with Stata10.*

As regards interaction terms, they were added to the estimable model in order to allow the partial effect of snowmaking equipment to vary with both the dummy OICH and the maximum altitude but the related coefficients were not found to be significant. Interaction terms between the variables OICH, dist1 and dist2 were not found to be significant either.

From *table 3.9*, we can observe that the effect of OICH is not only positive but it is also large. Our research indicates that snow conditions during the winter season 2003/04 were better in the eastern part of Switzerland than in the south and western regions of Switzerland. Therefore, it might also be the case that the variable OICH captures particularly favourable snow conditions compared to those faced by companies located both in other Swiss regions and in the vicinity of densely populated regions. We cannot also exclude the possibility that good snow conditions have a larger positive effect on a company's EBITDA when its clientele is made up of many "excursionists". Using our sample, we find that companies located in the central/eastern part of Switzerland display on average a higher value of Tdays than the other sample's companies that are also located in the vicinity of densely populated regions (143 days versus 114 days).

The possibility that the discrete variable OICH captures better snow condition could have an interesting implication for model building. Indeed, this seems to be a hint that snow conditions should be introduced in the model with one or several discrete variables rather than with one or several continuous variables. In order to derive these binary variables, one idea is to look more carefully at the available amount of natural snow (during the peak and non peak periods) for the companies located in the central and eastern part of Switzerland and then to derive some threshold values based on these amounts. If one or all of these variables were found to be significant, we could again test for interaction terms with the snowmaking investments related variables. We could also add an interaction term to the model so as to allow the financial impacts of better snow conditions to vary with the distance to the densely populated regions. We have tried to implement these changes. Unfortunately, no one of the planned discrete variables were retained despite the clues that some of them should have been found to be significant.

Using information from the previous paragraphs, we can now write down the new estimable model:

$$\begin{aligned} \log EBITDA_j &= \beta_0 + \beta_1 \log WTPF_j + \beta_2 \log Slopes_j + \beta_3 \log hbeds_j \\ &+ \beta_4 \log phbeds_j + \beta_5 dist1_j + \beta_6 dist2_j + \beta_7 artkm_j + \beta_8 artkm_j^2 \\ &+ \beta_9 Altm_j + \beta_{10} OICH_j + \varepsilon_j \end{aligned} \tag{3.7}$$

Some explanations on the error term displayed in equation 3.7 are required. The error term ε includes measurement errors and omitted factors influencing the EBITDA. In subsection 3.2.4, several variables are listed which could plausibly influence the EBITDA including professionalism, meteorological conditions (especially during the weekends), natural assets like landscape and viewpoint, summer activities, conditions of access to the ski resorts and public policies and measures. Being unobserved, they should be part of the error term. We also demonstrated above how errors associated to the measure of accommodation capacities in the para-hotel sector are eventually included in the error term.

#### *3.4.2.3 Remaining sources of endogeneity*

There exist serious motives to consider three explanatory variables of the model given in equation 3.7 as endogenous. More precisely, the variables WTPF, artkm and phbeds are thought to be correlated with the error term ε. Under the classical errors-in-variables (CEV) assumption, endogeneity of the phbeds variable has been demonstrated above. However, the source of endogeneity is different for the variables WTPF and artkm. The WTPF and artkm variables are both related to the intensity of investments. As regards endogeneity problems, we expect what the literature calls the simultaneous causality bias (or simultaneity bias). On the one hand, modernization of the transport facilities and extension of the snowmaking facilities must have an impact on the EBITDA; on the other hand, the better the financial situation of the company the higher are its financing ability and levels of investments. As far as factors explaining the good financial situation of the company are included in the error term, WTPF and artkm could be correlated with the error term. Such factors include professionalism, natural assets such as landscape and viewpoints, snow cover conditions, etc.

In order to cope with these sources of endogeneity, it is not possible to add a variable to the model as we have done to avoid omitted variables bias. However, statistical procedures such as instrumental variables (IV) regression and generalized method of moments (GMM) have been developed in order to produce consistent estimators. These procedures imply finding new variables which are called (excluded) instruments. Therefore, we now turn on discussing variables that could a priori be used as instruments in IV and GMM regressions. As explained in appendix 4, (excluded) instruments should be relevant and exogenous, i.e. correlated with the endogenous explanatory variables they replace and uncorrelated with the residual. Furthermore, IV and GMM regressions can only be carried out when the number of (excluded) instruments is at least equal to the number of (included) endogenous explanatory variables. Finally, overidentification of the coefficients is required to test the exogeneity of the instruments.

#### *3.4.2.4 Candidates for instrumental variables*

We will first try to find instruments for the variable phbeds. Based on data provided by the FSO, the phbeds variable is an inaccurate measure of the number of beds available in rented holiday houses and apartments, youth hostels, Bed and Breakfast establishments and group accommodations at the ski resorts level during the winter season 2003/04. In many cases, beds in the rented holiday houses and apartments constitute the major component of the variable. Therefore, values of this variable should be strongly influenced by the number of holiday houses and apartments in the ski resorts. The latter were counted during the last federal census of 2000 and included by the FSO in the statistic of the temporarily occupied housings. A nice feature of the statistic provided by the FSO for the temporarily occupied housings is that they are distinguished according to the number of rooms (1, 2, 3, 4, 5 and 6 rooms and more). Therefore, we could potentially inherit from six instrumental variables (lodg1, lodg2, lodg3, lodg4, lodg5 and lodg6). Referring to the previous discussion, we can hope that these variables satisfy the relevance requirement. Is it exogenous? There is no apparent reason to think that the numbers of temporarily occupied housings are correlated with the measurement error associated to the variable phbeds. As regards the other factors included in the error term, the discussion is a bit more complicated. In particular, reliable winter tourism products might have a positive effect on the numbers of holiday houses and apartments. In other words, there might be a link between snow-reliability of the ski area and development of the ski resort. Therefore, the numbers of temporarily occupied housings are perhaps endogenous even after having added the variable Altm to the model. By the way, the hypothesis of exogenous instruments will be tested. The J-statistic and its p-value are given for each regression.

Another possibility in order to find instruments for the variable phbeds would be to look at some measures taken at the local level. More precisely, we are thinking of the measures that give incentives to second homes owners to rent their lodgings. In Switzerland, numerous incentive measures were proposed including:

- Increase the costs linked to the ownership of second homes (e.g. by compelling owners of second homes to buy transmissible season passes to ski area operation companies).

- Exclude new lodgings from the fixing of quotas on second homes (when this form of quotas exists) every time the buyer commits himself to rent the lodging during his absence.

- Remove taxes on the rented lodgings.

- Grant advantages in kind or in cash to owners who rent their lodging in their absence (e.g. grant the same discounts as those granted to local people)

- Tax second homes and use the generated revenues so as to encourage the establishment of professional beds.

Indication of the presence of such measures at the communal level could serve as an instrument since they are aimed at increasing the level of rented beds in the holiday houses and apartments. However, a limited number of these measures are applied in practice and their real impacts are not proven. Moreover, it would be rather tiresome to determine which commune has recourse to which incentive measure (if any). Considering that the figures vary sufficiently from one commune to the other, a more easy way to get an instrumental variable would be to look at the percentage of foreigners among second homes owners. Though this idea is not unanimously shared among tourism stakeholders, it seems that, for obvious economical and practical reasons, foreign owners of second homes tend to rent more their lodgings than Swiss owners. Unfortunately, this statistic does not exist.

With regards to the variables artkm and WTPF, one idea to get instrumental variables is to look at the actions and decisions taken by some stakeholders which impact the companies' investments. If these actions or decisions are not directly observable, another solution would be to observe factors influencing these actions and decisions. Of course, the link between these factors and the companies' investments is thinner because such factors could not explain entirely decisions and measures taken by stakeholders. In other words, they might prove not to be enough relevant. In the next lines, we will use this thought process hoping that it will help us finding useful instruments for the variables artkm and WTPF.

Note first that exogenous variation in the variable artkm could possibly arise as a consequence of different regional development policy. Planning permissions might be more difficult to obtain in some cantons than in others and restrictions can be put on the type of conceivable projects. Because of the environmental impacts associated to snowmaking, some cantons might want to restrict snowmaking facilities on the ski areas. For instance, the Fribourg canton wishes to avoid snowmaking projects that allow covering an entire ski slope with artificial snow. On the contrary, public authorities in the Valais canton state that each ski resort can endow at least one entire ski slope with snowmaking facilities. Whether these different policies have generated differences in the current level of snowmaking investments across different regions is the question we might answer now. In fact, it seems unrealistic to think that this is the case for two main reasons. On the one hand, these rules have emerged only a few years ago. On the other hand, principles set in the regional development policy have not been yet a limiting factor for the snowmaking investments as emphasized by the example of the Fribourg canton. Though vigilant with respect to this kind of investments, public authorities have largely contributed to finance snowmaking investments that were carried out in this canton (cf. chapter 2).

Another idea still related to regional development and environmental impacts of snowmaking facilities is to look at the actions taken by environmentalists. Such actions could stop or delay some projects and even deter some companies from having recourse to snow cover use because they think that they will have to face oppositions. Therefore, these actions create some exogenous variation in the level of snowmaking investments across different companies. At the moment, several associations for the protection of the environment and the landscape are active in the mountain regions of Switzerland (ProNatura, WWF, Fondation Suisse pour la protection et l'aménagement du paysage). Legal procedures carried out by these environmentalist groups are also relevant for projects concerned with the renewal of transport facilities. Since the latter always bring about new environmental impacts, their actions may also create some exogenous variation in the level of the WTPF variable. Accordingly, a first set of two instruments (artop and transop) has been built by looking at the oppositions launched by environmentalist groups against snowmaking and transport facilities projects planned by ski area operation companies. A priori, this first set of two instruments is quite promising since oppositions clearly explain investments' delay in some ski resorts and do not depend neither on the financial situation of the companies nor on the determinants of their financial situation. Motives for oppositions to snowmaking projects are described in the next paragraph and are used to derive another instrument.

As regards the two associations more specifically concerned with nature preservation (i.e. WWF and Pro Natura), most of the oppositions to projected snowmaking facilities are motivated either by the direct damages that these facilities will cause to endangered and rare species and biotopes or by the conviction that the projected investments in snowmaking equipment are irrational from an economical and/or a regional development point of view. When the concern is focused on species or biotopes of great value, oppositions depend on whether the projects take care of the environment and respect the legal rules of nature preservation. Quite logically, the probability that the environmental groups be opposed to projected snowmaking facilities increases when many natural objects of great worth are located inside and/or close to ski areas. We could use this observation in order to derive one or several instruments. In fact, any indicators of the presence of these natural objects of great worth could be used as instruments according to this logic. This information is partly available in a set of existing and planned federal inventories that put the emphasis on biotopes and habitats protection. More precisely, these inventories list different kinds of marshes (two inventories in the OBM and OHM), breeding sites of batrachians (one inventory –IBat-) and dry meadows (one inventory –PPS-) which are important at the national level. As a brief reminder, we simply note here that snowmaking projects could potentially strongly impacts these habitats through water catchments activities (including direct pumping into the marshes) but also through the equipping of marshlands (water reservoirs and water pipes) and the modification of the soil equilibrium (temperature, nutrients, etc.). While impacts on dry meadows could only happen on the ski area (i.e. on the ski slope equipped with snowmaking facilities), marshlands could be subject to some damages even if they are located at a certain distance from the ski area. As the federal inventories localize the listed objects at the communal level, information from the dry meadows inventory cannot be used since it is not precise enough. However, this problem does not arise or arise to a much lesser extent with the other cited inventories. For each relevant commune, we therefore compute the total number of objects listed in the OBM, OHM and IBat's federal inventories that are located on their territory. Since ski area can be located on one or several communal territories, we allocate the objects to each ski resort accordingly to derive the instrument (inv). As it is constructed, the instrument should be exogenous. Whether it is relevant is less obvious and the fact that two instruments are already based on environmentalist groups' oppositions will tend to reduce its relevance. Contrary to the latter instruments, however, it could capture constraints linked to the presence of protected biotopes that have deterred the companies from planning new facilities.

In the next few lines, we will describe our last trial to build an instrument related to the variable WTPF. Since 1990, investments in transport facilities have allowed replacing many ski tows by more attractive and high-performance facilities. As explained in subsection 3.2.3.1, this evolution tended to increase the value of the weighted transport passenger flow (WTPF) associated to the transport facilities located on the Swiss ski areas. Because financing abilities were not the same across companies, this evolution led to additional differences of the WTPF index for different companies. In equation 3.7, we expect that this part of the variation in the variable is correlated with the error term which leads to WTPF being an endogenous variable. As always in this subsection, we are looking for some exogenous source of variation in the endogenous variable. In the case of the variable WTPF, the number of cable cars operated by a given company could be such a source. On the one hand, some elements tend to prove that the number of cable cars is not correlated with the error term. For instance, we note that the overall number of cable cars was nearly unchanged during the period from 1991 to 1999 (FOSD 2001). Therefore, we can ascertain that the variation in the number of cable cars is not a consequence of the pattern of investments made in transport facilities during the nineties. On the other hand, cable cars display rather high differences in level for rather low transport passenger flow compared to the other types of transport facilities. Therefore, they might negatively affect the value of WTPF. However, cable cars representing generally only a small fraction of the overall transport facilities operated by the Swiss ski area operation companies, the number of cable cars would only explain a small part in the variation of WTPF. This results in the number of cable cars being a weak instrument. Unfortunately, weak instruments are not useful for performing IV regression and we must finally only retain the instruments that we have already derived.

Finally, we end up with nine instruments though we have to cope with only three endogenous variables. However, this statement needs to be qualified in some respects. On the one hand, we have to deal with four rather than three endogenous variables since both artkm and $artkm^2$ are included in the model. Accordingly, the number of overidentifying restrictions is equal to five instead of six. What really matters however is the fact the number of (excluded) instruments be higher than the number of endogenous variables so that we can carry out statistical tests aimed at assessing the instruments' exogeneity. On the other hand, six instruments should be correlated with the same endogenous variable and will hardly help pinning down exogenous variations in the other endogenous variables. Therefore, only three (excluded) instruments remain for the other endogenous variables.

#### *3.4.2.5 OLS, TSLS and GMM regressions*

| Variables | OLS estimator<br>Est<br>(SE) | TSLS estimator<br>Est<br>(SE) | GMM estimator with heteroskedasticity<br>Est<br>(SE) | GMM estimator with clustering<br>Est<br>(SE) |
|---|---|---|---|---|
| Dependent variable: log(EBITDA) | | | | |
| Endogenous variables: log(WTPF), artkm, artkm², log(phbeds) | | | | |
| Excluded instruments: artop, transop, lodg1, lodg2, lodg3, lodg4, lodg5, lodg6, inv. | | | | |
| Explanatory variables: | | | | |
| Intercept | -1.8216 | -0.2088 | -0.1844 | 2.2497 |
| | (1.9019) | (4.9750) | (4.6367) | (5.8145) |
| log(WTPF) | 1.3152*** | 0.9582 | 1.0003 | 1.3647* |
| | (0.3070) | (0.8647) | (0.8221) | (0.8150) |
| log(Slopes) | 0.6575*** | 0.6486** | 0.4621 | 0.6082** |
| | (0.2354) | (0.3086) | (0.2867) | (0.2819) |
| log(hbeds) | 0.2511*** | 0.1717* | 0.0944 | 0.1694** |
| | (0.0678) | (0.1010) | (0.0887) | (0.0803) |
| log(phbeds) | 0.1291 | 0.3336* | 0.3833** | 0.2995** |
| | (0.1060) | (0.1776) | (0.1695) | (0.1462) |
| dist1 | -0.4627*** | -0.4653** | -0.4412** | -0.4700*** |
| | (0.1499) | (0.1978) | (0.1960) | (0.1828) |
| dist2 | -0.5870* | -0.4910 | -0.6396** | -0.4893* |
| | (0.3368) | (0.3069) | (0.2889) | (0.2979) |
| artkm | 0.1057*** | 0.1078*** | 0.1265*** | 0.0926*** |
| | (0.0191) | (0.0316) | (0.0284) | (0.0263) |
| artkm² | -0.0017*** | -0.0017*** | -0.0018*** | -0.0013*** |
| | (0.0003) | (0.0005) | (0.0005) | (0.0004) |
| Altm | 0.0006*** | 0.0005** | 0.0007*** | 0.0006*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| OICH | 0.6565*** | 0.8048*** | 0.9175*** | 0.8753*** |
| | (0.1600) | (0.2096) | (0.1834) | (0.1646) |
| Nbr of obs | 59 | 59 | 59 | 59 |
| Nbr of clusters | - | - | - | 36 |
| $R^2$ | 0.8849 | 0.8768 | 0.8641 | 0.8729 |
| J-statistic | - | 8.993 | 8.993 | 7.161 |
| (p-value) | | (0.1094) | (0.1094) | (0.2089) |

***Table 3.10*** *- Parameter estimates and standard errors for the OLS, TSLS and two GMM regressions. Heteroskedasticity-robust standard errors are reported for both OLS and TSLS regressions. *p≤0.1, **p≤0.05, ***p≤0.01. Regressions done with Stata10.*

Instruments derived in the previous subsection are used in the computation of both TSLS and GMM estimators. Based on the J-statistics, we cannot reject the hypothesis that all the instruments are orthogonal to the error term at the standard 5% significance level. Indeed, p-values of the J-statistics range from around 11% to 21%. This tends to prove that our instruments are exogenous.

Differences between OLS and TSLS estimates are interesting. On the one hand, the return to log(phbeds) (which must be interpreted as an elasticity) greatly increases passing from 0.13 to 0.33 and the parameter estimate becomes significantly different from zero at a 10% significance level. The return to log(WTPF) also changes and is decreasing. On the other hand, the return to snowmaking does not change significantly. By the way, this return is also nearly unchanged when assessing the two GMM regressions. In one of the GMM regression, the error term is taken to be heteroskedastic whereas clustering is considered in the other one. Clustering is more general than heteroskedasticity since both heteroskedasticity and non-zero intra-cluster covariance matrices are allowed. In other words, error terms can be correlated between different observations of the same cluster. In our empirical work, clusters are constituted of ski area operation companies that are closely located one from the other (e.g. companies located in the same valley). The advantage of GMM estimator over TSLS estimator results from the fact that, if heteroskedasticity or clustering is present, the former is more efficient than the latter. On the contrary, if the error is homoskedastic then TSLS estimator would be preferable to GMM estimators. For this reason a test for the presence of heteroskedasticity when endogeneity is present can be used in deciding whether TSLS or GMM is called for. We used the Pagan-Hall general test statistic. We find a very high p-value (i.e. 0.9670) and we cannot reject the null hypothesis that the disturbance term in equation 3.7 is homoskedastic. With our relative small sample constituted of 59 observations, it would therefore be preferable to rely on TSLS estimates rather than on GMM estimates. Actually, there is also a trade-off between OLS and TSLS estimators. The search for consistent estimators has a cost since OLS is more efficient than TSLS under the assumption of predetermined regressors. In other words, it is also important to test our assumption that log(phbeds), log(WTPF), artkm and $artkm^2$ are actual endogenous variables. In order to do so, we use the Durbin-Wu-Hausman (DWH) test. Quite surprisingly, result from the DWH test does not reject the null hypothesis that OLS is an appropriate estimation technique (p-value=0.7867)! According to this test, OLS should be preferred to TSLS. However, p-value from the DWH test is five-fold smaller when only log(phbeds) is taken to be endogenous. Though the p-value is still not enough small to reject the null at the 5% significance level (i.e. 0.1596), we think that considering log(phbeds) as the only endogenous variable in equation 3.7 is an interesting model. We have estimated it using several estimation techniques. Results are shown in the following table.

| Variables | OLS estimator<br>Est<br>(SE) | TSLS estimator<br>Est<br>(SE) | GMM estimator with heteroskedasticity<br>Est<br>(SE) | GMM estimator with clustering<br>Est<br>(SE) |
|---|---|---|---|---|
| Dependent variable: log(EBITDA) | | | | |
| Endogenous variables: log(phbeds) | | | | |
| Excluded instruments: lodg1, lodg2, lodg3, lodg4, lodg5, lodg6 | | | | |
| Explanatory variables: | | | | |
| Intercept | -1.8216 | - 0.7423 | -0.0189 | -1.3527 |
| | (1.9019) | (2.0764) | (1.9270) | (2.0263) |
| log(WTPF) | 1.3152*** | 0.9726*** | 0.8723*** | 1.1122*** |
| | (0.3070) | (0.3610) | (0.3236) | (0.3269) |
| log(Slopes) | 0.6575*** | 0.7004*** | 0.7180*** | 0.7088*** |
| | (0.2354) | (0.2537) | (0.1915) | (0.1936) |
| log(hbeds) | 0.2511*** | 0.1426* | 0.1002 | 0.1399** |
| | (0.0678) | (0.0851) | (0.0728) | (0.0609) |
| log(phbeds) | 0.1291 | 0.3977*** | 0.4151*** | 0.3583*** |
| | (0.1060) | (0.1419) | (0.1276) | (0.1141) |
| dist1 | -0.4627*** | -0.5095*** | -0.5307*** | -0.5297*** |
| | (0.1499) | (0.1740) | (0.1676) | (0.1516) |
| dist2 | -0.5870* | -0.4645 | -0.4668 | -0.4054 |
| | (0.3368) | (0.3337) | (0.2998) | (0.2963) |
| artkm | 0.1057*** | 0.1081*** | 0.1152*** | 0.1031*** |
| | (0.0191) | (0.0203) | (0.0182) | (0.0167) |
| $artkm^2$ | -0.0017*** | -0.0018*** | -0.0019*** | -0.0017*** |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) |
| Altm | 0.0006*** | 0.0005** | 0.0005** | 0.0005** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| OICH | 0.6565*** | 0.8317*** | 0.8512*** | 0.8519*** |
| | (0.1600) | (0.2016) | (0.1787) | (0.1528) |
| Nbr of obs | 59 | 59 | 59 | 59 |
| Nbr of clusters | - | - | - | 36 |
| $R^2$ | 0.8849 | 0.8731 | 0.8705 | 0.8740 |
| J-statistic | - | 7.217 | 7.217 | 6.839 |
| (p-value) | | (0.2050) | (0.2050) | (0.2329) |

***Table 3.11*** *- Parameter estimates and standard errors for the OLS, TSLS and two GMM regressions. Heteroskedasticity-robust standard errors are reported for both OLS and TSLS regressions. *p≤0.1, **p≤0.05, ***p≤0.01. Regressions done with Stata10.*

With one endogenous variable, both the exogeneity and the relevance of the instruments can be tested. The p-values of the J-statistics range from around 20.5% to 23.3% and we cannot reject the null that the instruments are exogenous. We have also used the value of the first-stage *F*-statistic in order to check whether our instruments are relevant. The first-stage *F*-statistic is equal to 2.35. Critical values are given in Stock and Yogo (2003) that allow identifying whether a group of instrumental variables is weak. When there is one endogenous variable and six instrumental variables, the critical values range from 5.15 to 19.28 depending on the desired maximal bias of the IV estimator relative to OLS. Our first-stage *F*-statistic is smaller than these critical values. Therefore, we need to reduce the number of instrumental variables that we use. We can do this by merging our six instrumental variables in three, two or one variable. Actually, a sufficient value of the first-stage *F*-statistic is obtained only when the six instrumental variables lodg1,…, lodg6 are merged into one unique variable. Moreover, value of the first-stage *F*-statistic is higher when we take the natural logarithm of the latter variable. In this case, the first-stage *F*-statistic is equal to 14.41 which is a clue that the new instrument is not weak[36]. As the equation is exactly identified when there are as many endogenous variables as instruments, it is not possible to carry out an overidentification test. However, we expect the new instrument to be also exogenous since exogeneity was verified when the six instrumental variables were merged into two variables. Therefore, we probably have a valid instrument that we call lnodg7. We will now present the results from the regressions carried out with lnodg7 as the only excluded instrument[37].

[36] For the case of a single endogenous regressor, Staiger and Stock (1997) suggested that a set of instruments is weak if the first-stage *F*-statistic is less than ten.

[37] When the equation is exactly identified, GMM and TSLS estimators are the same. Moreover, the TSLS estimator does not depend on the hypothesis made to describe the covariance matrix of the error terms. The latter feature explains why the estimates are the same in the third and fourth columns of *table 3.12*. The only difference between the two columns is constituted by the robust standard errors.

| Variables | OLS estimator<br>Est<br>(SE) | TSLS estimator<br>Est<br>(SE) | TSLS estimator with clustering<br>Est<br>(SE) |
|---|---|---|---|
| Dependent variable: log(EBITDA) | | | |
| Endogenous variables: log(phbeds) | | | |
| Excluded instruments: lnodg7 | | | |
| Explanatory variables: | | | |
| Intercept | -1.8216 | - 0.5000 | - 0.5000 |
| | (1.9019) | (2.0833) | (2.2671) |
| log(WTPF) | 1.3152*** | 0.8957** | 0.8957** |
| | (0.3070) | (0.3591) | (0.3851) |
| log(Slopes) | 0.6575*** | 0.7100*** | 0.7100*** |
| | (0.2354) | (0.2503) | (0.2530) |
| log(hbeds) | 0.2511*** | 0.1183 | 0.1183* |
| | (0.0678) | (0.0836) | (0.0716) |
| log(phbeds) | 0.1291 | 0.4580*** | 0.4580*** |
| | (0.1060) | (0.1748) | (0.1684) |
| dist1 | -0.4627*** | -0.5200*** | -0.5200*** |
| | (0.1499) | (0.1849) | (0.1660) |
| dist2 | -0.5870* | -0.4371 | -0.4371 |
| | (0.3368) | (0.3059) | (0.3022) |
| artkm | 0.1057*** | 0.1086*** | 0.1086*** |
| | (0.0191) | (0.0210) | (0.0211) |
| $artkm^2$ | -0.0017*** | -0.0018*** | -0.0018*** |
| | (0.0003) | (0.0004) | (0.0004) |
| Altm | 0.0006*** | 0.0005** | 0.0005** |
| | (0.0002) | (0.0002) | (0.0002) |
| OICH | 0.6565*** | 0.8711*** | 0.8711*** |
| | (0.1600) | (0.2003) | (0.1851) |
| Nbr of obs | 59 | 59 | 59 |
| Nbr of clusters | - | - | 36 |
| $R^2$ | 0.8849 | 0.8673 | 0.8673 |

***Table 3.12*** *- Parameter estimates and standard errors for the OLS and TSLS regressions. Heteroskedasticity-robust standard errors are reported in the first two columns. *p≤0.1, **p≤0.05, ***p≤0.01. Regressions done with Stata10.*

When log(phbeds*)* is the only variable considered to be endogenous and when lnodg7 is the only excluded instrument, the DWH test rejects the null hypothesis that OLS is an appropriate estimation technique at a 10% significance level (p-value=0.0995). This last result seems to indicate that it is better to choose the model estimated via TSLS. However, some of the results from the TSLS regressions do not seem to be really reliable. More precisely, our estimation results show that the percentage change in EBITDA when the number of beds in the para-hotel sector changes by one percent is equal to 0.46% whereas the elasticity of EBITDA with respect to the number of beds in the hotel sector is equal to 0.12%. Finding grounds to explain the difference between the two elasticities is not obvious and we would not have expected such a large difference. Though we have used Instrumental Variable estimation rather than Ordinary Least Squares estimation, all the problems linked to the estimation of these variables do not seem to have been completely alleviated. The high correlation existing between the numbers of beds in the hotel and para-hotel sectors must probably explain these unexpected results. For this reason, we will change our tack and run OLS with the overall lodging capacity and the percentage of hotel beds in the overall lodging capacity replacing the hbeds and phbeds variables. We will also redefine the location variables as our use of the variables dist1 and dist2 does not seem to be optimal.

### 3.4.3 Returning to OLS regression

The variables used in place of hbeds and phbeds are called hphbeds and perhbeds. For a given ski resort, the former variable gives the total number of beds in the hotel and para-hotel sectors whereas the latter variable gives the percentage of hotel beds of this total. Values of both variables are shown in *figure 3.9* for the ski resorts included in our 2004 sample.

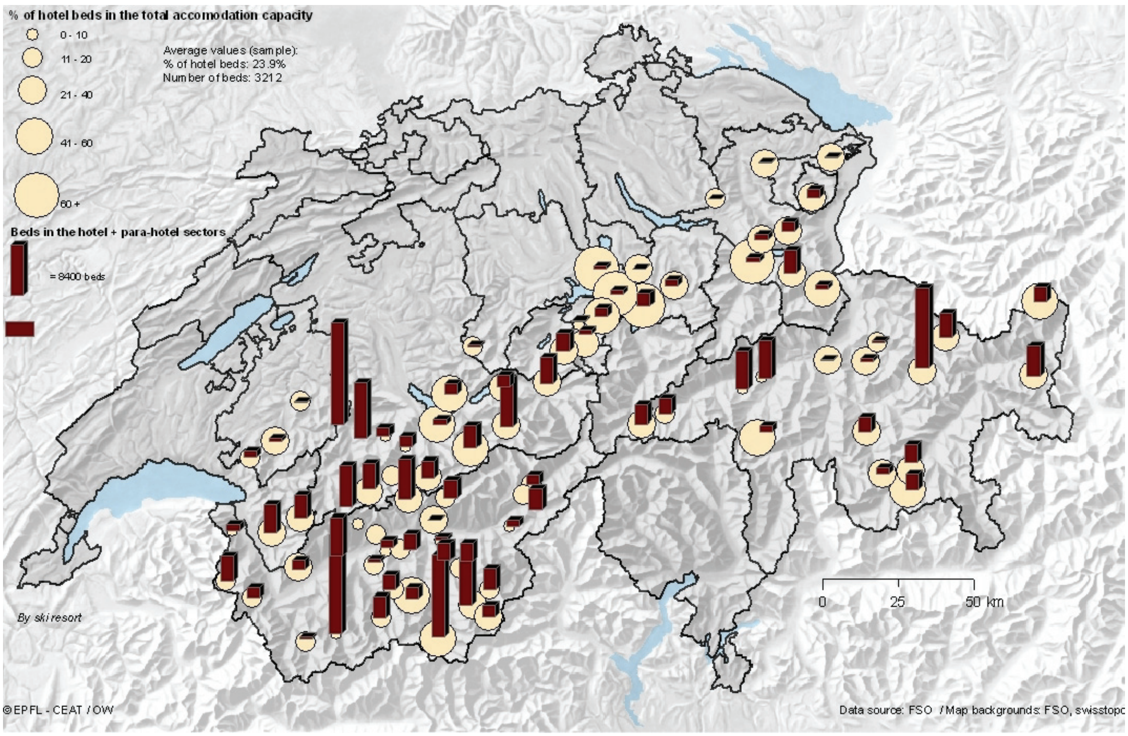


***Figure 3.9*** *- Accommodation capacity is given for a set of Swiss ski resorts along with the relative share of hotel beds in the total number of hotel and para-hotel beds (winter season 2003/04).*

Unlike hbeds and phbeds which are highly correlated (correlation coefficient equal to 0.723), the variables hphbeds and perhbeds are nearly uncorrelated (correlation coefficient equal to -0.088). In addition, we have tried to define empirically better threshold values for the location variables. Our results indicate that the best solution is to define only two classes with a threshold value set at 90 minutes. This leads to create a new binary variable which will be called dist90. These modifications change the estimable model as follows:

$$\log EBITDA_j = \beta_0 + \beta_1 \log WTPF_j + \beta_2 \log Slopes_j + \beta_3 \log hphbeds_j + \beta_4 perhbeds_j + \beta_5 dist90_j + \beta_6 artkm_j + \beta_7 artkm_j^2 + \beta_8 Altm_j + \beta_9 OICH_j + \varepsilon_j \quad (3.8)$$

Eventually, we will test again for interaction terms between the snowmaking investments related variables (artkm and artkm$^2$) and the variable indicating the maximum altitude of the ski area (Altm).

| Variables | OLS estimator without interaction terms<br><br>Est<br>(SE) | OLS estimator with interaction terms<br><br>Est<br>(SE) |
|---|---|---|
| Dependent variable: log(EBITDA) | | |
| Explanatory variables: | | |
| Intercept | -2.7723 | - 2.9046 |
| | (1.9283) | (1.9742) |
| log(WTPF) | 1.3409*** | 1.3797*** |
| | (0.2805) | (0.3018) |
| log(Slopes) | 0.6718*** | 0.6752*** |
| | (0.1717) | (0.1749) |
| log(hphbeds) | 0.3982*** | 0.4030*** |
| | (0.0796) | (0.0788) |
| perhbeds | 0.0096** | 0.0099** |
| | (0.0041) | (0.0041) |
| dist90 | -0.4668*** | -0.4687*** |
| | (0.1649) | (0.1663) |
| artkm | 0.1004*** | 0.0244 |
| | (0.0155) | (0.1029) |
| $artkm^2$ | -0.0016*** | -0.0003 |
| | (0.0003) | (0.0023) |
| Altm | 0.0006*** | 0.0005*** |
| | (0.0001) | (0.0002) |
| Altm*artkm | - | 2.77e-05 |
| | | (3.71e-05) |
| Altm*$artkm^2$ | - | -6.91e-07 |
| | | (8.03e-07) |
| OICH | 0.6662*** | 0.6886*** |
| | (0.1570) | (0.1551) |
| Nbr of obs | 59 | 59 |
| $R^2$ | 0.8841 | 0.8852 |

***Table 3.13*** *- Parameter estimates and standard errors for two OLS regressions. Only heteroskedasticity-robust standard errors are reported. *p≤0.1, **p≤0.05, ***p≤0.01. Regressions done with Stata10.*

Parameter estimates related to the interaction terms are not significantly different from zero. Therefore, we remove the interaction terms from the model. Results for this new model which corresponds to the estimable model in equation 3.8 are then shown in the second column of *table 3.13* (OLS estimator without interaction terms). As can be seen, variables related to the lodging capacity are significant at the one and five percent significance level. Choosing new variables in order to remove high correlation patterns among the set of explanatory variables seems to have been a successful strategy.

### 3.4.4 OLS regression using the 2004/05 winter season data

This subsection aims at estimating the model expressed in equation 3.8 using data from the financial year 2004/05. Such estimation would allow making some comparisons and determining whether our coefficients' estimates vary significantly from one winter season to another. Interpreting correctly such variations would require determining what the differences were between the two winter seasons under study. With this aim in view, *figure 3.10* presents how snow availability has changed between the two winter seasons.

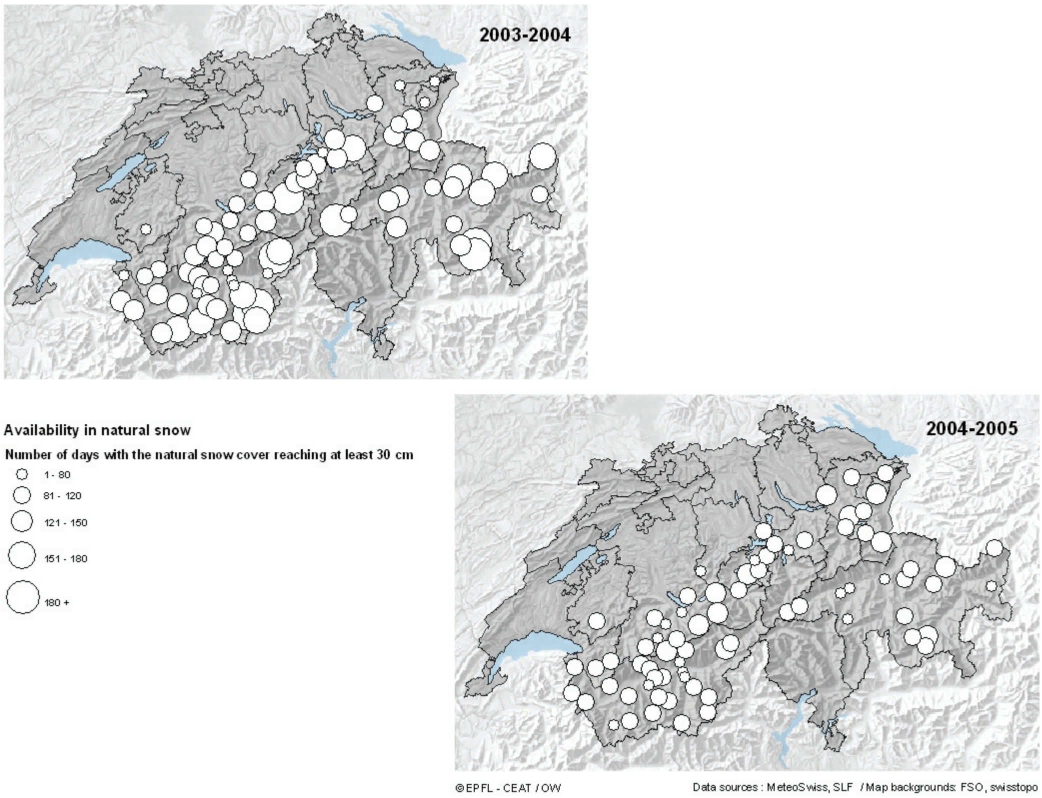


***Figure 3.10*** *- Availability of natural snow for our 2004 and 2005 sample's companies.*

As already mentioned, data were collected for the winter seasons 2003/04 and 2004/05. However, data on the para-hotel sector were lacking for the financial year 2004/05. In order to get rid of that problem, we will simply use the para-hotel sector data from the financial year 2003/04. What we should also say before presenting the estimation results is that the average and standard deviation of EBITDA values are nearly similar for both financial years. In terms of operations, the two winters seem therefore to share some similarities. *Table 3.14* shows results from the regression carried out with the 2004/05 data.

| Variables | OLS estimator for the 2004 sample<br>Est<br>(SE) | OLS estimator for the 2005 sample<br>Est<br>(SE) | OLS estimator for the 2005 sample with snow related predictors<br>Est<br>(SE) |
|---|---|---|---|
| Dependent variable: log(EBITDA) | | | |
| Explanatory variables: | | | |
| Intercept | -2.7723 | - 4.8191** | - 4.5845** |
| | (1.9283) | (1.9892) | (1.9920) |
| log(WTPF) | 1.3409*** | 1.7199*** | 1.6832*** |
| | (0.2805) | (0.2868) | (0.2882) |
| log(Slopes) | 0.6718*** | 0.6805*** | 0.7083*** |
| | (0.1717) | (0.1964) | (0.2003) |
| log(hphbeds) | 0.3982*** | 0.3261*** | 0.3156*** |
| | (0.0796) | (0.1091) | (0.1108) |
| perhbeds | 0.0096** | 0.0098** | 0.0101** |
| | (0.0041) | (0.0044) | (0.0043) |
| dist90 | -0.4668*** | -0.7237*** | -0.6832*** |
| | (0.1649) | (0.1755) | (0.1885) |
| artkm | 0.1004*** | 0.0833*** | 0.0814*** |
| | (0.0155) | (0.0150) | (0.0155) |
| $artkm^2$ | -0.0016*** | -0.0012*** | -0.0012*** |
| | (0.0003) | (0.0003) | (0.0003) |
| Altm | 0.0006*** | 0.0006*** | 0.0006*** |
| | (0.0001) | (0.0001) | (0.0001) |
| OICH | 0.6662*** | 0.5017** | 0.4624** |
| | (0.1570) | (0.2010) | (0.1930) |
| Snow130 | - | - | 0.3942*** |
| | | | (0.1451) |
| Snow130*dist90 | - | - | -0.5492* |
| | | | (0.2814) |
| Nbr of obs | 59 | 56 | 56 |
| $R^2$ | 0.8841 | 0.8577 | 0.8609 |

***Table 3.14*** *- Parameter estimates and standard errors for three OLS regressions. Heteroskedasticity-robust standard errors are reported. *p≤0.1, **p≤0.05, ***p≤0.01. Regressions done with Stata10.*

Comparing the results from *table 3.14* with the information contained in *figure 3.10* provides some interesting insights. Indeed, changes in snow availability as depicted in *figure 3.10* allow providing an explanation to some of the observed differences between the 2003/04 and 2004/05 estimation results. During the winter season 2003/04, we have already noted that there was a significant difference in snow availability between the western and the central/eastern part of Switzerland (especially for the companies located in the foothills of the Alps). Though we were not able to statistically demonstrate it, we made the hypothesis that this difference was partly responsible for the high partial effect of the variable OICH. Such a difference is also observed for the winter season 2004/05 but to a much lesser extent. In this context, it is striking to note that the partial effect of OICH has decreased in some important ways when the 2004/05 data are used to estimate the model formulated in equation 3.8. When estimated with the 2004 sample, the fact to be located in the vicinity of Zurich increases the level of EBITDA by 94.7%. This percentage decreases to 65.2% when use is made of the 2005 sample.

Another important difference between the two winter seasons is that snowfalls were limited in the high alpine regions during the winter season 2004/05. This distinctive feature of the 2004/05 winter season probably explains why the partial effect associated to the variable dist90 increases in absolute term when the model is evaluated with the 2004/05 data rather than with the 2003/04 data. Using the 2004 sample, we have shown that the level of EBITDA diminishes by 37.3% when the dummy dist90 takes the value one. With the 2005 sample, the level of EBITDA diminishes by 51.5% when the dummy dist90 takes the value one. When snow conditions are better in the foothills of the Alps, skiers from the densely populated regions had no incentives to increase their journey time in order to ski in the Alps. When better snow conditions prevail in the Alps (as was the case during the winter season 2003/04), the advantage in terms of clientele generated by the proximity to the densely populated regions is reduced. In terms of snow availability, we note however that both winter seasons were rather favourable to ski resorts located in low and medium altitude. The partial effect of dist90 would probably take a lower value (in absolute terms) in a situation where high alpine ski resorts benefit from much better snow conditions than the ski resorts located in lower altitude.

Differences in snow availability patterns could also explain the difference observed between the 2004 and 2005 estimates of the slope coefficients related to artkm and $artkm^2$. In both cases, the partial effect on EBITDA of the snowmaking investments is positive but tends to decrease as the level of investments becomes higher. However, the partial effect of snowmaking investments is weaker when being evaluated for the 2004/05 winter season. For the winter season 2004/05, equipping one kilometer with snowmaking facilities would have induced an 8.3% change in EBITDA given that no snowmaking investments were made previously. If the initial recourse to snowmaking were equal to 10, 20, 30, 40 km, the change in EBITDA would have been equal to 5.9%, 3.5%, 1.1%, -1.3%. As for the winter season 2003/04, the impact of additional snowmaking investments on EBITDA becomes negative for approximately 30 kilometers of slopes that can be already snowed artificially. We explain these differences by observing that companies endowed with snowmaking facilities (i.e. generally large companies located in medium and high altitude) have rather faced poor snow conditions during the 2004/05 winter season. On the one hand, operating costs generated by running the equipment were probably important because of the need to produce more artificial snow. On the other hand, the revenue generating effect of snowmaking investments was probably limited during the 2004/05 winter season because of the good snow conditions in low and medium locations.

Using the 2004/05 winter season data, we have also tested for several discrete variables related to the availability of natural snow. As explained in subsection 3.4.2.2, we decided also to test for interaction terms allowing the effect of natural snow availability to vary according to the distance to the big population basins. In contrast to the results obtained for the 2003/04 winter season, a discrete variable for the availability of natural snow (snow130) and an interaction term (snow130*dist90) were found to be statistically significant. For companies located in the vicinity of densely populated regions, the model indicates that the level of EBITDA increases by 48.4% when the variable snow130 takes the value 1 (i.e. when snow cover has reached at least 30 cm during 130 days or more). The effect on EBITDA of benefiting from good snow conditions changes dramatically for companies located far from the densely populated regions. In this case, the model indicates that the level of EBITDA decreases by 14.4% when the variable snow130 takes the value 1! Interpreting this last figure is not obvious as the sign of the partial effect seems rather counterintuitive. Eventually, we note that adding both variables to the model has decreased the partial effect of the OICH variable but only in a slight way.

## 3.5 Main results

Based on the 2004 sample, our final estimable model of EBITDA of the ski area operation companies with more than 15 kilometers of ski slopes includes information on the modernity of the transport facilities (as summarized by the variable WTPF), on the ski slopes' length, on the ski resort's lodging capacity (with indication on the proportion of beds in the hotel sector), on the proximity of the ski area to big population basins, on the length of ski slopes equipped with snowmaking facilities, on the maximum altitude of the ski area and on the vicinity to the agglomeration of Zurich. In this model, the variable that gives the maximum altitude of the ski area is used as a proxy variable for natural snow conditions. Prior to introduce this proxy, we have tried to construct some variables expressing the amount of natural snow available for ski activities in the different ski areas represented in our sample of 87 companies. However, these variables were not found to be significant either because of variables' inaccuracy, omitted variables bias or because the available amount of natural snow does not vary sufficiently from one case to another in our cross section sample in order to influence the dependent variable. These variables were not the only one to be removed from the model. Dummy variables indicating payments of public indemnities, existence of some types of integrated structure or exposure to the sun were not retained as well. Furthermore, all the attempts to add interaction terms in order to test whether the partial effect of snowmaking investments depends on the level of other explanatory variables were not fruitful.

Because we expect several variables to be endogenous in the early models we developed, we have searched for valid instruments in order to carry out TSLS and GMM estimations. Basically, two sets of instruments have been derived. For the first set, we have used information on the number of temporarily occupied housings in order to construct instruments for the variable given the number of beds in the para-hotel sector. Our second set of instruments has been mainly derived after having looked for legal procedures carried out by environmentalist groups. For the ski areas represented in our sample, our intention was to gather information on all legal procedure that delay investments in snowmaking or transport facilities during the winter season 2003/04.

After having derived a sufficient number of instruments, we have carried out TSLS and GMM estimations. In this process, endogeneity of the investments related variables was not verified (i.e. the simultaneous causality bias assumption was not verified). By assuming that the number of beds in the para-hotel sector is the only endogenous variable, we were able to verify both the relevance and the exogeneity of our instruments. We had to modify our initial set of instruments so as to end up with one relevant instrument. Having derived a valid instrument for the number of beds in the para-hotel sector, we were able to test the hypothesis that the latter variable is endogenous in our model. Using the Durbin-Wu-Hausman test, we were able to reject the hypothesis that OLS is an appropriate estimation technique at the 10% significance level (i.e. we validate the CEV assumption at the 10% significance level). Our model being exactly identified, GMM and TSLS estimators were the same. In this case, we could only compare estimation results from OLS and TSLS. Actually, using OLS or TSLS does not change significantly the results concerning the impacts of snowmaking investments. As should be expected, differences between the two estimation results mainly concern variables related to the number of beds in the hotel and para-hotel sectors. For these variables, the OLS estimates look however more plausible than the TSLS estimates. This has motivated us to rethink the estimation problem associated to the lodging capacity related variables and to concentrate on removing the high correlation patterns in the set of explanatory variables. For this purpose, we have introduced two new variables to express the lodging capacity in a ski resort. The first one expresses the overall number of beds in the hotel and para-hotel sectors and the second one gives the percentage of hotel beds in this total. We have also redefined the location variable by implementing a unique distance threshold. With these changes, we end with the estimable model described in equation 3.8. For this model, we present below the estimates obtained via OLS using heteroskedasticity-robust standard errors.

$$\begin{aligned}\log \hat{EBITDA}_j &= -\underset{(1.928)}{2.772} + \underset{(.2805)}{1.341}\log WTPF_j + \underset{(.1717)}{.6718}\log Slopes_j \\ &+ \underset{(.0796)}{.3982}\log hphbeds_j + \underset{(.0041)}{.0096}\, perhbeds_j - \underset{(.1649)}{.4668}\, dist90_j \\ &+ \underset{(.0155)}{.1004}\, artkm_j - \underset{(.0003)}{.0016}\, artkm_j^2 + \underset{(.0001)}{.0006}\, Altm_j + \underset{(.1570)}{.6662}\, OICH_j\end{aligned} \qquad (3.9)$$

Nbr of observations=59, $R^2$=0.8841

At the exception of the intercept, all variables are significant at the 1% or 5% significance level. Among the slope coefficients, perhbeds is significant at the 5% significance level. All the other slope coefficients are significant at the 1% significance level.

The impact of additional snowmaking investments on EBITDA is positive but tends to decrease as the level of snowmaking investments increase. This result agrees with the hypothesis that we have done in subsection 3.2.3.6. When there is no snowmaking, the fact to equip one kilometer with snowmaking facilities induces a 10% change in the EBITDA. When the initial recourse to snowmaking is equal to 10, 20, 30, 40 km, the partial effect shrinks to 6.8%, 3.6%, 0.4%, -2.8%. Based on the point estimates of $\beta_6$ and $\beta_7$, we can ascertain that the impact of additional snowmaking investments on EBITDA becomes negative when approximately 30 kilometers of ski slopes are already concerned with the use of artificial snow cover. This value is to be compared with the size of ski areas operated by the sample's companies. For our sample of companies operating more than 15 kilometers of ski slopes, 30 kilometers is higher than the lower quartile which is equal to 26.5 km. However, 30 km is smaller than the sample median which is equal to 40 km. At the sector level, we further note that the average length of ski slopes operated by a company is approximately equal to 20 km. The following figure provides 95% confidence intervals for the partial effect of snowmaking investments at different levels of snowmaking investments:

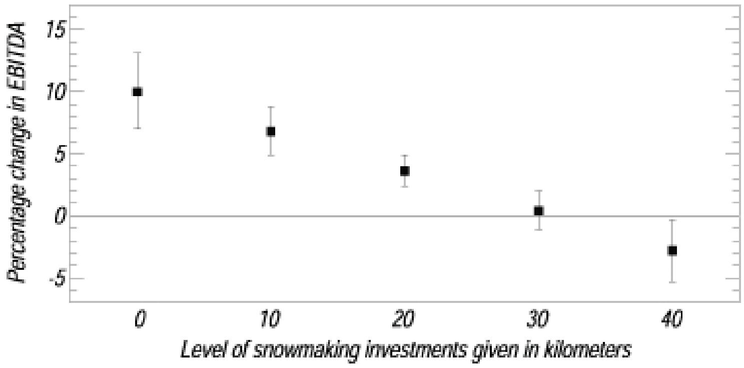


***Figure 3.11*** *- For companies operating more than 15 kilometers of ski slopes, 95% confidence intervals of the partial effect of artkm computed at different initial levels of snowmaking investments (i.e. for different initial values of artkm).*

Using again our point estimates of $\beta_6$ and $\beta_7$, we can show that there are very few firms of our sample for which additional investments in snowmaking would have decreased the EBITDA as shown in *table 3.15*. In the same table, we have computed the percentages of the sample's companies for which additional investments in snowmaking would have increased the cash flow and the net income during the financial year 2003/04. These percentages were derived in the same manner as for *table 3.7*.

| EBITDA enhancing | Cash flow enhancing | Net income enhancing |
|---|---|---|
| 94.9% | 91.5% | 69.5% |

***Table 3.15*** *- Figures giving the percentage of our sample's companies for which additional snowmaking investments would have increased 1/the EBITDA, 2/the cash flow and 3/the net income. The sample is constituted of 59 companies. Each company of that sample operates more than 15 kilometers of ski slopes.*

Because very few companies have already high level of investments towards snowmaking facilities, the impacts on the EBITDA of future snowmaking investments in the Swiss ski area operation will most probably be positive. However, things are a bit different when taking into account both the financial and depreciation costs associated to these future investments. For instance, the net income will decrease as a consequence of additional investments in snowmaking for 30.5% of our sample's companies.

As emphasized previously, a general result applying to all the companies is that additional investments in snowmaking facilities increases EBITDA up to roughly 30 km of equipped ski slopes. Taking into account additional costs linked to the investments (i.e. depreciation and financial costs), another general result directly flowing from the previous one is that artificial snow cover increases cash flow or net income up to values smaller than 30 km. An exact value then depends on a particular company. Taking the sample median of EBITDA which is equal to nearly 2 Mio CHF, we have computed the number of kilometers until which it is worth investing in snowmaking facilities on a net income basis. This value is equal to 23 km. For companies displaying a lower value of EBITDA, this limit decreases while it increases for companies displaying a higher value of EBITDA.

We will now present the estimation results obtained with the 2004 sample for some other variables. In general, these variables are continuous positive variables transformed with the natural logarithm. We will also interpret the estimation results for one bounded positive variable and two dummy variables. Depending on the type of variables, coefficients do not have the same interpretation. When the regressor is a log, the coefficient is an elasticity (i.e. the coefficient gives the percentage change in EBITDA when the regressor changes by one percent). When the regressor is a dummy, the coefficient does not have a direct interpretation. It is only the value obtained by subtracting one from the exponential of the coefficient that can be interpreted as the percentage change in the EBITDA when passing from the low level to the high level of the dummy. In the next table, we will therefore present 95% confidence intervals for the coefficients with elasticity interpretation only.

| Coefficient with elasticity interpretation | 95% Confidence interval | Point estimate |
|---|---|---|
| log(WTPF) coefficient $\beta_1$ | [0.79%, 1.89%] | 1.34% |
| log(Slopes) coefficient $\beta_2$ | [0.34%, 1.01%] | 0.67% |
| log(hphbeds) coefficient $\beta_3$ | [0.24%, 0.55%] | 0.40% |
| (perhbeds coefficient $\beta_4$)*100 | [0.16%, 1.76%] | 0.96% |

***Table 3.16*** *- 95% confidence intervals and point estimates for the coefficients that can be interpreted as elasticities.*

Looking at the point estimates, we can observe that the highest impact on the EBITDA is obtained by increasing WTPF by one percent. In general, WTPF is increased by making new investments in transport facilities. Beyond the positive impact on the EBITDA, one has therefore to keep in mind that increasing WTPF entails large financial and depreciation costs. Increasing the size of the ski area can also have a large impact on the EBITDA. Obviously, the impact is partly due to the scale effect that EBITDA increases with company size. This scale effect is also partly responsible for the high value of the $R^2$ in equation 3.9. However, EBITDA increases less than proportionally with an increase in the size of the ski area since the size elasticity of EBITDA is equal to 0.67 (i.e. the elasticity is less than one). This result is somewhat in contradiction with the hypothesis made in subsection 3.2.3.2. The accommodation capacity elasticity of EBITDA is equal to 0.40%. This is the impact on EBITDA of increasing the overall number of beds in the hotel and para-hotel sectors by one percent. Note however that this one percent increase is not arbitrary. As we are computing partial effects, the increase in the number of beds must be such that the mix of beds in the hotel and para-hotel sectors does not change (i.e. the value of the variable perhbeds remains unchanged). For a constant lodging capacity, changing the mix between beds in the hotel and para-hotel sectors has the following impact on EBITDA: the EBITDA increases by 0.96% when the share of hotel beds increases by one percent. This is a net effect since it encompasses both the effect of an increase in the number of hotel beds and the effect of a simultaneous and equal decrease in the number of para-hotel beds. We interpret this result by saying that the impact on EBITDA of hotel beds is higher than the impact on EBITDA of para-hotel beds. This result is not surprising given the data on lodging supply that we have used. Unlike beds entering in the hotel sector's account, there is for instance no certainty that beds entering in the para-hotel sector's account were actually rented during the winter season.

Eventually, impacts on the EBITDA of the dummy variables contained in our model are worth noting. Ceteris paribus, the level of EBITDA diminishes by 37.3% when the dummy dist90 takes the value one whereas the fact to be located in the vicinity of Zurich increases the level of EBITDA by 94.7%! Both the analysis of our data and the reading of reports giving some of the 2003/04 winter season's distinctive features have led us to think that the latter percentage change in EBITDA is not only linked to a potential advantage of being located near Zurich and its agglomeration. More precisely, we made the hypothesis that the high partial effect also reflects particularly good 2003/04 snow conditions in the eastern and central part of Switzerland. However, it was not possible to statistically verify this hypothesis.

Estimating our model with the data from the financial year 2004/05 has allowed analyzing how the estimation results depend on a particular winter season. Equation 3.10 presents the estimates obtained via OLS when the 2005 sample is used.

$$\begin{aligned} \log \hat{E}BITDA_j &= -\underset{(1.989)}{4.819} + \underset{(.2868)}{1.720} \log WTPF_j + \underset{(.1964)}{.6805} \log Slopes_j \\ &+ \underset{(.1091)}{.3261} \log hphbeds_j + \underset{(.0044)}{.0098}\ perhbeds_j - \underset{(.1755)}{.7237}\ dist90_j \\ &+ \underset{(.0150)}{.0833}\ artkm_j - \underset{(.0003)}{.0012}\ artkm_j^2 + \underset{(.0001)}{.0006}\ Altm_j + \underset{(.2010)}{.5017}\ OICH_j \end{aligned} \quad (3.10)$$

Nbr of observations=56, $R^2$=0.8577

All variables are significant at the 1% or 5% significance level. Among the slope coefficients, perhbeds and OICH are significant at the 5% significance level. All the other slope coefficients are significant at the 1% significance level.

The largest changes in the estimation results concern the OICH, dist90, artkm and $artkm^2$ variables. When estimated with the 2004 sample, the fact to be located in the vicinity of Zurich increases the level of EBITDA by 94.7% whereas the level of EBITDA diminishes by 37.3% when the dummy dist90 takes the value one. With the 2005 sample, the former percentage decreases to 65.2% whereas the latter percentage increases (in absolute term) to 51.5%. In regard to the partial effect on EBITDA of the snowmaking investments, it is weaker when being evaluated for the 2004/05 winter season. A similar result for both years is that the impact of additional snowmaking investments on EBITDA becomes negative when approximately 30 kilometers of slopes can already be snowed artificially.

The fact snow conditions in the foothills of the Alps were better than in the Alps during the 2004/05 winter season probably explains why the partial effect associated to the variable dist90 is larger (in absolute term) and the partial effect of the snowmaking investments is smaller when being evaluated with the data of that season. Compared to the 2003/04 winter season, our opinion is that the snow availability patterns of the 2004/05 winter season have strengthened the advantage in terms of clientele generated by the proximity to the densely populated regions. On the other hand, these snow availability patterns were rather unfavourable to companies owning snowmaking equipment. While a lack of snowfalls has increased the need to produce artificial snow in high alpine regions, the revenue generating effect of snowmaking was limited due to the fact that low and medium altitudes were benefiting from good snow conditions.

## 3.6 Conclusion

In this chapter, we investigated the effect of snowmaking investments on the financial situation of the ski area operation companies. Based on an initial sample of 87 Swiss companies for the financial year 2004, we have developed and estimated statistical models of the companies' EBITDA. In these models, the partial effect of snowmaking investments is interpreted as a percentage change in the EBITDA when the length of the ski slopes equipped with snowmaking facilities is increased by one kilometer. Furthermore, this partial effect has the particularity to depend on the existing level of snowmaking investments. By carrying out the statistical analysis, we have shown that this partial effect is positive but tends to decrease as the level of investment increases. This result agrees with our initial hypothesis that the benefits for the companies of making such investments decreases. Despite several changes in the estimable model, in the 2004 sample and in the estimation techniques that were made throughout the analysis, it is interesting to note that values of the snowmaking investments related coefficients have remained nearly unchanged. Therefore, these results are not intimately linked to the choice of a particular sub-sample or to the use of a particular estimation technique. Concentrating on the EBITDA is of limited interest if one recalls the high investments costs linked to snowmaking facilities. Taking into account interest payments and depreciation costs makes things more complex in assessing the impacts of additional snowmaking investments on the financial situation of the companies. In this case, the positive or negative effect of additional investments will not only depend on the existing kilometers of slopes equipped with snowmaking but also on the preexisting level of EBITDA.

With the obtained results, it is tempting to give some insights on the economic advisability of forthcoming investments in snowmaking. During the 2003/04 winter season, our predictions indicate that additional investments would have enhanced the EBITDA of 94.9% and the cash flow of 91.5% of the companies represented in our sub-sample of companies that operate at least 15 kilometers of ski slopes. Nonetheless, these additional investments would have enhanced the net income for only 69.5% of them. Because of the representativeness of our sample, these predictions should be also relevant for the set of Swiss ski area operation companies that operate at least 15 kilometers of ski slopes. The results that we found need some explanations and comments. On the one hand, very few firms are expected to worsen their EBITDA by investing in additional snowmaking facilities. This is due to the fact that the estimated partial effect of snowmaking investments only becomes negative at very high level of investments. On the other hand, operational gains from investments must compensate higher costs when financial and depreciations costs are taken into account. Therefore, it is quite logical that the percentages of companies for whom it is worth investing in snowmaking facilities decrease as these costs are gradually taken into account. Most importantly, these percentages seem to draw some economical limitations to the widespread and intensive use of snowmaking facilities as a way to cope with the impacts of climate change.

What should be public authorities' support towards snowmaking investments in view of these results? Note first that general arguments for supporting snowmaking investments in the ski area operation sector have already been given in chapter 2's introductory part. This being said, a striking feature of our results is that 69.5% of our sample's companies could have improved their net profit through snowmaking investments during the 2003/04 winter season. How is it possible to explain the existence of such unexploited opportunities? Under which conditions could public authorities help exploiting them? Several explanations can be put forward regarding the existence of unexploited profitable investments opportunities. As shown in chapter 2, snowmaking investments carried out in Switzerland have only begun to be important from the mid-nineties onward. As a result, the percentage of the overall area of ski slopes that can be snowed artificially is currently lower in Switzerland than in the neighbouring alpine countries. In other words, the general level of investments is still low. For some companies, legal procedures could have also stopped or delayed the investments. It could also be that investments are delayed because companies lack the financial means to finance them. The latter case would be an occasion for public support. To be more precise, this would be an occasion for public support to occur given that the overall benefits of the investments exceed the negative externalities. Indeed, we could very easily imagine cases where investments in snowmaking facilities are profitable but that their negative external effects are larger than the overall benefits. Reversing the argument, we could also imagine public authorities supporting a project that is not profitable given that positive externalities are sufficiently large. In all, it is difficult to use the results that we have derived in order to gain insights on the way public authorities should financially support snowmaking investments.

However, it is difficult to draw definitive conclusions on the financial impacts of snowmaking investments on the basis of only one financial year. As we have also collected data for the financial year 2005, we were able to perform some comparisons by estimating our model with the 2005 sample. As expected, snow availability patterns affect our estimates of the snowmaking investments partial effect. As the winter of 2003/04 was rather well endowed with natural snow, we might expect that the gains from running the snowmaking facilities was less than in a winter that would be less endowed with natural snow. Though the 2004/05 winter season was globally a winter season with less snow, our estimation results do not support this hypothesis. On the contrary, the partial effect of snowmaking investments on EBITDA was found to be lower during the 2004/05 winter season. Actually, snow availability patterns influence the financial impacts of snowmaking investments in a more subtle way. While a lack of snowfalls has increased the need to produce artificial snow in high alpine regions, the revenue generating effect of snowmaking was limited due to the fact that low and medium altitudes were benefiting from more advantageous snow conditions. In other words, snow availability patterns during the 2004/05 winter season were rather unfavourable to companies owning snowmaking equipment.

Though we have estimated our model for two different winter seasons, there is a clear need to analyze further how different snow availability patterns affect the financial impacts of snowmaking equipment and how these relationships could be introduced in our model. Furthermore, another study still has to be carried out in connection with the yearly variability in snow conditions. This study should analyze, for a sample of companies, whether snow production changes in some important way from one year to another and should also pin down what are the main factors responsible for those changes. For different kinds of winters, these future researches would then allow setting some hypothesis on both the possibility/intensity of use and the gains from securing snow cover that could be tested using an improved estimable model.

As regards the future situation, how can we use our results in order to derive the impacts of snowmaking investments under climate change? Again, this is not an easy question since climate change will change both the benefits and the costs associated to snowmaking facilities. In general, costs are going to be greater since more snow will need to be produced at higher temperatures. Moreover, additional investments which entail new operating costs will need to be carried out in order to provide the system with enough water. On the other hand, the benefits for companies that will succeed in securing snow cover through snowmaking will probably be greater. Taking the terminology developed previously, the possibility/intensity of use and the gains from securing snow cover will not be the same under climate change. As for the current situation, these two elements will also vary from one winter to another in a future climate. The approach proposed in the previous paragraph could also help us uncovering the impacts of snowmaking investments under climate change. Beyond this approach, the econometric analysis used in this chapter seems however to be of limited support in order to assess more precisely the impact of snowmaking investments under climate change. If some reference winters were defined, another idea would be to modify values of the EBITDA for each of these winters in order to take into account changes in both the benefits and the costs associated to snowmaking facilities. With these corrected values of EBITDA, it would be then possible to reassess the estimable model derived in this chapter for each reference winter. However, information needed to make modifications to the EBITDA is lacking.

By developing a model for explaining the EBITDA of ski area operation companies, we have also derived a set of results that are valuable outside the adaptation to climate change topic. For instance, regional policy concerns in alpine regions typically include the way to make ski area operation companies healthier from a financial point of view. With respect to this particular concern, what are the contributions from this chapter? First, we have verified the hypothesis that an increased number of beds in the hotel and para-hotel sectors increases the operating results of the companies (i.e. increases mechanically the number of customers for ski area operation companies). More precisely, our estimation results from the financial year 2004 show that the percentage change in EBITDA when the total number of beds in the hotel and para-hotel sectors changes by one percent is equal to 0.40%. Secondly, our estimation results might also be used to discuss what changes in (infra)structures have the highest impact on the companies' EBITDA. By making use of the coefficients' estimates with elasticity interpretation, our conclusion is that modernizing transport facilities has the highest impact on the EBITDA[38]. As already emphasized, positive effects are also associated to an increase in the overall lodging capacity. An even greater positive effect can however be reached by increasing the proportion of hotel beds while keeping the overall lodging capacity constant. Though the latter result must be regarded with caution as it also reflects heterogeneous characteristics of the different types of data on lodging supply, it seems nevertheless to indicate that hotel beds have a more important impact on EBITDA than beds in the para-hotel sector. Finally, increasing the size of the ski area (e.g. by merging two or more companies) does not seem a priori to be a measure which is worth recommending. When focusing on operating costs reduction potentials, our results do not permit us to state that there exists a positive effect associated to horizontal reconfiguration. However, costs optimization is not the

[38] However, modernization of transport facilities entails large financial and depreciation costs for the companies which are not taken into account in our analysis.

only impact expected from a merging strategy. Such a strategy is also expected to facilitate the transport infrastructure modernization and to increase both professionalism and market position. Transport infrastructure is introduced in the statistical model derived in this chapter through the explanatory variable WTPF and its related effect on EBITDA has been estimated to be strongly positive. By permitting an improvement in the transport infrastructure, a merging strategy could therefore have a strong indirect and positive impact on EBITDA. As regards professionalism, it has been identified as being part of the statistical models' error term. However, the effect on EBITDA of higher professionalism could be already somewhat captured by the Slopes coefficient's estimate given that professionalism is partially correlated with the size of the ski area. In all, we would not use the Slopes coefficient's estimate to say that merging strategies in the ski area operation sector reduce the sector's EBITDA instead of increasing it.

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# 4. Could efficiency improvements compensate for the detrimental effects of climate change?

## 4.1 Introduction

Results from the accounting year 2000/01 show that 9% of the companies from the cableway sector displayed an investment potential (as expressed by the ratio of cash flow to total assets) greater than 15% while 19% of the companies displayed a potential ranging from 10 to 14% and 33% of the companies had a potential between 5 to 9%. The remaining 38% of the companies presented a ratio lower than 5% which is considered by the umbrella organisation of the sector as an insufficient investment potential. When taking into account the accounting year 2002/03, the situation changed in some important ways due to the very favourable winter season. Indeed, only 15% of the companies did not reach the 5% threshold while 24% of the companies had an investment potential greater than 15% (SBS 2004). All these figures give us some insights on at least two elements. On the one hand, financial disparities are rather important for a given accounting year. On the other hand, the financial success strongly depends on some general and natural conditions (e.g. weather and snow conditions) that could not be influenced by the companies. In this context, it would be interesting to distinguish the share of the financial disparities that are attributable to differences in the circumstances under which different companies operate from the share of the financial disparities that are attributable to the relative performances of the companies. Focusing on the companies that do not reach some minimum financial requirements, we could ask whether their difficulties come from a poor performance or from unfavourable conditions (or from a combination of these two reasons). In the same way, we could carry out this thought process for the companies that fulfil the main financial requirements. Are these companies financially healthy because they are efficient or because they take advantage of very favourable conditions (or because of these two reasons)? Following the definition of Koopmans, efficiency is understood in this chapter as the impossibility to improve any input or output without worsening some other input or output[1].

The questions asked in the previous paragraph can be tackled using the Data Envelopment Analysis (DEA) which is the method that we will use in this chapter. It allows deriving a production possibility frontier and determining how inefficient companies could reach this frontier. In the perspective of climate change, the interest of this kind of analysis

[1] This definition of "Koopmans efficiency" also referred to as "Pareto-Koopmans efficiency" or "technical efficiency" is for instance given in Cooper et al (2007, p. 45). Other forms of efficiency include "scale efficiency" and "allocative efficiency".

carried out with a DEA approach is twofold. On the one hand, we can discuss the relative importance of companies' performance and exogenous conditions (including snow conditions) in determining the financial situation of ski area operation companies. On the other hand, we can detect efficiency improvements potentials that could be used to mitigate the detrimental impacts of climate change. In particular, inefficient companies presenting a good financial situation should be highlighted because they represent a very interesting case in the perspective of climate change: as their healthy financial situation might be interpreted as a consequence of good snow conditions, efficiency improvements could therefore partly compensate for the adverse effects of climate change and help them remain profitable. In this chapter, we have decided to focus our work on this second aspect. For certain classes of companies, we therefore build up on the idea that efficiency improvements can be seen as an adaptation measure to climate change. As we will exclusively try to identify, in this chapter, adaptation potentials through efficiency improvements for certain companies, we will not be able to discuss what their overall adaptation potentials to climate change could be. Throughout the chapter, the reader should therefore keep in mind that we will not make statements on companies' overall adaptation potentials.

Basic models of the DEA approach give the excess of discretionary inputs (i.e. inputs that are at the discretion of one company's management) used to produce a given level of outputs. There exist also some refined models which provide the excess of both discretionary and non-discretionary inputs that is used to produce a given set of outputs. We will choose a model among the latter class of models when carrying out our analysis. In order to build input and output variables for the ski area operation sector, we need information on both ski areas' operations (such as the number of persons transported by the facilities) and the resources used by companies to produce the supplied goods and services (such as labor, energy, etc). Unfortunately, data collected for chapter 3's analysis do not give this information. This is the reason why it was necessary to build another database for this chapter.

Under the constraint of a limited availability of data, section 4.2 will derive a set of inputs and outputs for companies of the ski area operation sector. Discretionary, non-discretionary and categorical variables will be derived and proposed. Furthermore, this section will also give some information on the sources of the available data. Then, the following chapters will present the choice of a relevant DEA model and the results of the DEA. Eventually, section 4 will provide a conclusion[2].

## 4.2 Deriving inputs and outputs for the ski area operation sector

### 4.2.1 Sources and characteristics of the data

Both operational and financial information on the cableway sector is provided by the FSO[3]. Due to data protection, the FSO however provides data with the name of the companies up to the year 1997 only. Given this statistic, we have focused on a set of companies of the Valais canton. This set is constituted of 20 companies that still exist today and we

[2] The mathematical formulations of some DEA models including the one that we will use in this chapter are briefly presented in appendix 6.

[3] This information is part of the statistic on the public transports.

have used the 1997 data for our analysis. *Figure 4.1* presents where these 20 companies are located in the Valais canton. In the following, we will however not give the name of these companies when we will assess their relative efficiency. We will merely identify them using capital letters **A**, **B**, **C**, etc.

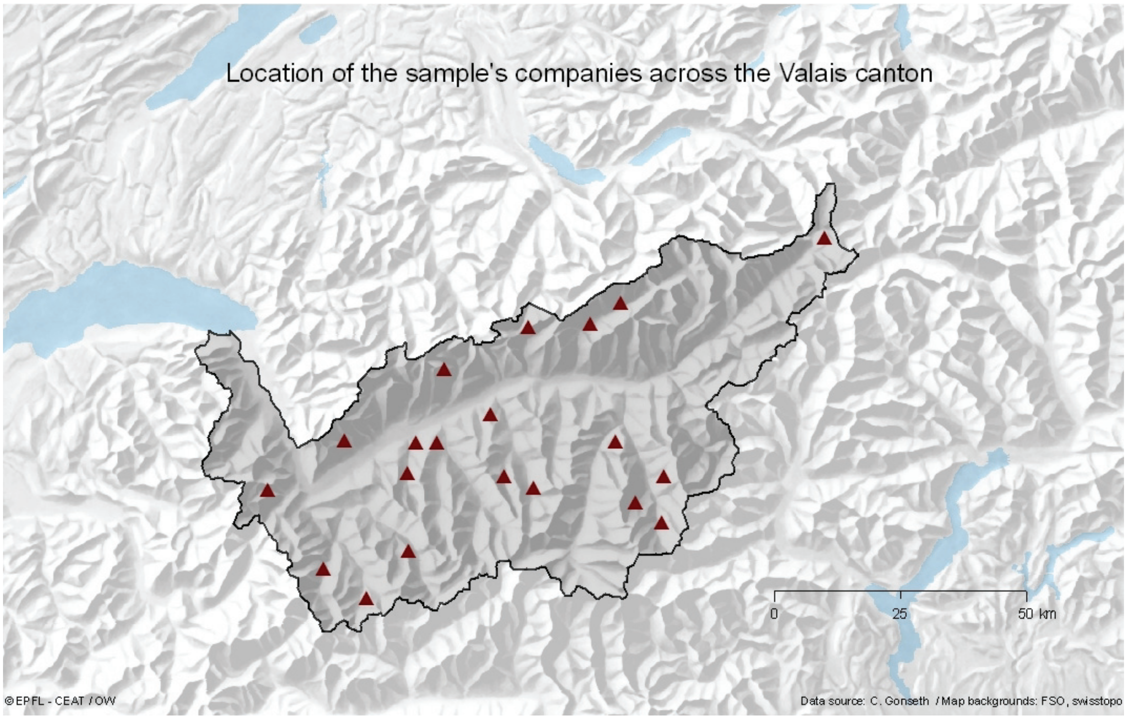


***Figure 4.1*** *- Location of the sample's companies across the Valais canton.*

In addition to the fact that they are not recent, another problem associated to the data provided by the FSO was that indication on the accounting period were lost by the FSO. For a given company, information on the exact period for which both the operational and financial data were collected was therefore lacking. We had to ask the companies for this information. We needed this information in order to build the variables related to the amount of natural snow available to the companies since the DEA approach taken in this chapter puts together operational data with the former type of data. Raw data on the available amount of natural snow were provided either by SLF or by MeteoSuisse. Besides snow conditions, another non-discretionary input introduced in the DEA below is the lodging capacity of the ski resorts. Data on the number of beds available in the hotels, in the rented holiday houses and apartments and in the group accommodations were found in the "Inventaire final du Tourisme 2000" valaisan dataset.

The operational data provided by the FSO for the cableway sector focus on the transport activities and give indications such as the number of people transported and the number of operation days for each transport facility benefiting from a federal authorization (i.e. it gives detailed operational information for those types of cableway necessitating such federal authorization). Based on these operational data, we will therefore not be able to derive outputs for all kinds of activities that are not central to the cableway sector. Accordingly, we decided to concentrate below on deriving inputs and outputs for the transportation activities and, more generally, for the operation of the ski slopes. As regards the financial data provided by the FSO, they distinguish revenues and costs associated to three different activities: transport of people and goods, ski area preparation and maintenance, other activities including catering. Both in terms of revenues and costs, only the financial data related to the transport activities are a bit disaggregated. Revenues generated from the transport activities are distinguished according to whether persons or baggage/goods have been transported. Moreover, the amount of revenues generated from transporting persons is given for the winter and the summertime. Also worthy to note is the fact that the costs generated from the transport activities are distinguished according to the following classes: labor costs, taxes and remaining operating costs and depreciation costs[4].

### 4.2.2 Choice of relevant outputs

#### *4.2.2.1 Preparation and maintenance of the ski slopes*

The challenge is to find a measure of what has been prepared in terms of kilometers of ski slopes during the winter season. Such a measure can be constructed based on the operational data provided by the FSO in the following manner. Let m transport facilities with known numbers of operating days during the winter season $z_1, z_2, \ldots, z_{r-1}, z_r, z_{r+1}, \ldots, z_{m-1}, z_m$ being operated by a given company (i.e. m facilities benefiting from a federal authorization)[5]. Our measure of the overall kilometers of ski slopes that have been prepared during the winter season by company j is then given by the following formula.

$$P_j = \frac{K_j}{m_j} \sum_{r=1}^{m_j} z_{rj} \quad \text{(j= 1, 2,…, 20)} \quad (4.1)$$

Where:

$K_j$ gives the maximum size of the ski area operated by company j in terms of kilometers of prepared ski slopes.

$m_j$ gives the number of transport facilities operated by company j which benefit from a federal authorization.

$z_{rj}$ gives the number of operating days during the winter season for facility r belonging to company j.[6]

Note that this formulation implies that a given ski area is entirely open to skiers when all the facilities benefiting from a federal authorization that are located on it are operated. When the operation of a transport facility stops, the formula implies that it is K/m kilometers of the ski area that are not open anymore. Actually, we implicitly allocate K/m kilometers of ski slopes to each of the m transport facilities benefiting from a federal authorization thereby assuming

[4] Note that the financial costs are probably included in the second class of costs.

[5] The FSO defines the winter season as the period encompassing the months of November till April. Accordingly, the months of May till October constitute the summer season. These definitions will be kept all along the chapter.

[6] In subsection 4.2.3.1, we will also use the equivalent of $z_{rj}$ for the summertime which will be noted $s_{rj}$.

that each of these facilities provides the access to the (1/m)*100 percent of the ski area. Contribution from facility r to the output as computed in equation 4.1 is therefore equal to $z_r$*K/m.

#### *4.2.2.2 Transport activities*

For the transport activities, we should ideally derive several outputs since both people and goods are transported and also because we can distinguish people that are transported during the wintertime from people that are transported during the summertime.

We will begin to derive outputs for the transportation of people. For the facilities benefiting from a federal authorization, the data provided by the FSO allow us distinguishing people that are transported during the wintertime from people that are transported during summertime[7]. For some companies but not for all of them, the FSO also provide the overall number of people that were transported by the ski lifts. Of course, the latter figure exclusively concerns the wintertime. For company j which operated $m_j$ facilities benefiting from a federal authorization as well as ski lifts, the numbers of transported people during the winter and the summertime are computed as follows:

Winter: $$T_j^w = T_j^{w,f} + T_j^{w,sl} = \sum_{r=1}^{m_j} t_{rj}^w + T_j^{w,sl} \quad (j= 1, 2,\ldots, 20) \quad (4.2)$$

Summer: $$T_j^s = T_j^{s,f} = \sum_{r=1}^{m_j} t_{rj}^s \quad (j= 1, 2,\ldots, 20) \quad (4.3)$$

Where:

$T^w_j$ gives the total number of people transported during the wintertime by company j.

$T^s_j$ gives the total number of people transported during the summertime by company j.

$T^{w,f}_j$ gives the total number of people transported during the wintertime by company j's transport facilities benefiting from a federal authorization.

$T^{w,sl}_j$ gives the total number of people transported during the wintertime by company j's ski lifts.

$T^{s,f}_j$ gives the total number of people transported during the summertime by company j's transport facilities benefiting from a federal authorization.

$t^w_{rj}$ is the number of people transported by facility r of company j during the wintertime.

$t^s_{rj}$ is the number of people transported by facility r of company j during the summertime.

[7] The number of transported people corresponds to the sum of people transported upwards and downwards.

We could use the above figures as outputs. However, one problem and one potential improvement are worth mentioning at this point. On the one hand, value of $T^{w,sl}_j$ is not available for all the companies of our sample of 20 companies. How could we then compare values of the $T^w_j$ between different companies? A priori, three approaches could be considered if operational data on (winter) transport activities are absolutely to be used as outputs in a DEA. The first approach would consist in determining $T^w_j$ by using only values of the $t^w_{rj}$ (i.e. by omitting that people are also transported on the ski area by the ski lifts). Though we would compare the same outputs in this way, the problem remains since we will see that the data used to derive the inputs do not allow differentiating the resources used to operate ski lifts from the resources used to operate other transport facilities. Another possibility would be to eliminate from the study all the sample's companies for which the information contained in $T^{w,sl}_j$ is not available. If applied, this solution would reduce the size of our sample from 20 to only 13 entities. This is also not desirable since we are thus loosing important information. Rather we will adopt an alternative approach which consists in using a special type of DEA model that allows coping partly with this data problem (cf. sections 4.3 and 4.4 below). At this point, we note that deriving outputs from financial rather than operational data is also an alternative. This idea will be developed further in the next subsection. With respect to the values derived in equations 4.2 and 4.3, there is a potential improvement that can be brought about by introducing a notion of covered distance. Hence, equations 4.2 and 4.3 would be modified in the following ways:

Winter: $$TD^w_j = TD^{w,f}_j + TD^{w,sl}_j = \sum_{r=1}^{m_j} t^w_{rj} * d_{rj} + T^{w,sl}_j * d^{sl}_j \quad (j= 1, 2,\ldots, 20) \quad (4.4)$$

Summer: $$TD^s_j = TD^{s,f}_j = \sum_{r=1}^{m_j} t^s_{rj} * d_{rj} \quad (j= 1, 2,\ldots, 20) \quad (4.5)$$

Where:

$TD^w_j$ gives the number of persons transported during the wintertime (persons-kilometers).

$TD^s_j$ gives the number of persons transported during the summertime (persons-kilometers).

$TD^{w,f}_j$ gives the number of persons transported during the wintertime by the cableways (persons-kilometers).

$TD^{w,sl}_j$ gives the number of persons transported during the wintertime by the ski lifts (persons-kilometers).

$TD^{s,f}_j$ gives the number of persons transported during the summertime by the cableways (persons-kilometers).

$d_{rj}$ is the length of the facility r owned by company j.

$d^{sl}_j$ is the average length of the ski lifts owned by company j[8].

Note that value of $TD^w_j$ cannot be determined for all the companies of our sample since value of $TD^{w,sl}_j$ is missing for some of them.

Up to now, we have dealt with the transport of people but many cableway companies are also paid for moving goods. An output related to this activity could be simply written as:

$$W_j = \sum_{r=1}^{m_j} w_{rj} \quad (j= 1, 2,..., 20) \quad (4.6)$$

Where:

$W_j$ is the overall tonnage transported by company j.

$w_{rj}$ is the tonnage transported by facility r of company j.

The tonnage of equation 4.6 could have been transported either downwards or upwards. As for the outputs related to the transport of persons, it is however preferable to use the following formula when wanting to incorporate in a DEA approach an output expressing the quantity of goods moved.

$$WD_j = \sum_{r=1}^{m_j} w_{rj} * d_{rj} \quad (j= 1, 2,..., 20) \quad (4.7)$$

#### *4.2.2.3 Revenues from the transport activities*

One question we could ask is whether all of the outputs already derived are useful for the companies? For instance, is the measure of what has been prepared in terms of kilometers of ski slopes really a relevant output? Actually, operating more kilometers of ski slopes during the winter season is not something that is valuable per se for the company since such an increase will not lead automatically to the strengthening of (or could even decrease) the company's earnings. Accordingly, the search for potential activities producing at least the same amount of outputs with fewer inputs (if we are looking for inputs reduction) looses a bit of its appeal. To avoid this problem, we could use instead some of the revenues generated by the company as outputs. This would also help avoiding another problem. Indeed, we would not have to care anymore about differences in the availability of operational data among our sample's companies. In the next sections, we will initially make the distinction between the revenues linked to the transport of persons from the revenues linked to the transport of baggage and goods.

[8] We used data from the ITT statistics (FOSD 2001) in order to compute the average length of the ski lifts.

### 4.2.3 Choice of relevant discretionary inputs

#### *4.2.3.1 Number of employees*

In this subsection, we will consider all the employees hired to operate the cableways and the ski lifts as well as the employees whose tasks are the preparation and the maintenance of the ski slopes[9]. The data provided by the FSO make the distinction between permanent and seasonal staff. The seasonal staff includes all the workers that are hired only temporarily by the companies. For each of these two categories, the number of employees is given as the average number of employees during the operating period[10]. Note also that all the part-time workers should be integrated in one or the other of these two categories.

In the following, we will keep this distinction between permanent and seasonal employees in order to derive two distinct inputs. For the seasonal employees, we must admit however that the data on the average number of employees is not optimal in order to derive an input. In this case, it would be more interesting to have the overall number of remunerated working days rather than the average number of employees. This is due to the fact that the operating period changes from one company to the other thereby meaning that the resources used by two different companies in terms of number of remunerated working days may be different even if they display the same average number of employees for the seasonal staff. By definition, this problem does not occur with the permanent staff. Unfortunately, information on the number of operating days as defined in footnote 10 is not given by the FSO. Therefore, it is a priori impossible to derive the number of remunerated working days from the average number of employees of the seasonal staff. However, we could approximate the number of operating days attributable to a company thanks to the values given to each transport facility benefiting from a federal authorization for the number of operating days. Let first approximate the number of operating days for the wintertime ($z_j^{max}$) and the summertime ($s_j^{max}$) in the following way:

$$z_j^{\max} = \max\left(z_{1j},...,z_{m_j j}\right) \quad \text{(j= 1, 2,..., 20)} \quad (4.8)$$

$$s_j^{\max} = \max\left(s_{1j},...,s_{m_j j}\right) \quad \text{(j= 1, 2,..., 20)} \quad (4.9)$$

The overall number of remunerated working days associated to the seasonal staff is then computed with the following formula:

$$NPE_j = ANPE_j * (z_j^{\max} + s_j^{\max}) \quad \text{(j= 1, 2,..., 20)} \quad (4.10)$$

[9] Therefore, we do take into account neither the employees hired by the ski area operation companies for other transport services (funicular, shuttle service) nor the employees hired in other business fields (catering, hotel trade).

[10] The operating period is defined as the number of days during which at least one transport facility benefiting from a federal authorization operates. This number does not include days where one or several of these transported facilities only operate for internal purposes. For the permanent staff, the average number of employees is computed as the ratio of the sum of the monthly numbers of employees to the length of the operating period (determined in months). As regards the seasonal staff, the average number of employees is computed as the ratio of the overall number of remunerated working days to the length of the operating period (determined in days).

Where:

$NPE_j$ is the overall number of remunerated working days associated to the seasonal staff for company j.

$ANPE_j$ is the average number of seasonal employees for company j.

From equation 4.10, note that the sum ($z_j^{max}+s_j^{max}$) gives a lower limit to the overall number of operating days for company j. Along with the value given in equation 4.10, we will eventually use the average number of permanent employees during the operating period as another input.

#### *4.2.3.2 Use of capital*

As is shown in *table 4.1* below, depreciation costs contribute strongly to the costs incurred by companies of the cableway sector. These depreciation costs are mainly associated to the transport facilities. Different approaches are possible as regards the way to measure the capital resources used in order to produce the outputs. A first possibility would be to compute the total transport capacity of the facilities owned by a given company. Furthermore, we could distinguish the transport capacity linked to ski lifts from the transport capacity linked to other types of facilities.

Cableways: $$DHT_j^f = \sum_{r=1}^{m_j} DH_{rj} \quad \text{(j= 1, 2,..., 20)} \quad (4.11)$$

Ski lifts: $$DHT_j^{sl} = DHT_j - DHT_j^f \quad \text{(j= 1, 2,..., 20)} \quad (4.12)$$

Where:

$DHT_j$ is the total number of persons that can be potentially transported upwards in one hour by company j.

$DHT^f_j$ is the total number of persons that can be potentially transported upwards in one hour by company j's transport facilities benefiting from a federal authorization.

$DHT^{sl}_j$ is the total number of persons that can be potentially transported upwards in one hour by company j's ski lifts.

$DH_{rj}$ gives the number of persons that can be potentially transported upwards in one hour by facility r of company j.

The total transport passenger flow as expressed in equation 4.11 for the transport facilities benefiting from a federal authorization can be computed directly from the data provided by the FSO. In addition to these data, computation of the total transport passenger flow for the ski lifts requires also the use of the ITT statistic (FOSD 2001). To be more precise, we need the latter information to derive the value of DHT (the total transport passenger flow) for each company. In order to keep things coherent with the outputs, we will nonetheless prefer expressing transport capacities using the two following formulas:

Cableways: $DHTD_j^f = \sum_{r=1}^{m_j} DH_{rj} * d_{rj}$ (j= 1, 2,…, 20) (4.13)

Ski lifts: $DHTD_j^{sl} = DHT_j^{sl} * d_j^{sl}$ (j= 1, 2,…, 20) (4.14)

Where:

$DHTD^f_j$ gives the total number of persons that can be potentially transported upwards in one hour by company j's transport facilities benefiting from a federal authorization (persons-kilometers/hour).

$DHTD^{sl}_j$ gives the total number of persons that can be potentially transported upwards in one hour by company j's ski lifts (persons-kilometers/hour).

$DH_{rj}$ gives the number of persons that can be potentially transported upwards in one hour by facility r of company j.

$d_{rj}$ is the length of the facility r owned by company j.

$d^{sl}_j$ is the average length of the ski lifts owned by company j.

We could also look at the depreciation and financial costs which are directly linked to the amount of capital used to produce a given level of outputs. Once again, we are confronted to the fact that the data provided by the FSO are not enough detailed. As already emphasized, the FSO makes the distinction between three types of activities. Within this framework, only the depreciation costs associated to the transport services (i.e. to the transport facilities) are given. However, we were also able to derive the depreciation costs associated to the snowmaking facilities, snow cats, etc. from the same dataset. As regards the financial costs, they are not communicated and there are no means to derive these costs from the rest of the data. Therefore, our measure of the costs of capital only includes depreciation costs as emphasized in the following formula:

$$KC_j = DC_j^{transport} + DC_j^{slopes} \quad (4.15)$$

Where:

$KC_j$ are the costs of capital for company j.

$DC_j^{transport}$ are the depreciation costs linked to the transport facilities of company j.

$DC_j^{slopes}$ are the (estimated) depreciation costs linked to the snowmaking facilities, the snow cats, etc. of company j.

#### *4.2.3.3 Use of artificial snow cover*

Though produced by companies, artificial snow is better thought as one of their inputs since it is nothing else than resources (energy, labor, etc.) used by the companies to ensure the production of some services. It is clear that artificial snow can be introduced directly in a DEA by defining the amount of artificial snow produced by companies as an input. However, a drawback of this approach is that it could not detect inefficiencies in the production of artificial snow. Doing so also implies that the values of other inputs simultaneously included in the DEA (e.g. labor, energy) should be netted from the resources used to produce artificial snow. In this chapter, this is not a strategy that we can afford. On the one hand, we do not know how many $m^3$ of artificial snow a given company has produced during the winter season under study. On the other hand, the FSO data on the cableway sector which are described in subsection 4.2.1 do not allow differentiating those resources used to produce artificial snow. But then why should we investigate the possibility to incorporate an additional input expressing the produced amount of artificial snow if the resources used to produce it are already incorporated in the inputs that we have derived from the FSO data? To be more precise, these resources are present in some but not all of the inputs that we have already derived and we must be aware of it.

*4.2.3.4 Summary table for the discretionary inputs*

<table>
<tr><th colspan="4">Costs</th><th colspan="2">Resources (inputs)</th></tr>
<tr><th colspan="2">Costs categories</th><th>Share in total costs</th><th>Possible measures to reduce costs</th><th>Inputs</th><th>Inputs derived for the DEA</th></tr>
<tr><td rowspan="2">Operating costs</td><td>Labor costs</td><td>37%</td><td>• Reduce the number of transport facilities<br>• Joint operation (e.g. maintenance)<br>• Optimize operating hours according to the demand</td><td>• Number of equivalent full-time staffs</td><td>1/ Number of remunerated working days (only seasonal staff)<br>2/ Average number of permanent employees during the operating period</td></tr>
<tr><td>Other costs</td><td>34%</td><td>• Better use of the resources<br>• Joint buying</td><td>• Quantity of energy, water and goods consumed</td><td>No available data</td></tr>
<tr><td colspan="2">Interest and taxes</td><td>5%</td><td>• Coordinated investments<br>• Joint financing</td><td rowspan="2">• Number of facilities<br>• Residual value of the facilities</td><td rowspan="2">1/ Sum of the products transport passenger flow*operated length for the cableways<br>2/ Total transport passenger flows of the ski lifts multiplied by the average operated length.<br>3/ Depreciation costs for the transport and ski area preparation and maintenance activities</td></tr>
<tr><td colspan="2">Depreciation costs</td><td>24%</td><td>• Coordinated investments<br>• Optimization of total transport capacity</td></tr>
</table>

***Table 4.1*** - *Resources used in the cableway sector are displayed along with the costs and some possible measures aimed at reducing these costs. The discretionary inputs derived for the DEA are shown in the last column. Source: share of the different costs categories in the total costs (including all the activities of companies) are given by SBS (2006) for the accounting year 2004/05.*

### 4.2.4 Choice of relevant non-discretionary inputs and categorical variables

The non-discretionary inputs share two properties: 1/ they cannot be chosen at the discretion of a company's management and 2/ they influence the amount of outputs produced by a given company. The second property explains why it is important to incorporate such inputs into the DEA. Without these inputs, measures of relative efficiencies would be meaningless. The introduction of categorical variables into the DEA follows the same goals. By assigning the entities under study to different classes, the aim is also to account for some relevant differences in the environment under which these entities operate.

Numerous non-discretionary factors have an influence on the outputs produced by ski area operation companies. For selecting the most relevant of them, we will use the results derived in the previous chapter. More specifically, our econometric models have shed light on both the impacts of lodging capacity and location on the operating earnings of the ski area operation companies. On the one hand, the positive impact on the EBITDA of higher lodging capacity has been demonstrated. However, it was not easy to statistically disentangle the effect of hotel beds and para-hotel beds. Therefore, we will only retain in this chapter one non-discretionary input related to the ski resorts' overall lodging capacity. For a given ski resort, this input is computed as the sum of the beds in the hotel and para-hotel sector[11]. On the other hand, the negative impact on EBITDA of being located far from the big population basins has also been emphasized. In chapter 3, the remoteness was finally accounted for by only one binary variable which takes a unitary value whenever more than 90 minutes is needed to reach a given ski resort from the nearest big population basin (cf. section 3.5). Therefore, we decide to split our sample's companies in two categories. The first category is constituted of the most remote companies while the second category is constituted of companies whose related ski resorts are reachable in less than (or just) 90 minutes from the nearest densely populated region. In chapter 3, it was also found that companies located near the Zurich agglomeration were enjoying an advantage compared to other companies. Because we are focusing in this chapter on a sample of companies from the same region, this result cannot however be used to explain differences in the environment of our sample's companies.

At this point, two exogenously fixed elements still have to be discussed: snow conditions and exposure to the sun of the ski areas. In chapter 3, the variables measuring these elements were not found to be statistically significant in the linear regression model describing EBITDA. As our aim is to introduce a measure of the availability of natural snow in the DEA, we will however introduce such a measure in the analysis below. In practice, a meteorological station was allocated to each relevant ski area. Data on snow cover were corrected (using the methodology developed previously for chapter 3) whenever there was a difference in altitude between the ski area and its related meteorological station. Then, the necessary computations were made to derive the average value of snow cover as well as the number of days with more than 30 cm of snow cover at three different altitudes (i.e. at the lowest altitude of the ski slopes, at the critical altitude of the ski area[12] and at the highest altitude of the ski slopes)[13]. Considering the variability in snow depth during the winter season, we prefer the measure given the number of days with more than 30 cm of snow cover at the critical altitude (i.e. number of days during the winter season where skiing is theoretically possible on the major part of the ski area)[14]. Eventually, exposure to the sun of the ski areas will not be taken into account in the DEA.

## 4.3 DEA models[15]

In this section, we will briefly discuss the choice of an adequate DEA model. First, many classes of DEA models offer the possibility to choose between input and output oriented models. As our aim in this chapter is to determine whether potential efficiency improvements can mitigate the detrimental impacts of deteriorating snow conditions (i.e. the detrimental impacts of having less of one input), we clearly position ourselves towards an input perspective. Within a given class of DEA models, we generally also have the possibility to choose between different shapes of the production

[11] The "para-hotel sector beds" cover the same types of beds than those covered by the variable phbeds in chapter 3 (cf. footnote 12, p. 48 which gives a definition of the latter variable). However, we note that beds in the youth hostels will not be taken into account when deriving values for the input.

[12] The critical altitude of a given ski area is defined as the altitude until which poor snow conditions would not diminish the main offer of the ski area in terms of prepared ski slopes.

[13] I am very grateful to Bastienne Uhlmann for having made all the corrections and computations which are mentioned in these lines.

[14] For this chapter, the winter season is defined in footnote 6.

[15] Appendix 6 is the technical counterpart of this section.

possibility set. The issue is to determine what kind of returns to scale prevails at the efficient frontier. Basic DEA models such as the CCR model imply constant returns to scale frontiers. With such constant returns to scale assumption, any activity obtained from scaling up or down an observed activity with a positive scalar would still belong to the production possibility set. Because of the very important initial investments that must be made in order to operate a ski area, we think that this assumption is not credible for the cableway sector. For that reason, we will use DEA models characterized by variable rather than constant returns to scale. Obviously, including non-discretionary inputs has also some implications as regards the choice of an adequate DEA model. An input oriented DEA model with non-discretionary inputs can be defined as a model whose aim is to minimize discretionary inputs while 1/ keeping at least the same level of outputs and 2/ using at most the observed amounts of non-discretionary inputs. Our definition emphasizes the two main features of non-discretionary inputs: though their amounts cannot be chosen by a company's management, they nonetheless influence one company's efficiency rating. As shown in appendix 6, introducing non-discretionary inputs in the DEA is a question of adding new constraints in the envelopment model. Such models will be abbreviated NDSC (non-discretionary) for highlighting the presence of one or several non-discretionary inputs. Furthermore, if the model is input-oriented and assumes variable returns to scale frontiers, the abbreviation will be expanded to NDSC-I-V.

In the following, we will define two categorical variables (both of them including two categories). Therefore, we have to tackle how a categorical variable could be introduced in the NDSC-I-V model. Actually, a categorical variable can be introduced in a very simple manner. Since categorical variables aim at evaluating entities such as our ski area operation companies under different operating handicaps, the basic idea is to estimate entities of a given category only with the entities of equally or more disadvantaged categories. In other words, the NDSC-I-V model can be applied first to the entities of the first category (i.e. companies of category 1 are evaluated only within their category). Then, the NDSC-I-V model can be applied to companies of categories 1 and 2. Companies in category 2 are therefore evaluated with reference to all the companies of our sample. As described in subsection 4.2.4, a first categorical variable is linked to the ski resorts' location. A second categorical variable is constructed in order to cope with a problem in data availability that we have emphasized in subsection 4.2.2.2. As we were not able to derive one of the outputs describing the transport activities for all the companies of our sample, the idea is to give a handicap to those companies for which it was possible to derive it.

Before proceeding further, we must warn the reader that we will carry out the DEA for two sets of data which differ mainly in the output variables. The output variables of the first set of data are based on the operational data provided by the FSO (i.e. the first set of data includes the output variables P, $TD^w$, $TD^s$ and WD defined in subsection 4.2.2.1 and 4.2.2.2) whereas the output variables contained in the second set of data are based on the financial data provided by the FSO (i.e. these output variables are based on the revenues generated by transport activities). These two sets of data share the same discretionary and non-discretionary variables. However, they do not share the same categorical variable. The categorical variable linked to the ski resorts' location will be used when revenues from the transport activities are taken as outputs in the DEA. On the contrary, the other categorical variable will be used when the operational data based outputs are taken as outputs in the DEA. The following table sums up information on these two sets of data:

| | First set of data | | Second set of data | |
|---|---|---|---|---|
| | **Items** | **Potential maximum number of items** | **Items** | **Potential maximum number of items** |
| Outputs | Amount of total ski slopes' length prepared during the winter season (km). number of transported persons (summer/winter) in (persons-kilometers) overall transported tonnage (tons-kilometers) | 4 | Revenues generated by the transport of persons (summer/winter) in ($10^3$ CHF) Revenues generated by the transport of goods in ($10^3$ CHF) | 3 |
| Discretionary inputs | Permanent staffs (nbr of employees) and seasonal staffs (nbr of working days) Transport capacities (persons-kilometers/hour) or depreciation costs ($10^3$ CHF) | 4 | Permanent staffs (nbr of employees) and seasonal staffs (nbr of working days) Transport capacities (persons-kilometers/hour) or depreciation costs ($10^3$ CHF) | 4 |
| Non-discretionary inputs | Total lodging capacity (nbr of beds) Snow availability (nbr of days) | 2 | Total lodging capacity (nbr of beds) Snow availability (nbr of days) | 2 |
| Categorical variable (with two categories) | Category 1 is made up of companies for which the number of persons transported during the wintertime by the ski lifts is unknown. | 1 | Category 1 is made up of companies whose related ski resorts are reachable in more than 90 minutes from the nearest densely populated region. | 1 |

***Table 4.2*** *- Presentation of the two sets of data that could be used for the DEA.*

Eventually, we will end the discussion of this section by tackling the problem related to the number of input and output items to be introduced in a DEA. For each of the two sets of data, *table 4.2* gives the potential maximum number of input and output items that could be used. We need to compare these figures with the number of companies of our sample. In fact, the number of inputs and outputs to be introduced in a DEA should not be too large compared to the number of entities for efficiency discrimination between entities to happen. For a given number of input and output items, a rule of thumb has been developed which gives the minimum number of entities that should be analyzed (cf. Cooper et al (2007, p. 116)). In our case, the rule indicates that we are just at the limit of what is admissible even though we have not taken the non-discretionary inputs into account. As we will use categorical variables, we also note that evaluation for companies of the most disadvantaged category are only carried out with companies of their own category. Therefore, there is clearly a need to reduce the number of input and output items that will be used in our DEA approach. The following table shows how we manage to reduce this number.

| | First set of data | | Second set of data | |
|---|---|---|---|---|
| | **Items** | **Potential number of items** | **Items** | **Potential number of items** |
| Outputs | $y_1$=Amount of total ski slopes' length prepared during the winter season (km) $y_2$=Total number of transported persons (persons-kilometers) | 2 | $y_1$=Total Revenues generated by the transport of persons in ($10^3$ CHF) | 1 |
| Discretionary inputs | $x_1$=Permanent staffs (nbr of employees) $x_2$=Seasonal staffs (nbr of working days) $x_3$=Transport capacities (persons-kilometers/hour) or depreciation costs ($10^3$ CHF) | 3 | $x_1$=Permanent staffs (nbr of employees) $x_2$=Seasonal staffs (nbr of working days) $x_3$=Transport capacities (persons-kilometers/hour) or depreciation costs ($10^3$ CHF) | 3 |
| Non-discretionary inputs | $x_4$=Snow availability (nbr of days) $x_5$=Total lodging capacity (nbr of beds) | 2 | $x_4$=Snow availability (nbr of days) $x_5$=Total lodging capacity (nbr of beds) | 2 |
| Categorical variable (with two categories) | Category 1 is made up of companies for which the number of persons transported during the wintertime by the ski lifts is unknown. | 1 | Category 1 is made up of companies whose related ski resorts are reachable in more than 90 minutes from the nearest densely populated region. | 1 |

***Table 4.3*** *- Presentation of the two sets of data that could be used for the DEA after reduction of the number of input and output items.*

The next table provides the descriptive statistics of the variables presented in *table 4.3*.

| Variables | Location | | Scale | | | | Shape |
|---|---|---|---|---|---|---|---|
| | Average | Median | Sample minimum | Sample maximum | Sample standard deviation | Interquartile range | Standardized sample skewness |
| $y_1$ (first dataset) | 5337 | 4270 | 1000 | 14625 | 3760 | 4415 | 1.06 |
| $y_2$ | 2787 | 1658 | 173 | 13161 | 3581 | 1737.5 | 1.77 |
| $y_1$ (second dataset) | 6441 | 4055 | 289 | 29558 | 8087 | 3876.5 | 1.86 |
| $x_1$ | 30 | 10 | 3 | 263 | 59 | 19 | 3.28 |
| $x_2$ | 5893 | 5202 | 0 | 22386 | 6412 | 7367.5 | 1.16 |
| $x_3$ (Transport capacities) | 11031 | 8836 | 1292 | 42721 | 11018 | 6252 | 1.59 |
| $x_3$ (Depreciation costs) | 1836 | 1185 | 0 | 8959 | 2341 | 1120 | 1.75 |
| $x_4$ | 133 | 129 | 72 | 242 | 34 | 16 | 1.57 |
| $x_5$ | 4200 | 2993 | 510 | 16314 | 3753 | 4388.5 | 1.74 |

***Table 4.4*** *- Descriptive statistics for the input and output items that will be used in the DEA approach.*

## 4.4 Results from the DEA[16]

Whatever the data that we are using, the NDSC-I-V model always pins down between 2 to 4 inefficient companies among our sample of 19 companies[17]. The entity **H** is always found to be inefficient. In all, 5 companies of our sample were at least estimated once as inefficient. Efficiency scores for the two data sets are presented in *table 4.5*.

[16] The DEA was carried out using the DEA-Solver attached to the book written by Cooper et al (2007).

[17] Initially, our sample of companies is made up of 20 companies. However, data on snow availability were lacking for one company which has therefore been removed from the sample. Accordingly, the descriptive statistics presented in *table 4.4* have been computed for 19 rather than 20 companies.

| Entity | NDSC-I-V score for the first data set | | NDSC-I-V score for the second data set | |
|---|---|---|---|---|
| | Transport capacity ($DHTD^f$+$DHTD^{sl}$) | Depreciation costs (KC) | Transport capacity ($DHTD^f$+$DHTD^{sl}$) | Depreciation costs (KC) |
| **A** | 1 | 1 | 1 | 1 |
| **B** | 1 | 1 | 1 | 1 |
| **C** | 1 | 1 | 1 | 1 |
| **D** | 1 | 1 | 1 | 1 |
| **E** | 1 | 1 | 0.641 | 0.664 |
| **F** | 1 | 1 | 1 | 1 |
| **G** | 1 | 1 | 1 | 1 |
| **H** | 0.913 | 0.913 | 0.752 | 0.754 |
| **I** | 1 | 1 | 1 | 1 |
| **J** | 1 | 1 | 1 | 1 |
| **K** | 1 | 1 | 1 | 1 |
| **L** | 0.753 | 0.733 | 0.620 | 1 |
| **M** | 1 | 0.757 | 0.745 | 0.794 |
| **N** | 1 | 1 | 1 | 1 |
| **O** | 1 | 0.905 | 1 | 1 |
| **P** | 1 | 1 | 1 | 1 |
| **Q** | 1 | 1 | 1 | 1 |
| **R** | 1 | 1 | 1 | 1 |
| **S** | 1 | 1 | 1 | 1 |

***Table 4.5*** *- NDSC-I-V model scores for different sets of input and output items.*

Efficiency scores as reported in *table 4.5* are concerned with technical efficiency (also called purely technical or radial efficiency) in the sense that they indicate whether all inputs can be reduced proportionally while keeping at least the same level of outputs production. Depending on the data, the model for instance emphasizes that it would have been possible for the ski area operation company **H** to reduce all its (discretionary) inputs by 8.7% to 24.8% while keeping the same level of outputs. Even when this kind of inefficiency is removed, there might still be some waste in the production process. This is referred to as mix-inefficiency. Though the inefficient entities in *table 4.5* could be projected on the production possibility frontier by means of the efficiency scores, they will not necessarily attain an efficient part of this frontier. The slack "vectors" give the additional reductions in inputs and/or the increases in outputs that are necessary for a company to reach an efficient part of the frontier. In order to complete the information provided in *table 4.5* for the companies found to be inefficient, t*able 4.6* therefore provides the slacks for the first data set while *table 4.7* provides the slacks for the second data set. Along with the slacks for the discretionary inputs and outputs, the slacks for the non-discretionary inputs are also displayed in these tables. The latter are central to our analysis. However, one has to note that there is an essential difference in the way these slacks are obtained from the NDSC-I-V model. For a given minimized value of the efficiency score, the NDSC-I-V model searches to maximize the sum of discretionary input excesses and output shortfalls. No such maximization is carried out for the non-discretionary input. The model only sets the constraint that the improved activity (i.e. the point on the efficient frontier used to evaluate an observed activity) should not use more of the non-discretionary inputs than the entity being evaluated. This distinction is essential for interpreting correctly the results presented in the next two tables. In particular, inefficient companies with a non-zero slack associated to the natural snow input are interesting in the sense that potential efficiency improvements are possible even with a decrease in snow availability. In other words, these companies could have produced the same quantity of outputs with less discretionary inputs even under worsening snow conditions. In the perspective of climate change, this is an interesting statement since it would imply that certain companies could compensate for the detrimental impacts of worsening snow conditions through efficiency improvements. The next two tables allow us discussing what the extent of these potential efficiency improvements possibly are under deteriorating snow conditions.

| | Use of capital | Inefficient entities | Score | Excess of discretionary inputs | | | Excess of non-discretionary inputs | | Shortfall of outputs | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $S_1^-$ | $S_2^-$ | $S_3^-$ | $S_4^-$ | $S_5^-$ | $S_1^+$ | $S_2^+$ |
| NDSC-I-V model with the first data set | Transport capacity $(DHTD^{f}+DHTD^{sl})$ | **H** | 0.913 | 0 | 9 (0.1%) | 1255 (11.2%) | 21 (17.9%) | 2313 (30.7%) | 1218 (29.1%) | 0 |
| | | **L** | 0.753 | 0 | 844 (6.9%) | 17 (0.1%) | 19 (14%) | 2591 (40.1%) | 0 | 0 |
| | Depreciation costs (KC) | **H** | 0.913 | 0 | 9 (0.1%) | 324 (26.5%) | 21 (17.9%) | 2313 (30.7%) | 1218 (29.1%) | 0 |
| | | **L** | 0.733 | 4 (16%) | 693 (5.7%) | 0 | 42 (30.9%) | 635 (9.8%) | 0 | 0 |
| | | **M** | 0.757 | 0 | 0 | 0 | 11 (8.1%) | 709 (23.7%) | 0 | 0 |
| | | **O** | 0.905 | 0 | 1633 (67.4%) | 49 (25.3%) | 0 | 0 | 370 (27.5%) | 0 |

***Table 4.6*** - *Input excesses and output shortfalls for the entities evaluated as inefficient by the NDSC-I-V model when use is made of the first data set. Each input excess/output shortfall is also expressed as a percentage of the amount of used input/produced output. Note that $s_i^-$ is associated to the input $x_i$ defined in the second column of table 4.3 and $s_i^+$ is associated to the output $y_i$ defined in the second column of table 4.3.*

| | Use of capital | Inefficient entities | Score | Excess of discretionary inputs | | | Excess of non-discretionary inputs | | Shortfall of outputs |
|---|---|---|---|---|---|---|---|---|---|
| | | | | $S_1^-$ | $S_2^-$ | $S_3^-$ | $S_4^-$ | $S_5^-$ | $S_1^+$ |
| NDSC-I-V model with the second data set | Transport capacity $(DHTD^{f}+DHTD^{sl})$ | **E** | 0.641 | 0 | 3685 (16.5%) | 1600 (5.6%) | 0 | 508 (8.4%) | 8 (0.06%) |
| | | **H** | 0.752 | 0 | 1666 (18.8%) | 641 (5.7%) | 0 | 3052 (40.5%) | 0 |
| | | **L** | 0.620 | 0 | 1850 (15.2%) | 16 (0.13%) | 2 (1.5%) | 3600 (55.7%) | 0 |
| | | **M** | 0.745 | 0 | 0 | 0 | 0 | 872 (29.1%) | 12 (0.36%) |
| | Depreciation costs (KC) | **E** | 0.664 | 0 | 2925 (13.1%) | 0 | 0 | 1271 (21%) | 0 |
| | | **H** | 0.754 | 0 | 724 (8.2%) | 0 | 0 | 3429 (45.5%) | 0 |
| | | **M** | 0.794 | 0 | 1269 (24.4%) | 0 | 0 | 630 (21%) | 6 (0.18%) |

***Table 4.7*** - *Input excesses and output shortfall for the entities evaluated as inefficient by the NDSC-I-V model when use is made of the second data set. Each input excess/output shortfall is also expressed as a percentage of the amount of used input/produced output. Note that $s_i^-$ is associated to the input $x_i$ defined in the fourth column of table 4.3 and $s_i^+$ is associated to the output $y_i$ defined in the fourth column of table 4.3.*

What we can observe from these tables is that the value taken by the slack variable associated to the availability of natural snow depends on the data set. When the analysis is based on the first data set, the variable expressing the availability of natural snow is not responsible for evaluating a company as inefficient (with the exception of company **O**). If we would have carried out the analysis without this variable, the efficient scores would not have changed (again with the exception of company **O**). In other words, the slack variable of interest is positive which permits us to carry out the kind of analysis that we are looking for. In these cases, the potential efficiency improvements pinned down by the NDSC-I-V model would have still been feasible under reductions ranging from 10 to 40 days in the number of days favourable to skiing activities (which represents an 8% to 31% reduction in the number of these favourable days). To be more instructive, these percentage reductions should be compared to those obtained from predicting the impacts of climate change. However, the latter percentages were unfortunately not available for the companies rated as inefficient.

We have also tried to link the DEA results to the companies' financial situation. Among the companies at least estimated once as inefficient, three displayed insufficient or very poor operating performance as measured by the ratio of cash flow to total revenues in 1997. Two companies were therefore rated as inefficient while displaying a sufficient or even a good financial ratio. Based on our data, we could however not interpret their good financial health as being only a consequence of good snow conditions. Things are completely reversed when using the second data set. In this case, the slack variable of interest is generally equal to zero and we cannot assume that the potential efficiency improvements pinned down by the NDSC-I-V are available under deteriorated snow conditions.

## 4.5 Conclusion

Data availability has shown to be a huge problem in the context of this chapter. On the one hand, recent data were not available and we cannot do better than dealing with data valid for the year 1997. While they were not recent, these data were neither complete and some central information on them were lacking. A necessary step has consisted in asking the ski area operation companies for this information which was rather time-consuming and uncertain. We tried to do our best by focusing on a set of companies located in the Valais canton. As a result, our sample was eventually made up of 19 companies from this canton. For this set of companies, we have derived many inputs and outputs that we have classified in discretionary and non-discretionary inputs, categorical variables and outputs. Due to our small sample of companies, it would have been however unproductive to introduce all these variables in the DEA. Therefore, we have carefully selected the input and output items to be used in the DEA. Our strategy was to reduce the number of items as much as possible even if it meant enlarging the set of used input and output items in a second phase. During our analysis, we found a maximum of four companies being inefficient with a given set of data. In this case, adding more items to the DEA would have been meaningless since it would have led to even smaller efficiency discrimination power among our sample of companies. Along with the relatively small sample size, several characteristics of the DEA model such as the assumption made on returns to scale and the use of a categorical variable can explain the large number of companies found to be efficient in our analysis. Given the chosen model and the number of input and output selected items, a larger sample of companies would have clearly been required for DEA to be more informative.

Due to these data limitations, it should be clear that our intention in this chapter was rather to carry out a kind of preliminary study which mainly aims at determining if efficiency analysis could be a fruitful area for future research in the adaptation to climate change topic. Using the DEA approach, we were able to uncover different types of relationships between the availability of natural snow and the evaluation of the ski area operation companies' performance. For three companies, the DEA approach has provided us with potential efficiency improvements which would have been accessible to the company even under worse natural snow conditions. More precisely, these potential efficiency improvements identified by the DEA model would have still been feasible under a reduction ranging from 10 to 40 days in the number of favourable days to skiing activities (which represents a 8% to 31% reduction in the number of these favourable days). Our initial intention was to compare these figures with some predictions on the future availability of natural snow. Due to data limitation, these predictions were however carried out for only one company of our sample which eventually did not show to be inefficient. Any comparison was therefore impossible. For the three above mentioned companies, efficiency improvements can be seen as a potential adaptation measure since they have a mean to mitigate the detrimental impacts of worsening snow conditions. By saying that, we do not mean however that adaptation through efficiency improvements is not possible for the other two companies of our sample that were at least rated once as inefficient. Probably that smaller efficiency improvements compared to those identified in our analysis are still available to these companies under deteriorating snow conditions. In a DEA approach, this could be potentially analyzed by looking again at the projections once the non-discretionary input of the entity being evaluated is diminished by one or several units. Inefficient companies with a zero slack associated to the natural snow input are also worth highlighting because the availability of snow influenced their efficiency rating. If we had carried out the DEA without the non-discretionary input related to the natural snow availability, these companies would have obtained even lower efficiency scores.

Our opinion is that viewing efficiency improvements as an adaptation measure is appealing. Compared to some technical adaptation measures like snowmaking facilities, no large investments are required and some environmental impacts of winter tourism activities could be reduced rather than increased. Indeed, efficiency improvements can be implemented through measures such as a better use of resources, coordinated investments, joint operation, optimization of total transport capacity, etc. The DEA approach used in this chapter has allowed linking potential efficiency improvements to the future impacts of climate though in a very loose way. The analysis of this link is in its early stages and further analysis should clearly be made in order to make it tighter.

## 4.6 Bibliography

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# 5. Conclusion

According to several studies, climate change will be very disruptive for the Swiss winter tourism sector. They all agree on the fact that the Swiss ski industry will suffer from the impacts of climate change. In this context, adaptation is crucial for reducing the burden of these detrimental changes. However, adaptation is a vague notion that can be understood in different ways. For instance, it is foreseen that climate change will also have some beneficial aspects on the Swiss “alpine” tourism sector which are responsible for alleviating the costs estimates of climate change: summer tourism in the mountain regions is expected to become more attractive in a warmer climate and to benefit from the reallocation of the money not spent anymore by households for winter sport activities. The Swiss ski industry will probably also take advantage of the fact that ski resorts located in the neighbouring countries will be even more affected by climate change. Clearly, adaptation of the existing structures will be necessary for those beneficial effects of climate change to take place (through capacity adaptation, higher investments in security, investments to develop the summer season, etc.). Nonetheless, adaptation measures are generally not presented as a way to take advantage of new opportunities. Rather, adaptation is more often thought as a way to mitigate the costs of climate change. In the winter tourism sector context, this means all the adaptation measures that will allow maintaining snow dependent sport activities (like skiing) in the mountain regions. With this respect, investments in snowmaking facilities are certainly one of the most important available adaptation measures. Accordingly, the main part of our work was devoted to discuss some issues related to snowmaking facilities from the channels used to finance them to their impacts on the ski area operation companies’ financial situation. Our work has first shown what the current level of these investments in Switzerland is. After having emphasized the fact that many snowmaking facilities will probably be planned in the years to come, we have come to the financing of these investments. Distinctive features of the public authorities’ support have then been carefully described as well as the public money granted for snowmaking investments. Quantitatively, we were able to estimate a cash equivalent for the overall support provided to snowmaking facilities until the end of 2006 in Switzerland. We were also able to discuss the different cantonal authorities’ commitments towards snowmaking investments. One of our objectives was then to uncover whether the vulnerability towards climate change of companies located in certain regions or of companies belonging to particular classes could be somewhat alleviated by public authorities’ support. While we have found that this might be the case for companies generating from 1 to 5 Mio CHF of transport revenues, such clear-cut conclusions could not be made for companies located in cantons where the support towards snowmaking facilities is relatively higher. Eventually, we have to warn the reader that our study on the public authorities' support towards snowmaking investments was not exhaustive. The support provided at the communal level was not tackled by our study as well as the public support provided to companies that consists in securing their loans.

After having estimated to which extent snowmaking investments have been supported by public authorities and having discussed the orientation in the support that will be provided to these facilities in the years to come, the next logical step was to assess the impacts of snowmaking investments on the companies' financial situation. A model was therefore constructed that aimed at predicting the EBITDA of companies whose core business has remained the transportation of persons. Snowmaking investments were basically measured and introduced in this model as the number of kilometers of ski slopes that could be snowed using the available snowmaking equipment. In addition to this variable, a quadratic term has been added to test the hypothesis of a decreasing impact of snowmaking investments on the companies' EBITDA. Both variables were found to be significant and the decreasing partial effect hypothesis of snowmaking investments was verified. In addition, we found that companies could increase their EBITDA by investing more in snowmaking facilities until a value approaching 30 km of ski slopes equipped with such facilities. This is a large value since the mean size of Swiss ski areas is approximately equal to 20 km. However, the limit until which it is worth investing in snowmaking facilities is lower than 30 km once the financial and depreciation costs of investments are taken into account. In this case, a unique threshold value is no longer available for all companies since the final impact of additional snowmaking investments will depend on a company' value of EBITDA. Another important feature of our model is that the partial effect on EBITDA of snowmaking investments does not vary with the available amount of natural snow.

One of the main criticisms that can be formulated against the results derived in chapter 3 for the partial effect of snowmaking investments is that they are not easily transposable to winter seasons with different conditions. Given these uncertainties, how can our results give any insights on the impacts of snowmaking facilities under climate change? Comparisons based on the 2003/04 and 2004/05 winter seasons reinforce this suspicion. Estimates of the partial effect were different for the two winter seasons probably due to different patterns of snow availability across the Swiss Alps. Snow conditions were poorer during the 2004/05 winter season. In this setting, we would have expected the partial effect of snowmaking investments to be higher when estimated for the 2004/05 winter season. Nonetheless, our results have shown the opposite. The reason is probably to be found in the very particular pattern of snow availability characterizing the 2004/05 winter seasons. Indeed, snow conditions were poorer in the high alpine regions than in the foothills of the Alps where snowmaking investments are lower. As a result, the net benefits from running the snowmaking equipment were lower during the 2004/05 winter season due simultaneously to higher operating costs and to a lower revenue generating effect. It is difficult determining whether one or the other of these two effects was predominant. However, some elements indicate that the operating costs from producing artificial snow do not change too strongly from one year to another. According to this hypothesis, a lower revenue generating effect should have been mainly responsible for the net benefits from running the snowmaking investments to be lower during the 2004/05 winter season.

Despite these insights, the influence of snow availability and temperatures (since temperatures should also have an influence on the gains obtained from running snowmaking facilities) on our estimation results must clearly be analyzed further. We think that it is possible to deal with this issue by carrying out the following tasks chronologically:

- Snow and weather conditions available during the winter seasons 2003/04 and 2004/05 need to be analyzed further. First, there is a need to categorize both winter seasons compared to the other winter seasons. In other words, we would like to determine more precisely what the distinctive features of these winter seasons were. As regards snow conditions, there is also a need to know more precisely to which extent snowfalls were heterogeneously distributed among different Swiss regions.
- We need to verify the assumption that a large part of the operating costs generated by running the snowmaking facilities does not vary from one year to another. This can be done by giving more comprehensive answers to the following questions. For which purposes snowmaking facilities are used? What is the variability of snow production from one year to another? What are the factors explaining the differences in snow production? Is the variability of operating costs higher than the variability of snow production? What part of the operating costs' variability can be attributed to differences in temperatures? We could answer these questions by carefully reviewing one more time the literature and by analyzing a group of several companies for which data on snow production and their related operating costs can be obtained.
- Once the characteristics of the 2003/04 and 2004/05 winter seasons and the determinants of snow production have been determined, we could try to find winter seasons which are quite different with respect to one or several weather variables (quantity and distribution of snowfalls, temperatures) from the winter seasons that we have already analyzed and for which data on the elements influencing the EBITDA are also available. In this case, it would be possible to check the relative gains of snowmaking investments under different winter seasons by comparing the estimation results obtained for winter seasons that are different in some relevant ways. By collecting data for different winter seasons, it would also be possible to use alternative statistical models like fixed effects regression models where the impacts of snow conditions on the companies' EBITDA would be probably easier to pin down.

The fact to have estimated the partial effect of snowmaking investments for only two winter seasons is also problematic when assessing the financial impacts of additional snowmaking investments for a given company. Our predictions of the impacts of additional investments for our sample of companies were rather simple as we have only computed the impact for the first year of investment. Ideally, these predictions should have taken into account the impacts on the whole investment's lifetime. Ideally, such predictions would have therefore implied that the partial effect of snowmaking investments could vary according to the winter season. Note also that the impact of changing snow conditions would have been twofold in this kind of evaluation. Besides influencing the value of the partial effect, it would have also influenced the EBITDA value. By gaining insights on the way the partial effect changes with different types of winter, we would therefore also be able to carry out more subtle predictions concerning the financial impacts of investing one more kilometer in artificial snow cover.

Up to now, we have not discussed potential improvements for the final estimable model that we have derived in chapter 3. However, several potential expansions of the model still have to be checked. In the following, we will only present two of them as examples. On the one hand, comparing the obtained estimation results with the snow availability patterns across the Swiss Alps sheds light on the importance of these patterns to explain ski area operation companies' financial results. In particular, we have seen how differences in snow availability between regions of the foothills of the Alps and high alpine regions have a strong impact on companies' financial results. This is an indication that a regressor summing up information on the snow conditions in competing and/or lower located resorts should be added to the model of EBITDA. Interaction terms between this regressor and the snowmaking related regressors should also be tested. On the other hand, we also note that, throughout chapter 3, we have never tackled the prices of ski passes as a potential variable explaining the companies' EBITDA even when describing the elements contained in the error term. As for any other explanatory variables, there must be some economical foundations motivating their inclusion in the model. If those exist, prices must also vary sufficiently to induce change in the dependent variable. Focusing on the first point, we must admit that there is not a unique type of ski pass but several types of ski passes and therefore several prices. These different types of ski pass are not aimed at the same sort of clientele. Weekly ski pass are aimed at people lodging in the ski resorts. In this case, ski pass only represents a small fraction of the daily tourist expenditure (in the order of 15% to 20%). Since the price of weekly ski pass can only explain weakly the clientele's choices, we do not consider introducing it into the model as an interesting option. Things are different for the "excursionists" since the price of the daily ski pass constitutes a significant part of the money spent for the one-day excursion. A better basis for comparison would then be obtained by dividing the price of the daily ski pass by the total ski slopes' length. However, this variable will hardly help predicting the EBITDA of companies located far from the densely populated regions. Therefore, the fact to introduce this variable in the model is also questionable.

In chapter 4, we have presented efficiency improvements of companies as a potential adaptation measure to climate change. Our contribution has mainly consisted in analyzing how the DEA approach could be used in order to identify potential for adaptation through efficiency improvements. After a first step which has consisted in choosing a suitable DEA model, we have carried out our analysis using a set of 19 valaisan companies. However, many of these companies were found to be efficient. Given the number of input and output items finally retained for the analysis and the characteristics of the DEA model that we have used, a larger sample would have been clearly required for the DEA to identify more inefficient companies. Under deteriorated snow conditions, only three companies of our sample could have produced the same quantity of outputs with less discretionary inputs. For these companies, potential efficiency improvements would have still been feasible under reductions ranging from 10 to 40 days in the number of days favourable to skiing activities (which represents an 8% to 31% reduction in the number of these favourable days). However, it is not sure that these potential efficiency improvements would have still been possible under a warmer climate. To be more instructive, these percentage reductions should have been compared to those obtained from predicting the impacts of climate change. Unfortunately, the latter percentages were not available for the companies of interest. In all, the significance of our quantitative results is limited due to the difficulty in finding recent, sufficient and reliable data. To have more convincing results, we will have to make the effort to develop further conceptually our idea and to find better data.

# Appendix 1: Financial ratios

## A 1.1 Definition of some financial ratios

In subsection 2.2.1, several frames of figure 2.1 refer to a set of financial ratios. We will give their definition below and also briefly discuss the type of information they carry:

EBITDA/R = EBITDA/Revenues

This ratio expresses the operating performance of a company or the cost-effectiveness of its turnover. It indicates the share of turnover that remains after having taken away operating costs from the former.

CF/TA = Cash flow/Total assets

Division by the value of total assets allows comparing the generated cash flows on a common basis. The CF/TA ratio gives an insight on a company's investment potential. It helps uncovering investment potentials since cash flow can be used either to finance investments or to allow for de-financing activities (principal payments on debts and cash dividends to stockholders). The ratio determines to which extent self-financing is sufficient to finance a company's long-term investments.

CF/D = Cash flow/Long term debt

This ratio is interpreted as the degree of indebtedness of a given company. Indeed, the inverse of this ratio gives the number of years that would theoretically be necessary for a company to repay long term debts. High degree of indebtedness can explain delay in investments since it reduces cash flow (through high financial costs) while pushing companies to give priority to the repayments of long term debts.

LC/R = Labor costs/Revenues

When the ratio EBITDA/R is small for a given company, the ratio LC/R then allows verifying whether the reason for this low value is due to abnormally high labor costs.

IP/R = Interest payments/Revenues

This ratio allows verifying whether cash flow is diminished in some important amounts by interest payments (i.e. by a high degree of indebtedness).

CF/R = Cash flow/Revenues

Compared to the ratio EBITDA/R, it is an alternative measure of any given company's performance.

E/TA = Equity/Total assets

Note that this ratio is equal to one minus the total debt ratio. The latter ratio is defined as the ratio of total liabilities to total assets. The total debt ratio simply indicates how much of the assets appearing on the balance sheet has been provided by debts.

## A 1.2 Threshold values for the cableway sector[1]

| Financial ratio | Companies with a ratio transport revenues to total revenues≤80% | | Companies with a ratio transport revenues to total revenues>80% | | Threshold given for any diversification level | |
|---|---|---|---|---|---|---|
| | Minimum value | Desirable/ good value | Minimum value | Desirable/ good value | Minimum value | Desirable/ good value |
| Operation – operating performances | | | | | | |
| Labor Costs/Revenues | ≤36% | ≤32% | ≤32% | ≤27% | ≤35% (Vikuna and SBS) | ≤30% (Vikuna) |
| EBITDA/Revenues | ≥25% | ≥35% | ≥30% ≥25% (SBS) | ≥40% | ≥25% (Vikuna and SBS) | ≥30% (Vikuna) |
| Cash Flow/Revenues | ≥20% | ≥30% | ≥25% | ≥35% | ≥20% (Vikuna and SBS) | ≥25% (Vikuna) |
| Financial structure – self-financing possibilities | | | | | | |
| Equity/Total Assets | ≥30% | ≥40% | ≥30% | ≥40% | ≥30% (Vikuna and SBS) | ≥40% (Vikuna) |
| Cash Flow/Total Assets | - | - | - | - | ≥6% (Vikuna) ≥5% (SBS) | ≥9% (Vikuna) |

***Table A 1.1*** *- The table gathers information from three institutions (Grischconsulta AG, SBS and Vikuna AG) concerning the threshold values of several financial ratios which are relevant to the cableway sector.*

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[1] All the values below are proposed as thresholds by Grischconsulta AG (cf. Zegg and Gujan 2003) unless otherwise noted.

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# Appendix 2: Determination of the vacation periods

## A 2.1 Determination of the vacation periods for some relevant cantons

| | | | | | |
|---|---|---|---|---|---|
| Genève | *2003/04* | Primaire | | | |
| | | 2nd, Ier deg. | Mon 22.12-Fri 02.01 | Mon 16.02-Fri 20.02 | Thu 08.04-Fri 16.04 |
| | | 2nd, IIème deg. | | | |
| | *2004/05* | Primaire | | | |
| | | 2nd, Ier deg. | Mon 20.12-Fri 31.12 | Mon 07.02-Fri 11.02 | Thu 24.03-Fri 01.04 |
| | | 2nd, IIème deg. | | | |
| Vaud | *2003/04* | Primaire | | | |
| | | 2nd, Ier deg. | Wed 24.12-Fri 09.01 | Mon 23.02-Fri 27.02 | Mon 05.04-Fri 16.04 |
| | | 2nd, IIème deg. | | | |
| | *2004/05* | Primaire | | | |
| | | 2nd, Ier deg. | Fri 24.12-Fri 07.01 | Mon 14.02-Fri 18.02 | Mon 21.03-Fri 01.04 |
| | | 2nd, IIème deg. | | | |
| Haut Valais | *2003/04* | Primaire | | | |
| | | 2nd, Ier deg. | Mon 22/24.12-Fri 02.01 | Mon 16.02-Fri 05.03[1] | Thu 08/09.04-Fri 16.04 |
| | | 2nd, IIème deg. | Mon 22.12-Fri 02.01 | Mon 23.02-Fri 27.02 | Fri 09.04-Fri 16.04 |
| | *2004/05* | Primaire | | | |
| | | 2nd, Ier deg. | Fri 24.12-Wed 05.01 | Wed 02.02-Xxx 04.03[2] | Fri 25.03-Fri 01.04[3] |
| | | 2nd, IIème deg. | Fri 24.12-Mon 04.01 | Mon 31.01-Fri 04.02 | Thu 24.03-Fri 01.04 |
| Fribourg | *2003/04* | Primaire | | | |
| | | 2nd, Ier deg. | Mon 22.12-Fri 02.01 | Mon 23.02-Fri 27.02 | Mon 05.04-Fri 16.04 |
| | | 2nd, IIème deg. | | | |
| | *2004/05* | Primaire | | | |
| | | 2nd, Ier deg. | Fri 24.12-Fri 07.01 | Mon 07.02-Fri 11.02 | Mon 21.03-Fri 01.04 |
| | | 2nd, IIème deg. | | | |
| Valais romand | *2003/04* | Primaire | | | |
| | | 2nd, Ier deg. | Mon 22.12-Fri 02.01[4] | Mon 23.02- Fri 27.02[5] | Thu 08.04-Fri 16.04[6] |
| | | 2nd, IIème deg. | Mon 22.12-Fri 02.01 | Mon 23.02-Fri 27.02 | Thu 08.04-Fri 16.04 |
| | *2004/05* | Primaire | | | |
| | | 2nd, Ier deg. | Thu 23/24.12-Wed 05.01 | Mon 07.02-Fri 11.02 | Thu 24/25.03-Fri 01.04 |
| | | 2nd, IIème deg. | | | Wed 23/24.03-Fri 01.04 |

## A 2.2 Vacation periods for the Swiss cantons

EDK Schweizerische Konferenz der kantonalen Erziehungsdirektoren
CDIP Conférence suisse des directeurs cantonaux de l'instruction publique

IDES Information Dokumentation Erziehung Schweiz/Information Documentation Education Suisse, Postfach/Case postale 5975, 3001 Bern, Tel. 031-309 51 00, Fax 031-309 51 10

### Schulferien 2002 / Vacances scolaires 2002

Stand/Etat 15.5.2003

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| AG | Alle Schulen | - | 13.04.2002 - 27.04.2002 | 20.07.2002 - 11.08.2002 | 28.09.2002 - 13.10.2002 | 23.12.2002 - 04.01.2003 |
| | | Sportferien gestaffelt, wenn möglich regional koordiniert, gesamthaft 4 weitere Ferienwochen, vom Schulrat des Bezirks festgelegt | | | | |
| AI | Alle Schulen | 08.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 29.06.2002 - 11.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| AI | Oberegg | 16.02.2002 - 24.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 11.08.2002 | 28.09.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| AR | Alle Schulen | - | 29.03.2002 - 14.04.2002 | 07.07.2002 - 11.08.2002 | 06.10.2002 - 20.10.2002 | 22.12.2002 - 05.01.2003 |
| | | Sportwoche variiert; zusätzlich eine Woche individuell nach Gemeinden | | | | |
| BE | Bern Volksschule | 02.02.2002 - 10.02.2002 | 06.04.2002 - 21.04.2002 | 06.07.2002 - 11.08.2002 | 21.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| BE | Burgdorf alle Schulen | 09.02.2002 - 17.02.2002 | 29.03.2002 - 21.04.2002 | 29.06.2002 - 04.08.2002 | 14.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| BE | Thun Volksschule | 16.02.2002 - 24.02.2002 | 13.04.2002 - 28.04.2002 | 06.07.2002 - 11.08.2002 | 28.09.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| BL | Alle Schulen | 09.02.2002 - 24.02.2002 | 28.03.2002 - 07.04.2002 | 29.06.2002 - 11.08.2002 | 28.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| BL | Gymn. Laufen-Thierst. | 09.02.2002 - 17.02.2002 | 28.03.2002 - 14.04.2002 | 06.07.2002 - 11.08.2002 | 28.09.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| BS | Alle Schulen | 09.02.2002 - 23.02.2002 | 28.03.2002 - 06.04.2002 | 29.06.2002 - 10.08.2002 | 28.09.2002 - 12.10.2002 | 21.12.2002 - 04.01.2003 |
| FL | Alle Schulen | 09.02.2002 - 17.02.2002 | 28.03.2002 - 14.04.2002 | 06.07.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 06.01.2003 |
| FR | Ecoles primaires | 09.02.2002 - 17.02.2002 | 23.03.2002 - 07.04.2002 | 06.07.2002 - 21.08.2002 | 12.10.2002 - 26.10.2002 | 21.12.2002 - 05.01.2003 |
| FR | E.sec.sup.+ Gymn. | 09.02.2002 - 17.02.2002 | 23.03.2002 - 07.04.2002 | 29.06.2002 - 31.08.2002 | 12.10.2002 - 26.10.2002 | 22.12.2002 - 05.01.2003 |
| GE | Toutes les écoles | 11.02.2002 - 15.02.2002 | 28.03.2002 - 05.04.2002 | 01.07.2002 - 23.08.2002 | 14.10.2002 - 18.10.2002 | 23.12.2002 - 05.01.2003 |
| GL | Alle Schulen | 26.01.2002 - 03.02.2002 | 29.03.2002 - 14.04.2002 | 29.06.2002 - 11.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| GR | Chur Volksschule | 23.02.2002 - 03.03.2002 | 13.04.2002 - 28.04.2002 | 29.06.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| GR | Chur Maturitätsschule | 23.02.2002 - 03.03.2002 | 13.04.2002 - 29.04.2002 | 22.06.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 23.12.2002 - 05.01.2003 |
| GR | Davos Volksschule | 23.02.2002 - 03.03.2002 | 20.04.2002 - 12.05.2002 | 06.07.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| GR | Davos SAM | 23.02.2002 - 03.03.2002 | 24.04.2002 - 13.05.2002 | 06.07.2002 - 19.08.2002 | 05.10.2002 - 21.10.2002 | 21.12.2002 - 06.01.2003 |
| JU | Ecoles publiques | 11.02.2002 - 15.02.2002 | 25.03.2002 - 05.04.2002 | 08.07.2002 - 16.08.2002 | 07.10.2002 - 18.10.2002 | 23.12.2002 - 03.01.2003 |
| LU | Alle Schulen | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 18.08.2002 | 28.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| | | variiert je nach Gemeinde, Angabe für Stadt und Agglomeration | | | | |
| NE | Ecole obligatoire | 24.02.2002 - 03.03.2002 | 29.03.2002 - 12.04.2002 | 08.07.2002 - 16.08.2002 | 07.10.2002 - 18.10.2002 | 23.12.2002 - 03.01.2003 |

## Schulferien 2002 / Vacances scolaires 2002

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| NW | Volksschule | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 16.08.2002 | 28.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| NW | Gymnasium | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 29.06.2002 - 25.08.2002 | 28.09.2002 - 13.10.2002 | 21.12.2002 - 05.01.2003 |
| OW | Volksschule | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 18.08.2002 | 28.09.2002 - 13.10.2002 | 21.12.2002 - 02.01.2003 |
| OW | Engelberg Volksschule | 07.02.2002 - 12.03.2002 | 28.03.2002 - 14.04.2002 | 29.06.2002 - 11.08.2002 | 05.10.2002 - 27.10.2002 | 21.12.2002 - 02.01.2003 |
| SG | St. Gallen alle Schulen | - | 29.03.2002 - 14.04.2002 | 07.07.2002 - 11.08.2002 | 29.09.2002 - 20.10.2002 | - |
| | | Sportwoche variiert, Weihnachten in Kompetenz der Schulgemeinde | | | | |
| SH | Alle Schulen | 26.01.2002 - 09.02.2002 | 13.04.2002 - 27.04.2002 zum Teil bis 04.05.2002 | 06.07.2002 - 10.08.2002 | 28.09.2002 - 19.10.2002 | 21.12.2002 - 04.01.2003 |
| SO | Volksschule | 02.02.2002 - 17.02.2002 | 06.04.2002 - 21.04.2002 | 06.07.2002 - 11.08.2002 | 28.09.2002 - 20.10.2002 | 24.12.2002 - 05.01.2003 |
| | | variiert nach Gemeinde, viele Gemeinden richten sich aber nach der Kantonsschule, Dorneck-Thierstein eher nach Laufen | | | | |
| SO | Mittelschule | 02.02.2002 - 17.02.2002 | 06.04.2002 - 21.04.2002 | 06.07.2002 - 11.08.2002 | 28.09.2002 - 20.10.2002 | 24.12.2002 - 05.01.2003 |
| SZ | Volksschule | - | - | 06.07.2002 - | 30.09.2002 - | 23.12.2002 - |
| | | variiert nach Gemeinde, keine gemeinsamen Ferien. Ab 2002/03 Empfehlung 1. Ferientag | | | | |
| TG | Volks- u. Kant.schule | 28.01.2002 - 02.02.2002 | 29.03.2002 - 13.04.2002 | 08.07.2002 - 10.08.2002 | 07.10.2002 - 19.10.2002 | 22.12.2002 - 04.01.2003 |
| | | 12. Ferienwoche zur freien Disposition der Schulgemeinden | | | | |
| TI | Tutte le scuole | 09.02.2002 - 17.02.2002 | 29.03.2002 - 07.04.2002 | 14.06.2002 - 01.09.2002 | 26.10.2002 - 03.11.2002 | 21.12.2002 - 06.01.2003 |
| UR | Volksschule | 02.02.2002 - 12.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 06.01.2003 |
| | | Rahmenplan der Erziehungsdirektion | | | | |
| UR | Mittelschule | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 29.06.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 06.01.2003 |
| VD | Ecoles sec. sup. | 16.02.2002 - 24.02.2002 | 28.03.2002 - 07.04.2002 | 06.07.2002 - 25.08.2002 | 12.10.2002 - 27.10.2002 | 21.12.2002 - 05.01.2003 |
| | | Les établissements communaux (enseignement obligatoire) adoptent en général ce même calendrier | | | | |
| VS | Toutes les écoles | 09.02.2002 - 13.02.2002 | 27.03.2002 - 07.04.2002 | 22.06.2002 - 18.08.2002 | 12.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| | | Calendrier cantonal indicatif | | | | |
| ZG | Alle Schulen | 02.02.2002 - 17.02.2002 | 29.03.2002 - 14.04.2002 | 06.07.2002 - 18.08.2002 | 05.10.2002 - 20.10.2002 | 21.12.2002 - 05.01.2003 |
| ZH | Alle Schulen | - | 22.04.2002 - 04.05.2002 | 15.07.2002 - 17.08.2002 | 07.10.2002 - 19.10.2002 | 23.12.2002 - 04.01.2003 |
| | | Sportwoche variiert, Volksschulen: Die Gemeinden richten sich in der Regel nach obenstehenden Daten | | | | |


Für die Daten einzelner Gemeinden fragen Sie bitte beim Erziehungsdepartement des betreffenden Kantons nach.

Pour les dates des différentes communes veuillez vous adresser au Département de l'Instruction publique du canton, s.v.p.

Legende: AG = Aargau, AI = Appenzell Innerrhoden, AR = Appenzell Ausserrhoden, BE = Bern, BL = Basel- Landschaft, BS = Basel-Stadt, FR = Fribourg/Freiburg, GE = Genève, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St.Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Wallis/Valais, ZG = Zug, ZH = Zürich, FL = Fürstentum Liechtenstein

EDK Schweizerische Konferenz der kantonalen Erziehungsdirektoren
CDIP Conférence suisse des directeurs cantonaux de l'instruction publique

IDES Information Dokumentation Erziehung Schweiz/Information Documentation Education Suisse, Postfach/Case postale 5975, 3001 Bern, Tel. 031-309 51 00, Fax 031-309 51 10

## Schulferien 2003 / Vacances scolaires 2003

***provis.***
Stand 28.1.2003

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| AG | Alle Schulen | - | 12.04.2003 - 27.04.2003 | 19.07.2003 - 10.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| | | Sportferien gestaffelt, wenn möglich regional koordiniert. Gesamthaft 4 weitere Wochen, vom Schulrat des Bezirks festgelegt | | | | |
| AI | Alle Schulen | 28.02.2003 - 09.03.2003 | 05.04.2003 - 21.04.2003 | 28.06.2003 - 10.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| AI | Oberegg | 15.02.2003 - 23.02.2003 | 05.04.2003 - 21.04.2003 | 06.07.2003 - 10.08.2003 | 27.09.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| AR | Alle Schulen | - | 06.04.2003 - 21.04.2003 | 06.07.2003 - 10.08.2003 | 05.10.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| | | Sportwoche variiert; zusätzlich eine Woche individuell nach Gemeinden | | | | |
| BE | Bern Volksschule | 01.02.2003 - 09.02.2003 | 05.04.2003 - 21.04.2003 | 05.07.2003 - 10.08.2003 | 20.09.2003 - 12.10.2003 | 20.12.2003 - 04.01.2004 |
| BE | Burgdorf alle Schule | 08.02.2003 - 16.02.2003 | 29.03.2003 - 21.04.2003 | 05.07.2003 - 10.08.2003 | 27.09.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| BE | Thun Volkschule | 15.02.2003 - 23.02.2003 | 12.04.2003 - 27.04.2003 | 05.07.2003 - 10.08.2003 | 27.09.2003 - 19.10.2003 | 20.12.2003 - 04.01.2004 |
| BL | Alle Schulen | 01.03.2003 - 16.03.2003 | 17.04.2003 - 27.04.2003 | 28.06.2003 - 10.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| BL | Gymn. Laufen-Thierst. | 22.02.2003 - 09.03.2003 | 17.04.2003 - 27.04.2003 | 05.07.2003 - 10.08.2003 | 27.09.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| BS | Alle Schulen | 01.03.2003 - 15.03.2003 | 17.04.2003 - 27.04.2003 | 28.06.2003 - 10.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| FL | Alle Schulen | 01.03.2003 - 09.03.2003 | 17.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 06.01.2004 |
| FR | Ecoles primaires | 01.03.2003 - 09.03.2003 | 12.04.2003 - 27.04.2003 | 05.07.2003 - 20.08.2003 | 11.10.2003 - 26.10.2003 | 20.12.2003 - 04.01.2004 |
| FR | E.sec.sup.+ Gymn. | 01.03.2003 - 09.03.2003 | 12.04.2003 - 27.04.2003 | 05.07.2003 - 30.08.2003 | 11.10.2003 - 26.10.2003 | 20.12.2003 - 04.01.2004 |
| GE | Toutes les écoles | 17.02.2003 - 21.02.2003 | 17.04.2003 - 27.04.2003 | 30.06.2003 - 24.08.2003 | 13.10.2003 - 19.10.2003 | 20.12.2003 - 04.01.2004 |
| GL | Alle Schulen | 01.02.2003 - 09.02.2003 | 03.04.2003 - 21.04.2003 | 28.06.2003 - 10.08.2003 | 04.10.2003 - 19.10.2003 | 20.12.2003 - 04.01.2004 |
| GR | Chur Volksschule | 22.02.2003 - 02.03.2003 | 12.04.2003 - 27.04.2003 | 28.06.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 06.01.2004 |
| GR | Chur Maturitätsschule | 22.02.2003 - 02.03.2003 | 12.04.2003 - 27.04.2003 | 21.06.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 06.01.2004 |
| GR | Davos Volksschule | 22.02.2003 - 02.03.2003 | 17.04.2003 - 11.05.2003 | 05.07.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 20.12.2003 - 04.01.2004 |
| GR | Davos SAM | 22.02.2003 - 02.03.2003 | 18.04.2003 - 12.05.2003 | 05.07.2003 - 18.08.2003 | 04.10.2003 - 20.10.2003 | 20.12.2003 - 04.01.2004 |
| JU | Ecoles publiques | 10.02.2003 - 16.02.2003 | 14.04.2003 - 27.04.2003 | 07.07.2003 - 17.08.2003 | 06.10.2003 - 19.10.2003 | 22.12.2003 - 04.01.2004 |

## Schulferien 2003 / Vacances scolaires 2003

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| LU | Alle Schulen | 22.02.2003 - 09.03.2003 | 18.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| | | variiert je nach Gemeinde, Angabe für Stadt und Agglomeration | | | | |
| NE | Ecole obligatoire | 22.02.2003 - 02.03.2003 | 06.04.2003 - 21.04.2003 | 06.07.2003 - 17.08.2003 | 05.10.2003 - 19.10.2003 | 22.12.2003 - 04.01.2004 |
| NW | Volksschule | 22.02.2003 - 09.03.2003 | 18.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| NW | Gymnasium | 22.02.2003 - 09.03.2003 | 18.04.2003 - 04.05.2003 | 28.06.2003 - 24.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| OW | Volksschule | 22.02.2003 - 09.03.2003 | 18.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 27.09.2003 - 12.10.2003 | 24.12.2003 - 04.01.2004 |
| OW | Engelberg Volksschule | 27.02.2003 - 05.03.2003 | 17.04.2003 - 04.05.2003 | 28.06.2003 - 10.08.2003 | 04.10.2003 - 27.10.2003 | 24.12.2003 - 04.01.2004 |
| SG | St. Gallen Volksschule | - | 06.04.2003 - 21.04.2003 | 06.07.2003 - 10.08.2003 | 28.09.2003 - 19.10.2003 | - |
| | | Sportwoche variiert, Weihnachten in Kompetenz der Schulgemeinde | | | | |
| SH | Alle Schulen | 25.01.2003 - 08.02.2003 | 12.04.2003 - 26.04.2003 | 05.07.2003 - 09.08.2003 | 27.09.2003 - 18.10.2003 | 24.12.2003 - 03.01.2004 |
| SO | Volks- u. Mittelschule | 03.02.2003 - 15.02.2003 | 07.04.2003 - 21.04.2003 | 07.07.2003 - 10.08.2003 | 29.09.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| | | Volksschule: Die Sport- und Frühlingsferien können je nach Gemeinde variieren | | | | |
| SZ | Volksschule | 24.02.2003 - | 28.04.2003 - | 07.07.2003 - | 29.09.2003 - | 22.12.2003 - |
| | | Empfehlung immer 1. Ferientag im ganzen Kanton gemeinsam. Die Dauer bestimmt der Schulträger | | | | |
| TG | Volks- u. Kant.schule | 27.01.2003 - 01.02.2003 | 07.04.2003 - 21.04.2003 | 07.07.2003 - 09.08.2003 | 06.10.2003 - 18.10.2003 | 24.12.2003 - 03.01.2004 |
| | | 12. Ferienwoche zur freien Disposition der Schulgemeinden | | | | |
| TI | Tutte le scuole | 01.03.2003 - 09.03.2003 | 18.04.2003 - 27.04.2003 | 19.06.2003 - 01.09.2003 | 25.10.2003 - 02.11.2003 | 20.12.2003 - 06.01.2004 |
| | | | Scuole arti e mestieri e d'arte applicata: 28.06.2003 | | | |
| UR | Volksschule | 22.02.2003 - 04.03.2003 | 18.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 06.01.2004 |
| | | kantonaler Rahmenplan | | | | |
| UR | Mittelschule | 22.02.2003 - 09.03.2003 | 18.04.2003 - 04.05.2003 | 28.06.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 06.01.2004 |
| VD | Toutes les écoles | 22.02.2003 - 02.03.2003 | 12.04.2003 - 27.04.2003 | 05.07.2003 - 24.08.2003 | 11.10.2003 - 26.10.2003 | 24.12.2003 - 11.01.2004 |
| | | Quelques communes bénéficieront encore d'exceptions pour l'école primaire | | | | |
| VS | Oberwallis | 22.02.2003 - 04.03.2003 | 18.04.2003 - 27.04.2003 | 19.06.2003 - 20.08.2003 | 15.10.2003 - 26.10.2003 | 20.12.2003 - 04.01.2004 |
| | | | | variiert: 19.6.-28.6. | | |
| VS | Valais romand | 01.03.2003 - 09.03.2003 | 18.04.2003 - 27.04.2003 | 19.06.2003 - 20.08.2003 | 15.10.2003 - 26.10.2003 | 20.12.2003 - 04.01.2004 |
| | | | | varie selon la comm.: 19.6.-28.6. | | |
| ZG | Alle Schulen | 01.02.2003 - 16.02.2003 | 18.04.2003 - 04.05.2003 | 05.07.2003 - 17.08.2003 | 04.10.2003 - 19.10.2003 | 24.12.2003 - 04.01.2004 |
| ZH | Alle Schulen | - | 22.04.2003 - 03.05.2003 | 14.07.2003 - 16.08.2003 | 06.10.2003 - 18.10.2003 | 22.12.2003 - 03.01.2004 |
| | | Sportwoche variiert Ende Januar bis Mitte März, Volksschulen: Die Gemeinden richten sich in der Regel nach obenstehenden Daten | | | | |



Legende: AG = Aargau, AI = Appenzell Innerrhoden, AR = Appenzell Ausserrhoden, BE = Bern, BL = Basel- Landschaft, BS = Basel-Stadt, FR = Fribourg/Freiburg, GE = Genève, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St.Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Wallis/Valais, ZG = Zug, ZH = Zürich, FL = Fürstentum Liechtenstein

EDK Schweizerische Konferenz der kantonalen Erziehungsdirektoren
CDIP Conférence suisse des directeurs cantonaux de l'instruction publique

IDES Information Dokumentation Erziehung Schweiz/Information Documentation Education Suisse, Postfach/Case postale 5975, 3001 Bern, Tel. 031-309 51 00, Fax 031-309 51 10

## Schulferien 2004 / Vacances scolaires 2004

Stand/Etat 29.11.2004

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| **AG** | Alle Schulen | - | 08.04.2004 - 25.04.2004 | 12.07.2004 - 08.08.2004 | 27.09.2004 - 10.10.2004 | 18.12.2004 - 02.01.2005 |
| | | Ferien der einzelnen Gemeinden sind unter www.ag.ch/Volksschule –>Ferienpläne. | | | | |
| **AI** | Alle Schulen | 20.02.2004 - 29.02.2004 | 03.04.2004 - 18.04.2004 | 03.07.2004 - 15.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| **AI** | Oberegg | 07.02.2004 - 15.02.2004 | 03.04.2004 - 18.04.2004 | 10.07.2004 - 15.08.2004 | 25.09.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| **AR** | Alle Schulen | - | 04.04.2004 - 18.04.2004 | 04.07.2004 - 08.08.2004 | 03.10.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| | | Sportwoche variiert; zusätzlich eine Woche individuell nach Gemeinden | | | | |
| **BE** | Bern Volksschule | 31.01.2004 - 08.02.2004 | 03.04.2004 - 18.04.2004 | 03.07.2004 - 08.08.2004 | 18.09.2004 - 10.10.2004 | 18.12.2004 - 02.01.2005 |
| | | Schulferien einzelner Gemeinden bitte bei betreffender Gemeindeverwaltung nachfragen | | | | |
| **BE** | Biel Volksschule | 07.02.2004 - 15.02.2004 | 03.04.2004 - 18.04.2004 | 03.07.2004 - 15.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 09.01.2005 |
| **BE** | Burgdorf alle Schulen | 07.02.2004 - 15.02.2004 | 27.03.2004 - 18.04.2004 | 03.07.2004 - 08.08.2004 | 25.09.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| **BE** | Thun Volksschule | 14.02.2004 - 22.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 08.08.2004 | 25.09.2004 - 17.10.2004 | 25.12.2004 - 09.01.2005 |
| | | | | KG bis 6. Klasse 26.06. - 08.08. | | |
| **BL** | Alle Schulen | 21.02.2004 - 07.03.2004 | 08.04.2004 - 18.04.2004 | 26.06.2004 - 08.08.2004 | 25.09.2004 - 10.10.2004 | 24.12.2004 - 02.01.2005 |
| **BL** | Gymn. Laufen-Thierst. | 21.02.2004 - 29.02.2004 | 08.04.2004 - 25.04.2004 | 03.07.2004 - 08.08.2004 | 25.09.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| **BS** | Alle Schulen | 21.02.2004 - 06.03.2004 | 08.04.2004 - 17.04.2004 | 26.06.2004 - 07.08.2004 | 25.09.2004 - 09.10.2004 | 23.12.2004 - 01.01.2005 |
| **FL** | Alle Schule | 21.02.2004 - 29.02.2004 | 08.04.2004 - 25.04.2004 | 03.07.2004 - 16.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 09.01.2005 |
| **FR** | E.sec.sup.+ Gymn. | 23.02.2004 - 29.02.2004 | 05.04.2004 - 18.04.2004 | 05.07.2004 - 29.08.2004 | 18.10.2004 - 01.11.2004 | 24.12.2004 - 05.01.2005 |
| **FR** | Ecoles primaires (ville) | 21.02.2004 - 29.02.2004 | 03.04.2004 - 18.04.2004 | 03.07.2004 - 25.08.2004 | 16.10.2004 - 01.11.2004 | 24.12.2004 - 09.01.2005 |
| **GE** | Toutes les écoles | 14.02.2004 - 22.02.2004 | 08.04.2004 - 18.04.2004 | 26.06.2004 - 22.08.2004 | 11.10.2004 - 15.10.2004 | 20.12.2004 - 31.12.2004 |
| **GL** | Alle Schulen | 31.01.2004 - 08.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 15.08.2004 | 09.10.2004 - 24.10.2004 | 23.12.2004 - 05.01.2005 |
| **GR** | Chur alle Schulen | 21.02.2004 - 28.02.2004 | 10.04.2004 - 24.04.2004 | 26.06.2004 - 14.08.2004 | 02.10.2004 - 16.10.2004 | 23.12.2004 - 05.01.2005 |
| **GR** | Davos alle Schulen | 28.02.2004 - 07.03.2004 | 24.04.2004 - 16.05.2004 | 03.07.2004 - 15.08.2004 | 09.10.2004 - 24.10.2004 | 23.12.2004 - 05.01.2005 |
| **JU** | Ecoles publiques | 09.02.2004 - 13.02.2004 | 05.04.2004 - 16.04.2004 | 05.07.2004 - 13.08.2004 | 04.10.2004 - 15.10.2004 | 24.12.2004 - 07.01.2005 |
| **LU** | Alle Schulen | 14.02.2004 - 29.02.2004 | 09.04.2004 - 25.04.2004 | 10.07.2004 - 22.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| | | variiert je nach Gemeinde, Angabe für Stadt und Agglomeration | | | | |
| **NE** | Ecole obligatoire | 01.03.2004 - 07.03.2004 | 05.04.2004 - 18.04.2004 | 05.07.2004 - 15.08.2004 | 04.10.2004 - 17.10.2004 | 24.12.2004 - 09.01.2005 |
| **NW** | Gymnasium | 14.02.2004 - 29.02.2004 | 09.04.2004 - 25.04.2004 | 26.06.2004 - 22.08.2004 | 25.09.2004 - 10.10.2004 | 24.12.2004 - 02.01.2005 |

## Schulferien 2004 / Vacances scolaires 2004

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| **NW** | Volksschule | 14.02.2004 - 29.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 15.08.2004 | 25.09.2004 - 10.10.2004 | 24.12.2004 - 02.01.2005 |
| **OW** | Engelberg Volksschule | 19.02.2004 - 22.02.2004 | 08.04.2004 - 25.04.2004 | 25.06.2004 - 08.08.2004 | 02.10.2004 - 24.10.2004 | 23.12.2004 - 02.01.2005 |
| **OW** | Volksschule | 14.02.2004 - 29.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 15.08.2004 | 25.09.2004 - 10.10.2004 | 24.12.2004 - 02.01.2005 |
| **SG** | St. Gallen alle Schulen | - | 04.04.2004 - 18.04.2004 | 04.07.2004 - 08.08.2004 | 26.09.2004 - 17.10.2004 | - |
| | | Sportwoche variiert, Weihnachten in Kompetenz der Schulgemeinde | | | | |
| **SH** | Alle Schulen | 24.01.2004 - 08.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 08.08.2004 | 25.09.2004 - 17.10.2004<br>Hallau: 02.10. - 23.10. | 24.12.2004 - 02.01.2005 |
| **SO** | Volks- und Mittelschule | 31.01.2004 - 15.02.2004 | 09.04.2004 - 25.04.2004 | 10.07.2004 - 15.08.2004 | 04.10.2004 - 23.10.2004 | 24.12.2004 - 01.01.2005 |
| | | Sport- und Frühlingsferien in der Volksschule variieren je nach Gemeinde | | | | |
| **SZ** | Volksschule | 22.02.2004 - | 25.04.2004 - | 04.07.2004 - | 26.09.2004 - | 19.12.2004 - |
| | | Ferienbeginn im ganzen Kanton gemeinsam. Die Dauer bestimmt der Schulträger | | | | |
| **TG** | Volks- u. Kant.schule | 26.01.2004 - 30.01.2004 | 29.03.2004 - 12.04.2004 | 05.07.2004 - 06.08.2004 | 04.10.2004 - 15.10.2004 | 24.12.2004 - 02.01.2005 |
| | | 12. Ferienwoche zur freien Disposition der Schulgemeinden | | | | |
| **TI** | Tutte le scuole | 21.02.2004 - 29.02.2004 | 09.04.2004 - 18.04.2004 | 19.06.2004 - 01.09.2004 | 30.10.2004 - 07.11.2004 | 24.12.2004 - 09.01.2005 |
| | | | | Esami finali delle scuole postobligatorie a partire dal 21 giugno | | |
| **UR** | Alle Schulen | 14.02.2004 - 24.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 15.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 09.01.2005 |
| | | variiert nach Gemeinde, Rahmenplan des Erziehungsrates | | | | |
| **VD** | Toutes les écoles | 21.02.2004 - 29.02.2004 | 03.04.2004 - 18.04.2004 | 03.07.2004 - 22.08.2004 | 09.10.2004 - 24.10.2004 | 24.12.2004 - 08.01.2005<br>12 h 00 |
| | | Quelques communes bénéficieront encore d'exceptions pour l'école primaire jusqu'aux vacances d'été | | | | |
| **VS** | Toutes les écoles | 20.02.2004 - 28.02.2004 | 07.04.2004 - 18.04.2004 | 25.06.2004 - 22.08.2004 | 12.10.2004 - 24.10.2004 | 22.12.2004 - 05.01.2005 |
| | | Sportwoche variiert im deutschsprachigen Wallis, Angabe für das französischsprachige Wallis | | | | |
| **ZG** | Alle Schulen | 31.01.2004 - 15.02.2004 | 09.04.2004 - 25.04.2004 | 03.07.2004 - 15.08.2004 | 02.10.2004 - 17.10.2004 | 24.12.2004 - 02.01.2005 |
| **ZH** | Alle Schulen | 09.02.2004 - 20.02.2004 | 08.04.2004 - 25.04.2004 | 12.07.2004 - 15.08.2004 | 04.10.2004 - 17.10.2004 | 24.12.2004 - 09.01.2004 |
| | | Sportwoche variiert, Volksschulen: Die Gemeinden richten sich in der Regel nach obenstehenden Daten | | | | |



Legende: AG = Aargau, AI = Appenzell Innerrhoden, AR = Appenzell Ausserrhoden, BE = Bern, BL = Basel- Landschaft, BS = Basel-Stadt, FR = Fribourg/Freiburg, GE = Genève, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St.Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Wallis/Valais, ZG = Zug, ZH = Zürich, FL = Fürstentum Liechtenstein

EDK Schweizerische Konferenz der kantonalen Erziehungsdirektoren
CDIP Conférence suisse des directeurs cantonaux de l'instruction publique

IDES Information Dokumentation Erziehung Schweiz/Information Documentation Education Suisse, Postfach/Case postale 5975, 3001 Bern, Tel. 031-309 51 00, Fax 031-309 51 10

## Schulferien 2005 / Vacances scolaires 2005

Stand/Etat 16.1.2006

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| **AG** | Alle Schulen | - | 08.04.2005 - 24.04.2005 | 09.07.2005 - 08.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 08.01.2006 |
| | | Sportwoche variiert; Ferien der einzelnen Gemeinden sind unter www.ag.ch/Volksschule –>Ferienpläne. | | | | |
| **AI** | Alle Schulen | 04.02.2005 - 13.02.2005 | 25.03.2005 - 10.04.2005 | 02.07.2005 - 15.08.2005 | 08.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| **AI** | Oberegg | 12.02.2005 - 20.02.2005 | 25.03.2005 - 10.04.2005 | 09.07.2005 - 15.08.2005 | 01.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| **AR** | Alle Schulen | - | 25.03.2005 - 10.04.2005 | 10.07.2005 - 14.08.2005 | 09.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| | | Sportwoche variiert; zusätzlich eine Woche individuell nach Gemeinden | | | | |
| **BE** | Bern Volksschule | 05.02.2005 - 13.02.2005 | 09.04.2005 - 24.04.2005 | 02.07.2005 - 14.08.2005 | 24.09.2005 - 16.10.2005 | 24.12.2005 - 08.01.2006 |
| **BE** | Biel Volksschule | 12.02.2005 - 20.02.2005 | 02.04.2005 - 17.04.2005 | 02.07.2005 - 14.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 08.01.2006 |
| **BE** | Burgdorf alle Schulen | 12.02.2005 - 20.02.2005 | 25.03.2005 - 17.04.2005 | 02.07.2005 - 07.08.2005 | 24.09.2005 - 16.10.2005 | 24.12.2005 - 03.01.2006 |
| **BE** | Thun Volkschule | 18.02.2005 - 26.02.2005 | 08.04.2005 - 23.04.2005 | 08.07.2005 - 13.08.2005 | 30.09.2005 - 22.10.2005 | 23.12.2005 - 08.01.2006 |
| **BL** | Alle Schulen | 05.02.2005 - 20.02.2005 | 24.03.2005 - 03.04.2005 | 02.07.2005 - 14.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |
| **BL** | Gymn. Laufen-Thierst. | 05.02.2005 - 20.02.2005 | 24.03.2005 - 03.04.2005 | 09.07.2005 - 14.08.2005 | 24.09.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |
| **BS** | Alle Schulen | 05.02.2005 - 19.02.2005 | 24.03.2005 - 02.04.2005 | 02.07.2005 - 13.08.2005 | 01.10.2005 - 15.10.2005 | 24.12.2005 - 02.01.2006 |
| **FL** | Alle Schulen | 05.02.2005 - 13.02.2005 | 24.03.2005 - 10.04.2005 | 02.07.2005 - 16.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 08.01.2006 |
| **FR** | Ecoles primaires (ville) | 07.02.2005 - 11.02.2005 | 21.03.2005 - 01.04.2005 | 11.07.2005 - 24.08.2005 | 17.10.2005 - 28.10.2005 | 26.12.2005 - 06.01.2006 |
| | | Vacances scolaires jusqu'en juillet 2010 sur le site www.fr.ch/dip | | | | |
| **FR** | Ecoles sec. II | 07.02.2005 - 11.02.2005 | 21.03.2005 - 01.04.2005 | 04.07.2005 - 26.08.2005 | 17.10.2005 - 28.10.2005 | 26.12.2005 - 06.01.2006 |
| | | Vacances scolaires jusqu'en juillet 2010 sur le site www.fr.ch/dip | | | | |
| **GE** | Toutes les écoles | 05.02.2005 - 13.02.2005 | 24.03.2005 - 03.04.2005 | 02.07.2005 - 28.08.2005 | 15.10.2005 - 23.10.2005 | 24.12.2005 - 08.01.2006 |
| **GL** | Alle Schulen | 29.01.2005 - 06.02.2005 | 08.04.2005 - 24.04.2005 | 02.07.2005 - 14.08.2005 | 08.10.2005 - 23.10.2005 | 22.12.2005 - 04.01.2006 |
| **GR** | Chur Maturitätsschule | 26.02.2005 - 06.03.2005 | 16.04.2005 - 30.04.2005 | 25.06.2005 - 21.08.2005 | 08.10.2005 - 23.10.2005 | 22.12.2005 - 04.01.2006 |
| **GR** | Chur Volksschule | 26.02.2005 - 06.03.2005 | 16.04.2005 - 30.04.2005 | 25.06.2005 - 21.08.2005 | 08.10.2005 - 23.10.2005 | 22.12.2005 - 04.01.2006 |
| **GR** | Davos SAM | 26.02.2005 - 06.03.2005 | 23.04.2005 - 16.05.2005 | 02.07.2005 - 14.08.2005 | 08.10.2005 - 23.10.2005 | 23.12.2005 - 08.01.2006 |
| **GR** | Davos Volksschule | 26.02.2005 - 06.03.2005 | 23.04.2005 - 16.05.2005 | 02.07.2005 - 14.08.2005 | 01.10.2005 - 23.10.2005 | 24.12.2005 - 08.01.2006 |
| **JU** | Ecoles publiques | 14.02.2005 - 20.02.2005 | 21.03.2005 - 03.04.2005 | 04.07.2005 - 15.08.2005 | 03.10.2005 - 16.10.2005 | 26.12.2005 - 08.01.2006 |
| **LU** | Alle Schulen | 29.01.2005 - 13.02.2005 | 25.03.2005 - 10.04.2005 | 09.07.2005 - 21.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |
| | | variiert je nach Gemeinde, Angabe für Stadt und Agglomeration | | | | |
| **NE** | Ecole obligatoire | 28.02.2005 - 06.03.2005 | 25.03.2005 - 10.04.2005 | 04.07.2005 - 14.08.2005 | 03.10.2005 - 16.10.2005 | 25.12.2005 - 08.01.2006 |
| **NW** | Gymnasium | 29.01.2005 - 13.02.2005 | 25.03.2005 - 10.04.2005 | 02.07.2005 - 28.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |

## Schulferien 2005 / Vacances scolaires 2005

| | | Sport | Frühling/Printemps | Sommer/Eté | Herbst/Automne | Weihnachten/Noël |
|---|---|---|---|---|---|---|
| **NW** | Volksschule | 29.01.2005 - 13.02.2005 | 25.03.2005 - 10.04.2005 | 09.07.2005 - 21.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |
| **OW** | Engelberg Volksschule | 03.02.2005 - 08.02.2005 | 24.03.2005 - 10.04.2005 | 01.07.2005 - 15.08.2005 | 01.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| **OW** | Volksschule | 29.01.2005 - 13.02.2005 | 25.03.2005 - 10.04.2005 | 09.07.2005 - 21.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 02.01.2006 |
| **SG** | St. Gallen alle Schulen | - | 25.03.2005 - 10.04.2005 | 10.07.2005 - 14.08.2005 | 02.10.2005 - 23.10.2005 | - |
| | | Sportwoche variiert, Weihnachten in Kompetenz der Schulgemeinde | | | | |
| **SH** | Alle Schulen | 29.01.2005 - 12.02.2005 | 16.04.2005 - 30.04.2005 | 09.07.2005 - 13.08.2005 | 01.10.2005 - 22.10.2005 | 24.12.2005 - 02.01.2006 |
| **SO** | Volks- und Mittelschule | 05.02.2005 - 20.02.2005 | 09.04.2005 - 24.04.2005 | 09.07.2005 - 15.08.2005 | 01.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| | | Sport- und Frühlingsferien in der Volksschule variieren je nach Gemeinde | | | | |
| **SZ** | Volksschule | 28.02.2005 - | 02.05.2005 - | 11.07.2005 - | 03.10.2005 - | 24.12.2005 - |
| | | Immer 1. Ferientag im ganzen Kanton gemeinsam. Die Dauer bestimmt der Schulträger | | | | |
| **TG** | alle Schulen | 31.01.2005 - 04.02.2005 | 25.03.2005 - 08.04.2005 | 11.07.2005 - 12.08.2005 | 10.10.2005 - 21.10.2005 | 24.12.2005 - 02.01.2006 |
| | | 12. Ferienwoche zur freien Disposition der Schulgemeinden | | | | |
| **TI** | Tutte le scuole | 05.02.2005 - 13.02.2005 | 25.03.2005 - 03.04.2005 | 18.06.2005 - 31.08.2005 | 29.10.2005 - 06.11.2005 | 24.12.2005 - 08.01.2006 |
| **UR** | alle Schulen | 29.01.2005 - 08.02.2005 | 25.03.2005 - 10.04.2005 | 02.07.2005 - 15.08.2005 | 01.10.2005 - 16.10.2005 | 24.12.2005 - 08.01.2006 |
| | | variiert nach Gemeinde, Rahmenplan des Erziehungsrates | | | | |
| **VD** | Toutes les écoles | 12.02.2005 - 20.02.2005 | 19.03.2005 - 03.04.2005 | 02.07.2005 - 21.08.2005 | 08.10.2005 - 23.10.2005 | 24.12.2005 - 09.01.2006 |
| | | Quelques communes bénéficieront encore d'exceptions pour l'école primaire | | | | |
| **VS** | Oberwallis | 04.02.2005 - 13.02.2005 | 23.03.2005 - 03.04.2005 | 24.06.2005 - 17.08.2005 | 08.10.2005 - 23.10.2005 | 24.12.2005 - 04.01.2006 |
| **VS** | romand | 04.02.2005 - 13.02.2005 | 23.03.2005 - 03.04.2005 | 24.06.2005 - 22.08.2005 | 22.10.2005 - 02.11.2005 | 24.12.2005 - 08.01.2006 |
| **ZG** | Alle Schulen | 05.02.2005 - 20.02.2005 | 25.03.2005 - 10.04.2005 | 09.07.2005 - 21.08.2005 | 08.10.2005 - 23.10.2005 | 24.12.2005 - 02.01.2006 |
| **ZH** | Mittelschulen | 14.02.2005 - 27.02.2005 | 25.04.2005 - 08.05.2005 | 18.07.2005 - 21.08.2005 | 10.10.2005 - 22.10.2005 | 24.12.2005 - 08.01.2006 |
| | | Volksschulen: Die Gemeinden richten sich in der Regel nach obenstehenden Daten | | | | |
| **ZH** | Winterthur | 07.02.2005 - 20.02.2005 | 25.04.2005 - 08.05.2005 | 18.07.2005 - 21.08.2005 | 10.10.2005 - 22.10.2005 | 24.12.2005 - 08.01.2006 |



Legende: AG = Aargau, AI = Appenzell Innerrhoden, AR = Appenzell Ausserrhoden, BE = Bern, BL = Basel- Landschaft, BS = Basel-Stadt, FR = Fribourg/Freiburg, GE = Genève, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St.Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Wallis/Valais, ZG = Zug, ZH = Zürich, FL = Fürstentum Liechtenstein

# Appendix 3: Determination of the activity peaks

| Cantons/Regions | *Swiss Customers' regions* | *Years* | Christmas[1] | February | Easter |
|---|---|---|---|---|---|
| Vaud | VD + GE | *2003/04* | 20.12-23.12 ; 27.12-11.01 | 14.02-29.02 | 03.04-18.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 05.02-20.02 | 19.03-03.04 |
| Fribourg | VD + FR | *2003/04* | 20.12-23.12 ; 27.12-11.01 | 21.02-29.02 | 03.04-18.04 |
| | | *2004/05* | 27.12-09.01 | 05.02-20.02 | 19.03-03.04 |
| Bas-Valais | VD + GE +bVS | *2003/04* | 20.12-23.12 ; 27.12-11.01 | 14.02-29.02 | 03.04-18.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 05.02-20.02 | 19.03-03.04 |
| Haut-Valais | VD+BE +hVS | *2003/04* | 20.12-23.12 ; 27.12-11.01 | 31.01-07.03 | 27.03-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 29.01-06.03 | 19.03-24.04 |
| Berner Oberland | BE, BL/BS, AG, SO | *2003/04* | 20.12-23.12 ; 27.12-04.01 | 31.01-07.03 | 03.04-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 05.02-27.02 | 24.03-24.04 |
| Surselva (Oberland) | GR, ZH, AG, BE | *2003/04* | 20.12-23.12 ; 27.12-06.01 | 07.02-07.03 | 25.03-16.05 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 12.02-06.03[2] | 25.03-08.05 |
| Davos/ Samnaun valley | GR, ZH, AG, SG | *2003/04* | 20.12-23.12 ; 27.12-06.01 | 07.02-07.03 | 03.04-16.05 |
| | | *2004/05* | 27.12-09.01 | 12.02-06.03[3] | 25.03-16.05 |
| Engadine | GR, ZH, LU, SZ, NW, OW | *2003/04* | 20.12-23.12 ; 27.12-06.01 | 07.02-07.03 | 08.04-16.05 |
| | | *2004/05* | 27.12-09.01 | 29.01-06.03 | 25.03-16.05 |
| Albula | ZH,SG, TG,TI | *2003/04* | 20.12-23.12 ; 27.12-06.01 | 07.02-07.03 | 27.03-16.05 |
| | | *2004/05* | 27.12-09.01 | 29.01-06.03 | 25.03-10.04 ; 16.04-16.05 |
| Toggenburg | ZH,AG, SG,TG | *2003/04* | 20.12-23.12 ; 27.12-04.01 | 24.01-22.02 | 27.03-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 29.01-20.02 | 25.03-08.05 |
| Flumserberg | ZH,AG, SG,ZG | *2003/04* | 20.12-23.12 ; 27.12-04.01 | 31.01-22.02 | 03.04-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 05.02-20.02 | 25.03-08.05 |
| Nidwald | AG, BL/BS, NW | *2003/04* | 27.12-04.01 | 14.02-07.03 | 08.04-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-02.01 | 29.01-20.02 | 24.03-24.04 |
| Schwyz | ZH,AG,SZ | *2003/04* | 20.12-23.12 ; 27.12-04.01 | 07.02-29.02 | 08.04-25.04 |
| | | *2004/05* | 18.12-23.12 ; 27.12-09.01 | 29.01-06.03 | 25.03-08.05 |

***Table A 3.1*** *- For thirteen Swiss regions, table A 3.1 presents the cantons from which originate the majority of their Swiss customers as well as their activity peaks for the winter seasons 2003/04 and 2004/05.*

[1] December 24, 25 and 26 are not taken into account.

[2] This is equivalent to three weeks. This is interesting to note that this length is described in the activity reports of some companies as a detrimental factor affecting their financial results. Indeed, the length of the vacations taking place in February 2004 (i.e. one year before) was four rather than three weeks.

[3] Idem as footnote 2.

# Appendix 4: Statistical models

## A 4.1 The classical linear regression model

### A 4.1.1 Model assumptions

The classical linear regression model is based on a set of assumptions that are described in several textbooks. In this subsection, we mainly follow Hayashi (2000) which provides a careful and thorough discussion of the model. Prior to present the assumptions, it is worth noting that both the dependent ***and*** the explanatory variables (also called regressors) are treated as random variables. The model is based on four assumptions (Hayashi 2000, p. 3-14):

(a) Linearity

$$y_i = \mathbf{x}_i^T \boldsymbol{\beta} + \varepsilon_i \quad \text{(i = 1, 2, ..., n)} \quad \text{(A 4.1)}$$

Where $\mathbf{x}_i$ is the (KX1) vector of regressors, $\boldsymbol{\beta}$ the (KX1) vector of unknown coefficients and $\varepsilon_i$ is the unobservable error term.

In matrix notation, the model is rewritten as:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \quad \text{(A 4.2)}$$

Where $\mathbf{y}$, $\boldsymbol{\varepsilon}$ are (nX1) vectors and $\mathbf{X}$ is a (nXK) matrix.

(b) Strict exogeneity

$$E(\varepsilon_i | \mathbf{X}) = 0 \quad \text{(i = 1, 2, ..., n)} \quad \text{(A 4.3)}$$

Which implies:

$$E(\varepsilon_i) = 0 \quad \text{(i = 1, 2, ..., n)} \quad \text{(A 4.4)}$$

$$\text{cov}(x_{jk}, \varepsilon_i) = 0 \quad \text{(i ,j= 1, 2, ..., n; k= 1, 2, ..., K)} \quad \text{(A 4.5)}$$

(c) No multicollinearity

The rank of the (nXK) data matrix X, is K with probability 1.

(d) Spherical error variance

*Conditional homoskedasticity*

$$E\left(\varepsilon_i^2 \middle| \mathbf{X}\right) = \sigma^2 > 0 \quad \text{(i = 1, 2, …, n)} \quad \text{(A 4.6)}$$

*Uncorrelated error terms*

$$E\left(\varepsilon_i \varepsilon_j \middle| \mathbf{X}\right) = 0 \quad \text{(i,j = 1, 2, …, n; i≠j)} \quad \text{(A 4.7)}$$

If $\{y_i; \mathbf{x_i}\}$ is independently and identically distributed (i.e. if the sample (**y**, **X**) is a random sample) then the strict exogeneity and the spherical error variance assumptions are restated as:

$$E\left(\varepsilon_i \middle| \mathbf{x_i}\right) = 0 \quad \text{(i = 1, 2, …, n)} \quad \text{(A 4.8)}$$

$$E\left(\varepsilon_i^2 \middle| \mathbf{x_i}\right) = \sigma^2 > 0 \quad \text{(i = 1, 2, …, n)} \quad \text{(A 4.9)}$$

**A 4.1.2 Formula and properties of the OLS estimators**

The OLS estimators of β and σ are the following:

$$\boldsymbol{\beta}^{\mathbf{OLS}} = \left(\mathbf{X}^{\mathrm{T}}\mathbf{X}\right)^{-1}\mathbf{X}^{\mathrm{T}}\mathbf{y} \quad \text{(A 4.10)}$$

$$\sigma_{OLS}^2 = \frac{(\mathbf{y} - \mathbf{X}\boldsymbol{\beta}^{\mathbf{OLS}})^{\mathrm{T}}(\mathbf{y} - \mathbf{X}\boldsymbol{\beta}^{\mathbf{OLS}})}{n - K} = \frac{\mathbf{SSR}}{n - K} \quad \text{(A 4.11)}$$

Where **SSR** is the abbreviation for the residual sum of squares.

Next, we present the finite-sample properties of the OLS estimators under the assumptions of the classical linear regression model:

(*i*) Unbiasedness

$$E\left(\boldsymbol{\beta}^{\mathbf{OLS}} \middle| \mathbf{X}\right) = \boldsymbol{\beta} \quad \text{(A 4.12)}$$

$$E\left(\sigma^2_{OLS}\middle|\mathbf{X}\right)=\sigma^2 \quad \text{(A 4.13)}$$

Which implies:

$$E\left(\boldsymbol{\beta}^{\mathbf{OLS}}\right)=\boldsymbol{\beta} \quad \text{(A 4.14)}$$

$$E\left(\sigma^2_{OLS}\right)=\sigma^2 \quad \text{(A 4.15)}$$

(*ii*) Expression for the variance

$$\mathrm{var}\left(\boldsymbol{\beta}^{\mathbf{OLS}}\middle|\mathbf{X}\right)=\sigma^2\left(\mathbf{X}^T\mathbf{X}\right)^{-1} \quad \text{(A 4.16)}$$

A natural estimate of this conditional variance is given by:

$$\mathrm{var}\left(\boldsymbol{\beta}^{\mathbf{OLS}}\middle|\mathbf{X}\right)\approx\sigma^2_{OLS}\left(\mathbf{X}^T\mathbf{X}\right)^{-1} \quad \text{(A 4.17)}$$

In particular, the standard error of the OLS estimate of $\beta_k$ is equal to:

$$SE(\beta_k^{OLS})=\sqrt{\sigma^2_{OLS}\left(\left(\mathbf{X}^T\mathbf{X}\right)^{-1}\right)_{kk}} \quad \text{(A 4.18)}$$

(*iii*) Efficiency

$\beta^{OLS}$ is efficient in the class of linear unbiased estimators (Gauss-Markov theorem). It is called the Best Linear Unbiased Estimator (BLUE).

(*iv*) Uncorrelated with the residuals

$$\mathrm{cov}\left(\boldsymbol{\beta}^{\mathbf{OLS}},\mathbf{e}\middle|\mathbf{X}\right)=\mathbf{0} \quad \text{(A 4.19)}$$

**A 4.1.3 Inference procedures in the classical linear regression model**

A distributional assumption is required to derive the finite-sample distribution of the OLS estimator. More precisely, the error term is considered to follow a normal distribution. This gives rise to a fifth assumption that can be stated as follow:

(e) normality of the error term

$$\boldsymbol{\varepsilon}\middle|\mathbf{X}\sim N\left(\mathbf{0},\sigma^2\mathbf{I_n}\right) \quad \text{(A 4.20)}$$

Which implies the fact that **ε** and **X** are independent.

Using all the five assumptions, we can now derive the distribution of the OLS estimator from which standard inference procedures are based:

$$\boldsymbol{\beta}^{\mathbf{OLS}} \left| \mathbf{X} \sim N\left(\boldsymbol{\beta}, \sigma^2 \left(\mathbf{X}^{\mathbf{T}}\mathbf{X}\right)^{-1}\right)\right. \quad \text{(A 4.21)}$$

With this result, we can either test hypothesis about individual regression coefficients or construct confidence interval using the statistic of the t-ratio (or t-value). Under the null hypothesis $H_0$: $\beta_k = \overline{\beta}_k$ , the t-ratio is written as:

$$t_k = \frac{\beta_k^{OLS} - \overline{\beta}_k}{SE(\beta_k^{OLS})} \quad \text{(A 4.22)}$$

Where $t_k$ is distributed as t(n-K) (the t-distribution with n-K degrees of freedom).

The next equation gives the formula for a (1-α) confidence interval:

$$\beta_k^{OLS} \pm SE(\beta_k^{OLS}) t_{\alpha/2}(n-K) \quad \text{(A 4.23)}$$

**A 4.1.4 Generalized and weighted least squares**

This subsection deals with situations in which the spherical error variance assumption no longer holds. Without this assumption, the OLS estimator is not BLUE anymore. In order to derive the BLUE, we need first to make some weaker assumptions on the second moments of the error terms. Considering the conditional variance matrix of the error terms to be nonsingular is a much weaker assumption than the spherical error variance assumption. In this case, the conditional matrix of second moments can be written as:

$$\operatorname{var}(\boldsymbol{\varepsilon}|\mathbf{X}) = E(\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}^T|\mathbf{X}) = \sigma^2 V(\mathbf{X}) \quad \text{(A 4.24)}$$

Where V(**X**) is a nonsingular matrix and $\sigma^2$ is a positive scalar.

In general, each element of the (nXn) matrix V(**X**) is a nonlinear function of **X**. Given that V(**X**) is known, the generalized least squares (GLS) estimator is efficient. Expressions for the estimator and its variance are given in the following two equations:

$$\boldsymbol{\beta}^{\mathbf{GLS}} = \left(\mathbf{X}^{\mathbf{T}} V(\mathbf{X})^{-1} \mathbf{X}\right)^{-1} \mathbf{X}^{\mathbf{T}} V(\mathbf{X})^{-1} \mathbf{y} \quad \text{(A 4.25)}$$

$$\operatorname{var}\left(\boldsymbol{\beta}^{\mathbf{GLS}} \middle| \mathbf{X}\right) = \sigma^2 \left(\mathbf{X}^T \mathbf{V}(\mathbf{X})^{-1} \mathbf{X}\right)^{-1} \quad \text{(A 4.26)}$$

The standard error of the GLS estimate of $\beta_k$ is computed using the GLS estimate of $\sigma^2$:

$$\sigma^2_{GLS} = \frac{(\mathbf{y} - \mathbf{X}\boldsymbol{\beta}^{\mathbf{GLS}})^{\mathbf{T}} \mathbf{V}(\mathbf{X})^{-1} (\mathbf{y} - \mathbf{X}\boldsymbol{\beta}^{\mathbf{GLS}})}{n - K} \quad \text{(A 4.27)}$$

If there is no correlation in the error term between observations, the matrix V(**X**) is diagonal and the GLS estimator becomes the weighted least square (WLS) estimator. The WLS estimator is therefore efficient when the error is conditionally heteroskedastic and when there is no correlation in the error terms.

Computation of both GLS and WLS estimators requires knowledge of the matrix V(**X**) that is to say knowledge of each of the nonlinear functions from which depend the elements of V(**X**). However, the required information is smaller for WLS than for GLS since only n functions must be known in the former case to compute the estimator. In addition, if the sample (**y**, **X**) is a random sample, then only one function depending only on K variables need to be known in order to compute the WLS estimator. We will note this function v($\mathbf{x}_i$).

## A 4.2 Properties of the OLS estimator in large sample

In this subsection, we will still consider the explanatory variables as random variables. However, we will now assume we have available a random sample from the population. The first aim of this subsection is to derive the large sample properties of the OLS estimator under a set of assumptions different from those of the classical linear regression model. These properties are very interesting since the OLS estimator shows to be both consistent and asymptotically normally distributed. The interest of these large sample results lies in the fact that the assumptions under which these good large sample properties are derived suit well many empirical situations faced in economics. Indeed, strict exogeneity of the regressors and normality of the error terms are no longer required. The material of this subsection is mainly taken from Wooldridge (2001).

### A 4.2.1 Model assumptions

The fact to deal with a random sample from the population simplifies the notation of the assumptions because we do not have to care anymore about the indexes i and j. Actually, the indexes i and j are no longer required whenever we are dealing with population moments. As in the previous subsection, we continue to include an intercept in the model (its coefficient is $\beta_1$).

(a) Linearity

Same linearity assumption as in the classical linear regression model.

(b) Predetermined regressors

$$E(\mathbf{x}\varepsilon) = \mathbf{0} \quad \text{(A 4.28)}$$

Which implies the two following properties of the error term:

$$E(\varepsilon) = 0 \quad \text{(A 4.29)}$$

$$\text{cov}(x_k, \varepsilon) = 0 \quad \text{(k= 1, 2, ..., K)} \quad \text{(A 4.30)}$$

(c) Rank condition

$$\text{rank } E(\mathbf{x}\mathbf{x}^{\mathrm{T}}) = K \quad \text{(A 4.31)}$$

**A 4.2.2 Asymptotic properties of the OLS estimators**

We now present the large sample properties of the OLS estimators of β and $\sigma^2$ under the assumptions of the previous subsection:

(*i*) Consistency

$$plim_{n\to\infty} \boldsymbol{\beta}^{\mathbf{OLS}} = \boldsymbol{\beta} \quad \text{(A 4.32)}$$

$$plim_{n\to\infty} \sigma^2_{OLS} = \sigma^2 \quad \text{(A 4.33)}$$

(ii) Asymptotic normality of the OLS estimator

$$\sqrt{n}\left(\boldsymbol{\beta}^{\mathbf{OLS}} - \boldsymbol{\beta}\right) \underset{d}{\rightarrow} N\left(\mathbf{0}, \left[E(\mathbf{x}\mathbf{x}^{\mathrm{T}})\right]^{-1} E(\varepsilon^2 \mathbf{x}\mathbf{x}^{\mathrm{T}}) \left[E(\mathbf{x}\mathbf{x}^{\mathrm{T}})\right]^{-1}\right) \text{ as } n \rightarrow \infty \quad \text{(A 4.34)}$$

This means that the asymptotic variance of the OLS estimate of **β** is equal to:

$$A\,\text{var}\left(\boldsymbol{\beta}^{\mathbf{OLS}}\right) = \frac{1}{N}\left[E(\mathbf{x}\mathbf{x}^{\mathrm{T}})\right]^{-1} E(\varepsilon^2 \mathbf{x}\mathbf{x}^{\mathrm{T}}) \left[E(\mathbf{x}\mathbf{x}^{\mathrm{T}})\right]^{-1} \quad \text{(A 4.35)}$$

Under conditional homoskedasticity (i.e. $E\left(\varepsilon^2 \middle| \mathbf{x}\right) = \sigma^2$), the asymptotic variance simplifies to:

$$A\,\text{var}\left(\boldsymbol{\beta}^{\mathbf{OLS}}\right) = \frac{1}{N}\sigma^2\left[E(\mathbf{x}\mathbf{x}^{\mathrm{T}})\right]^{-1} \quad \text{(A 4.36)}$$

**A 4.2.3 Inference procedures**

In large sample, equation (A 4.34) allows us to treat the OLS estimate of **β** as approximately normal with mean **β** and variance given in equation (A 4.35) or (A 4.36). Equation (A 4.36) gives the asymptotic variance of the OLS estimator under the conditional homoskedasticity assumption. Estimate of this variance is the same as the usual OLS variance matrix estimator derived for the classical linear regression model. Supposing we have available a random sample and that the regressors are predetermined, this result therefore shows that the usual OLS standard errors, t statistics, and F statistics are asymptotically valid under conditional homoskedasticity.

If there is some arbitrary heteroskedasticity, two solutions are conceivable. On the one hand, we can try to compute the WLS estimator. As emphasised in subsection A 4.1.1.4, this requires to specify and estimate a model for the function v(**x**$_i$). Taking into account the relative precision of the observations in the computation of the estimator of **β** allows gaining efficiency. However, efficiency gains from WLS estimator are guaranteed only if the model for V(**x**$_i$) is correctly specified. Moreover, it is not guaranteed that the WLS estimator is consistent with predetermined regressors. A more easy way to cope with heteroskedasticity is therefore to adjust the standard errors so that they are valid in the presence of arbitrary heteroskedasticity. This sums up to find the estimate of the variance given in equation (A 4.35). The heteroskedasticity-robust variance matrix estimator of the OLS estimate of **β** is:

$$A\,\mathrm{var}\left(\boldsymbol{\beta}^{\mathbf{OLS}}\right) \approx \left(\mathbf{X}^{\mathbf{T}}\mathbf{X}\right)^{-1}\left(\sum_{i=1}^{N}\left(y_i - \mathbf{x}_i^T\boldsymbol{\beta}^{\mathbf{OLS}}\right)^2 \mathbf{x}_i\mathbf{x}_i^T\right)\left(\mathbf{X}^{\mathbf{T}}\mathbf{X}\right)^{-1} \quad \text{(A 4.37)}$$

The square roots of the diagonal elements of equation (A 4.37) are often called the White standard errors or heteroskedasticity-robust standard errors. We can use these standard errors to compute the t statistics and the confidence intervals in the usual way.

## A 4.3 The general instrumental variables regression model

Instrumental variables (IV) regression is a general way to obtain a consistent estimator of the unknown coefficients of the population regression function when some of the regressors are correlated with the error term (i.e. some of the regressors are endogenous). As explained in the previous subsection, OLS gives an inconsistent estimator whenever one of the regressor is correlated with the error term. Consistency is a nice feature of an estimator since it ensures that the latter will be close to the true value of the regression coefficients when the sample becomes large. The idea of IV regression is to make use of some particular variables that have special statistical properties. These variables are called instrumental variables or instruments and they allow pinning down some exogenous variation in the endogenous variables. The material of this subsection is directly inspired from the book by Stock and Watson (2003).

The general IV regression model is determined by rewriting equation (A 4.1) with a new notation that allows distinguishing the endogenous from the exogenous variables.

$$y_i = \mathbf{x}_\mathbf{i}^\mathbf{T}\boldsymbol{\beta}_1 + \mathbf{w}_\mathbf{i}^\mathbf{T}\boldsymbol{\beta}_2 + \varepsilon_i \quad \text{(i = 1, 2, ..., n)} \quad \text{(A 4.38)}$$

Where **x**$_i$ is the (HX1) vector of included endogenous regressors and **w**$_i$ is the (RX1) vector of included exogenous regressors. In the same way, $\boldsymbol{\beta}_1$ is a (HX1) vector of unknown coefficients and $\boldsymbol{\beta}_2$ is a (RX1) vector of unknown coefficients.

In the general IV regression model, the K initial explanatory variables are split in H endogenous variables and R exogenous variables. These R exogenous variables are sometimes called the included instruments. In the following, we will however keep the term instrument for the exogenous variables which do not enter equation (A 4.38) and which are sometimes referred to in the literature as the excluded instruments. The vector of instruments is noted $\mathbf{z}_i$ which is a (MX1) vector. For IV regression to be possible, there must be at least as many instruments as endogenous regressors. As a matter of fact, the following terminology has been developed:

- If M=H, the regression coefficients are said to be exactly identified.
- If M>H, the coefficients are overidentified.

The key to successful empirical analysis using IV regression is to find valid instruments. Valid instrument refer both to a notion of relevance and exogeneity. These characteristics will be treated in turn (Stock and Watson 2003, p.):

- Instrument relevance: For i=1,…,n, let $\hat{\mathbf{x}}_\mathbf{i}$ be the predicted values of $\mathbf{x}_i$ from the population regression of the exogenous regressors on the instruments and the included exogenous regressors, and let “1” denote a regressor that takes on the value “1” for all observations (its coefficient is the intercept). Then $\left(\hat{x}_{i1},...,\hat{x}_{iH},w_{i1},...,w_{iR},1\right)$ are not perfectly multicollinear.
- Instrument exogeneity: The instruments are uncorrelated with the error term, that is, $corr(z_{1i},\varepsilon_i)=0,\ldots,corr(z_{mi},\varepsilon_i)=0,\ldots, corr(z_{Mii}, \varepsilon_i)=0$.

It is possible to estimate the coefficients of the population regression function using an IV estimator called two stage least squares (TSLS). As emphasized by its name, the TSLS estimator is computed in two stages:

- Regression of each of the endogenous regressors on all of the instruments and all of the included exogenous regressors is carried out first. Therefore, each endogenous regressor requires its own first-stage regression. Using OLS, these first-stage regressions produce predicted values of each of the endogenous regressors.
- Equation (A 4.38) is then estimated by OLS after having replaced $\mathbf{x}_i$ by the predicted values $\hat{\mathbf{x}}_i$ computed in the first stage.

Along with other hypothesis, the relevance and exogeneity of the instruments insure that the TSLS estimator is consistent and has a sampling distribution that, in large samples, is approximately normal. Under these assumptions, statistical inference could therefore be carried out using standard procedures (e.g. t-statistic for hypothesis tests). To be a little bit more precise, the role of instrument relevance is twofold with regards to the TSLS estimator. As emphasized in Stock and Watson (2003 p. 349-352), instrument relevance plays a role akin to the sample size. On the one hand, the effect of an increase in the relevance of the instruments is similar to an increase in the sample size: the more the instruments furnish information by explaining the (exogenous) variation in the included endogenous variables (i.e. the more the instruments are relevant) and the more the estimator is accurate. On the other hand, for the normal distribution to provide a good approximation to the sampling distribution of the TSLS estimator in large sample, the instruments should also be highly relevant. Instruments that do not satisfy this condition are called weak instruments. What if one or more instruments are not exogenous? In this case, the TSLS estimator is inconsistent. Besides insights provided by knowledge of the empirical problem at hand, exogeneity of the instruments can be checked by the mean of a statistical test. Actually, this test is available only when the coefficients are overidentified. Accordingly, the test is called the overidentifiying restrictions test (or the J-statistic). It tests the null hypothesis that the vector containing all the instruments (i.e. included and excluded instruments) is orthogonal to the error term.

## A 4.4 The generalized method of moments

The IV estimator presented in the previous subsection is a special case of a Generalized Method of Moments (GMM) estimator. The notion of moment conditions is central to GMM estimators. It arises when explicitly writing the assumption that some variables are exogenous. Taking the notation from the previous subsection, we have R+M orthogonality conditions that will be satisfied at the true value of **β**:

$$E(\mathbf{d}\varepsilon) = E\left(\mathbf{d}\left(y - \mathbf{x}^{\mathbf{T}}\boldsymbol{\beta}\right)\right) = E(\mathbf{g}(\boldsymbol{\beta})) = \mathbf{0} \quad \text{(A 4.39)}$$

Where:

$\mathbf{d}^T=(\mathbf{w}^T,\mathbf{z}^T)$

**d** is (R+M)X1 and **g(β)** is (R+M)X1.

Each of the R+M moments corresponds to a sample moment:

$$\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}}) = \frac{1}{n}\sum_{i=1}^{n}\mathbf{g}_i(\hat{\boldsymbol{\beta}}) = \frac{1}{n}\sum_{i=1}^{n}\mathbf{d}_i\left(y_i - \mathbf{x}_i^T\hat{\boldsymbol{\beta}}\right) = \frac{1}{n}\mathbf{D}^{\mathbf{T}}(\mathbf{y} - \mathbf{X}\hat{\boldsymbol{\beta}}) \quad \text{(A 4.40)}$$

Where:

$\mathbf{D}^T=[\mathbf{d}_1\ \mathbf{d}_2 \ldots \mathbf{d}_n]$ is a (R+M)Xn matrix.

GMM estimator is the estimator of **β** that solves $\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}}) = \mathbf{0}$. In fact, equation A 4.40 is a system of R+M equations with K unknowns. If the number of excluded instruments M is equal to the number of included endogenous variables H then R+M will be equal to K and $\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}}) = \mathbf{0}$ will have a unique solution. In this case, GMM and IV estimators are the same. However, if the number of excluded instruments M is greater than the number of included endogenous variables H then R+M will be greater than K and $\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}}) = \mathbf{0}$ will not have a unique solution. When R+M is greater than K, a GMM estimator for **β** is the estimator of **β** that minimizes the following objective function:

$$J(\hat{\boldsymbol{\beta}}) = n\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}})^{\mathbf{T}}\mathbf{W}\overline{\mathbf{g}}(\hat{\boldsymbol{\beta}}) \quad \text{(A 4.41)}$$

Where:

**W** is an arbitrary (R+M)X(R+M) weighting matrix.

Given an arbitrary weighting matrix **W**, formulas for the GMM estimator and its asymptotic variance-covariance matrix are the following:

$$\boldsymbol{\beta}^{\mathbf{GMM}} = \left(\mathbf{X}^{\mathbf{T}}\mathbf{DWD}^{\mathbf{T}}\mathbf{X}\right)^{-1}\mathbf{X}^{\mathbf{T}}\mathbf{DWD}^{\mathbf{T}}\mathbf{y} \quad \text{(A 4.42)}$$

$$A\,\mathrm{var}(\boldsymbol{\beta}^{\mathbf{GMM}}) = \frac{1}{n}\left(\mathbf{Q}_{\mathbf{XZ}}^{\mathbf{T}}\mathbf{W}\mathbf{Q}_{\mathbf{XZ}}\right)^{-1}\left(\mathbf{Q}_{\mathbf{XZ}}^{\mathbf{T}}\mathbf{WSW}\mathbf{Q}_{\mathbf{XZ}}\right)\left(\mathbf{Q}_{\mathbf{XZ}}^{\mathbf{T}}\mathbf{W}\mathbf{Q}_{\mathbf{XZ}}\right)^{-1} \quad \text{(A 4.43)}$$

Where:

$$\mathbf{S} = \frac{1}{n}E(\mathbf{D}^{\mathbf{T}}\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}^{\mathbf{T}}\mathbf{D}) \quad \text{(A 4.44)}$$

$$\mathbf{Q}_{\mathbf{XZ}} = E(\mathbf{xd}^{\mathbf{T}}) \quad \text{(A 4.45)}$$

The efficient GMM estimator is the GMM estimator with an optimal weighting matrix. An optimal weighting matrix is a matrix which minimizes the asymptotic variance written in equation A 4.43. The optimal weighting matrix is given by the following equality:

$$\mathbf{W} = \mathbf{S}^{-1} \quad \text{(A 4.46)}$$

Therefore, formulas for the efficient GMM estimator are obtained by replacing **W** by $\mathbf{S}^{-1}$ in equations A 4.42 and A 4.43. TSLS estimator is a special case of the GMM estimator since it can be derived from A 4.42 using a particular weighting matrix. Under conditional homoskedasticity, this particular weighting matrix is optimal and the efficient GMM estimator becomes the TSLS estimator. If conditional homoskedasticity does not hold, the TSLS estimator is not efficient and is different from the efficient GMM estimator.

Along with other hypothesis, the orthogonality conditions presented in A 4.39 insure that GMM estimators are consistent and have a sampling distribution that, in large samples, is approximately normal. Hypothesis testing can therefore be carried out using the standard inference procedures. It is also possible to test the orthogonality conditions in the GMM context by using the Hansen's test of overidentifying restrictions.

## A 4.5 Bibliography

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# Appendix 5: Classical linear regression model

## A 5.1 Descriptive statistics and analysis of the scatterplot matrix

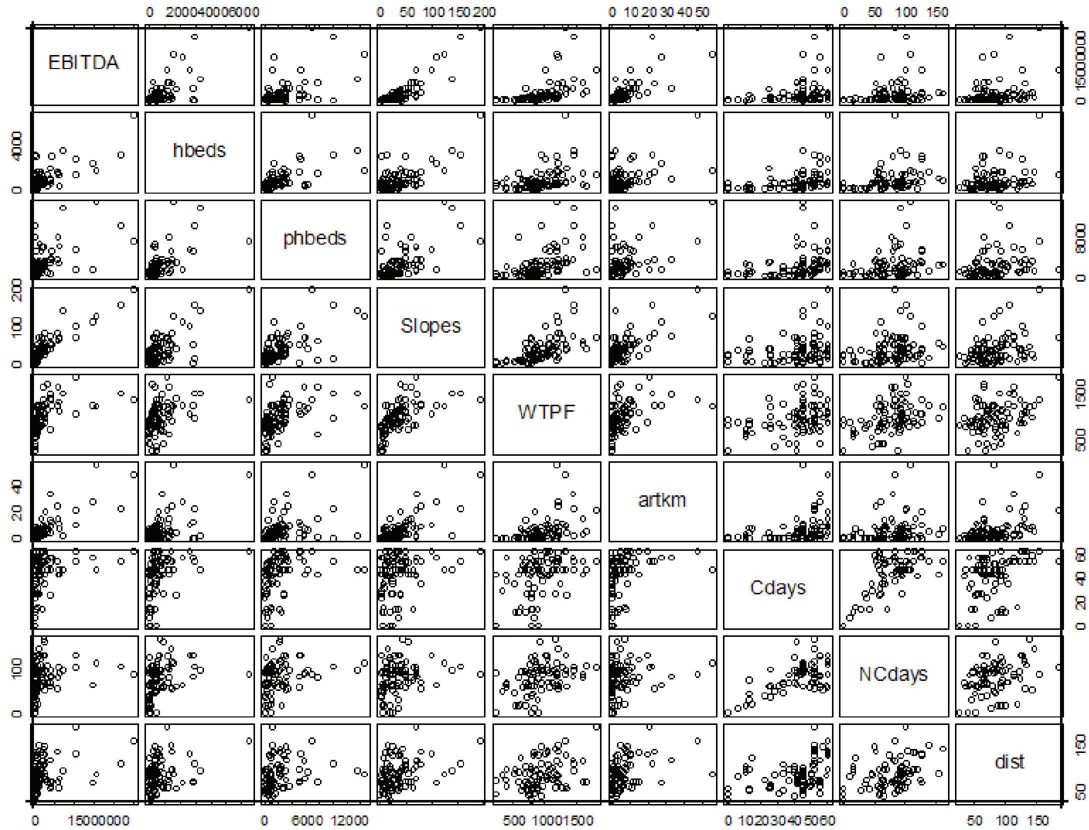



***Figure A 5.1*** *- Scatterplot matrix of the data.*

In *figure A 5.1*, we note the presence of an apparently unusual point in several frames in the scatterplot matrix. This point relates to a very high number of beds in the hotel industry. It corresponds to the case of Zermatt. No error was done when copying the value from the FSO database to our data set. Therefore, we decided not to delete this case from our sample.

As regards the values of the EBITDA contained in our sample, they have the following features: the average EBITDA is equal to 2.5 Mio CHF whereas the median is only equal to 0.96 Mio CHF. Values of the EBITDA are heavily spread out since the interquartile range is equal to 2.375 Mio CHF (the standard deviation is equal to 4.4 Mio CHF). The sample minimum is equal to -0.29 Mio CHF while the sample maximum is equal to 25 Mio CHF. In all, four cases display a negative EBITDA. Note also that the upper tail of the EBITDA distribution is fat: the standardized sample skewness is equal to 3.22 meaning that the data are skewed to the right. The next table presents the same elements for the continuous explanatory variables introduced in *figure A 5.1* and for the variable Altm:

| **Variables** | **Location** | | **Scale** | | | | **Shape** |
|---|---|---|---|---|---|---|---|
| | **Average** | **Median** | **Sample minimum** | **Sample maximum** | **Sample standard deviation** | **Interquartile range** | **Standardized sample skewness**[1] |
| WTPF (persons/hour) | 954 | 911 | 235 | 1835 | 319 | 409.5 | 0.21 |
| Slopes (km) | 38 | 30 | 1 | 195 | 35 | 36 | 1.99 |
| hbeds | 768 | 478 | 0 | 6512 | 968 | 731 | 3.07 |
| phbeds | 2444 | 1373 | 62 | 14692 | 2852 | 2341.5 | 2.20 |
| Cdays[2] | 44 | 46 | 6 | 61 | 14 | 13 | -1.00 |
| NCdays[3] | 81 | 85 | 10 | 164 | 31 | 36.5 | -0.02 |
| artkm (km) | 6 | 3 | 0 | 56 | 10 | 7.8 | 2.92 |
| dist (min) | 85 | 83 | 28 | 187 | 31 | 41.5 | 0.68 |
| Altm (m) | 2293 | 2270 | 1040 | 3900 | 558 | 750 | 0.11 |

***Table A 5.1*** *- Statistics related to three basic features of any distribution (location, scale and shape) are given for a set of nine continuous variables.*

Information contained both in *figure A 5.1* and *table A 5.1* suggest transforming some of the above variables. The scatterplot matrix with the transformed variables is shown below:

[1] We will quote Davison (2003, p.18) in order to explain how to interpret the standardized sample skewness (noted as $g_1$ by Davison): "If the data are perfectly symmetric, $g_1=0$, while if they have a heavy upper tail, $g_1>0$, and conversely".

[2] The statistics displayed on this row are based on a sample of 84 rather than 87 companies. This is due to the fact that data on the availability of natural snow were lacking for three companies.

[3] Idem as footnote 1.

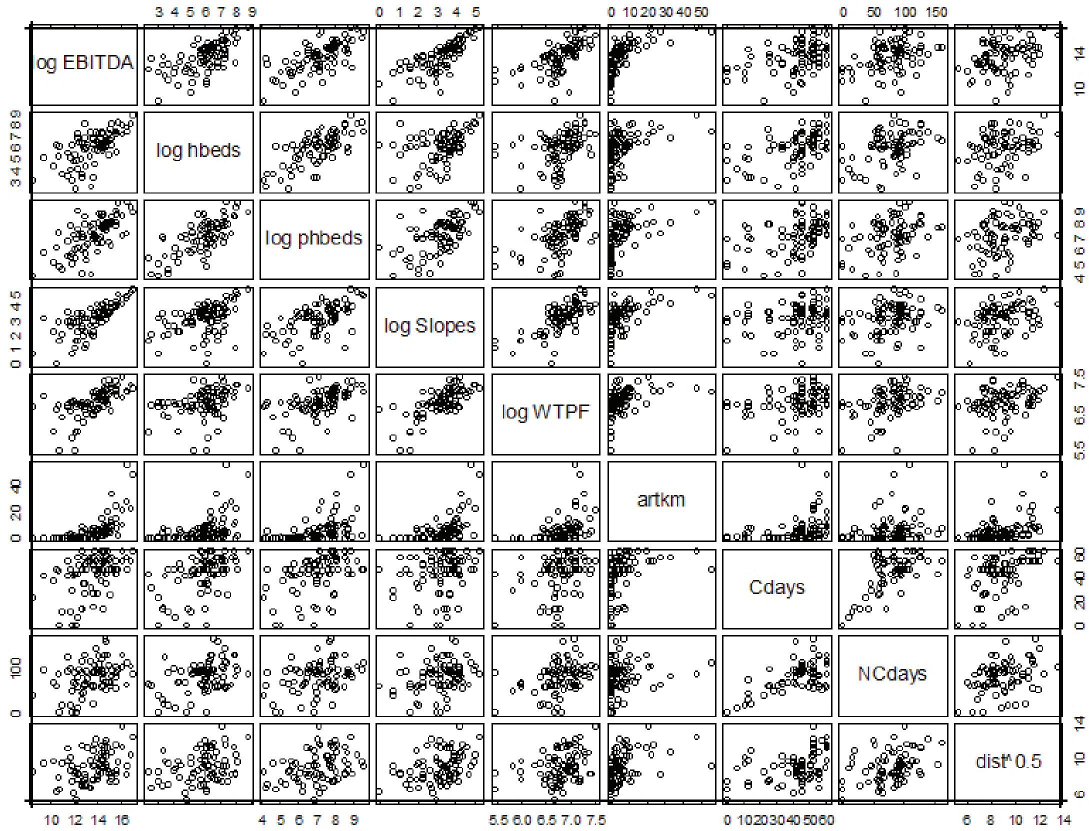



***Figure A 5.2*** *- Scatterplot matrix for the transformed dependent and independent variables.*

When implying transformed variables, we note that the points of the 2D plots of predictors are more evenly spread out and that the relationships between predictors appear to be more nearly linear. The marginal response plots are all nearly linear (except when the predictor is artkm which is not transformed). Looking at the three marginal response plots log EBITDA versus log hbeds, log Slopes and log WTPF, we can see that the variance is not constant. This is a strong hint that the variance will not be constant for the full regression model. Moreover, the variance for the full regression model is expected to decrease motivating us to define some weights: $w_j$=log($Slopes_j$) and to use WLS. In doing so, one case is ignored in the fitting since it has Slopes=1km. We also note that we have deleted four more cases from our data set thereby not appearing in the frames of the scatterplot matrix. Because we transform the dependent variable with the natural logarithm, we were forced to eliminate the four cases for which the EBITDA was negative. Eventually, *table A 5.2* presents the sample correlation coefficients for the new set of continuous explanatory variables.

| | loghbeds | logphbeds | logSlopes | logWTPF | artkm | artkm$^2$ | Cdays | NCdays | dist$^{0.5}$ | Altm |
|---|---|---|---|---|---|---|---|---|---|---|
| loghbeds | 1 | - | - | - | - | - | - | - | - | - |
| logphbeds | 0.723 | 1 | - | - | - | - | - | - | - | - |
| logSlopes | 0.485 | 0.640 | 1 | - | - | - | - | - | - | - |
| logWTPF | 0.370 | 0.534 | 0.712 | 1 | - | - | - | - | - | - |
| artkm | 0.449 | 0.468 | 0.548 | 0.419 | 1 | - | - | - | - | - |
| artkm$^2$ | 0.300 | 0.349 | 0.399 | 0.257 | 0.917 | 1 | - | - | - | - |
| Cdays | 0.495 | 0.374 | 0.227 | 0.293 | 0.334 | 0.201 | 1 | - | - | - |
| NCdays | 0.369 | 0.261 | 0.332 | 0.331 | 0.176 | 0.110 | 0.589 | 1 | - | - |
| dist$^{0.5}$ | 0.289 | 0.337 | 0.380 | 0.319 | 0.399 | 0.248 | 0.347 | 0.328 | 1 | - |
| Altm | 0.485 | 0.612 | 0.694 | 0.439 | 0.467 | 0.341 | 0.388 | 0.463 | 0.669 | 1 |

***Table A 5.2*** *- Sample correlation coefficients for the new set of continuous explanatory variables. The sample is constituted of 80 rather than 83 companies when computing the sample correlation coefficients associated to Cdays and NCdays.*

## A 5.2 Estimation and inference

Estimation of the full model using WLS gives the following results:

*Model 1*

```
Coefficients:
              Value Std. Error t value Pr(>|t|)
(Intercept)  4.1965  2.4768     1.6943  0.0949
log(Slopes)  0.4519  0.2103     2.1489  0.0353
 log(hbeds)  0.2620  0.1143     2.2917  0.0251
log(phbeds)  0.2191  0.1294     1.6932  0.0951
  log(WTPF)  0.6320  0.4219     1.4981  0.1388
      artkm  0.1197  0.0299     4.0060  0.0002
 I(artkm^2) -0.0017  0.0005    -3.1820  0.0022
      dist1 -0.3287  0.2578    -1.2751  0.2067
      dist2 -0.4762  0.2871    -1.6588  0.1018
      Cdays -0.0035  0.0103    -0.3416  0.7337
     NCdays  0.0040  0.0043     0.9417  0.3498
      grant  0.5328  0.4372     1.2187  0.2272
Residual standard error: 1.453 on 67 degrees of freedom
Multiple R-Squared: 0.7817
```

We first concentrate on the variables concerned with the amount of natural snow available to the companies (Cdays and NCdays). Within the normal linear model, we make the further hypothesis that Cdays and NCdays don't influence the mean function (i.e. no effect on log EBITDA of Cdays and NCdays after allowing for the effect of the other explanatory variables). Under these hypothesis, the $F$ statistic follows a $F_{p-q,n-p}$ distribution. In our case, $F$= 0.511 and when we compare it to the value $F_{2,67}(0.95)$ = 3.134, we find that the model without Cdays and NCdays is adequate. We note also that the model with Tdays (=Cdays + NCdays) replacing Cdays and NCdays does not change this conclusion. Finally, Cdays and NCdays are also removed when using backward elimination as a device for model selection.

Without the natural snow variables, the estimations are as follow:

*Model 2*

```
Coefficients:
               Value Std. Error t value Pr(>|t|)
(Intercept)  4.1302  2.3677     1.7444  0.0854
log(Slopes)  0.4680  0.1876     2.4941  0.0149
 log(hbeds)  0.2996  0.1050     2.8526  0.0057
log(phbeds)  0.2102  0.1247     1.6853  0.0963
  log(WTPF)  0.6356  0.3970     1.6010  0.1138
      artkm  0.1200  0.0281     4.2773  0.0001
 I(artkm^2) -0.0018  0.0005    -3.4005  0.0011
      dist1 -0.3409  0.2457    -1.3877  0.1695
      dist2 -0.4393  0.2604    -1.6869  0.0960
      grant  0.2940  0.3606     0.8154  0.4176
Residual standard error: 1.423 on 72 degrees of freedom
Multiple R-Squared: 0.7873
```

As a next step, we decide to eliminate the variable grant from our model.

*Model 3*

```
Coefficients:
               Value Std. Error t value Pr(>|t|)
(Intercept)  4.5561  2.3040     1.9775  0.0518
log(Slopes)  0.4907  0.1851     2.6512  0.0098
 log(hbeds)  0.2966  0.1047     2.8322  0.0060
log(phbeds)  0.1970  0.1234     1.5967  0.1146
  log(WTPF)  0.5798  0.3902     1.4860  0.1416
      artkm  0.1270  0.0266     4.7675  0.0000
 I(artkm^2) -0.0019  0.0005    -3.8112  0.0003
      dist1 -0.3834  0.2395    -1.6006  0.1138
      dist2 -0.4772  0.2557    -1.8664  0.0660
Residual standard error: 1.42 on 73 degrees of freedom
Multiple R-Squared: 0.7853
```

This is the model found by using different automated processes of model selection. A natural step is now to analyse the fit of this last model by looking at the residuals but also at the leverage and the influence of the cases. *Figure A 5.3* presents these elements.

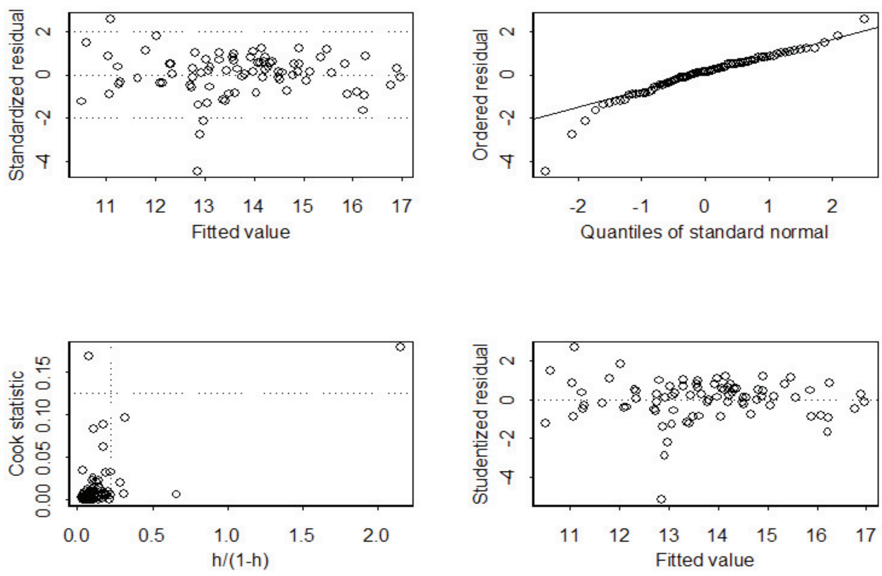



***Figure A 5.3*** *- Diagnostic plots of model 3.*

The lower left panel shows that there are two cases with a large influence on the least square estimates and also one case with a high leverage but a low influence. The other graphs shed into light a case with a high (absolute) value of the residual. *Figure A 5.4* aims at defining the cases that deserve closer inspection.

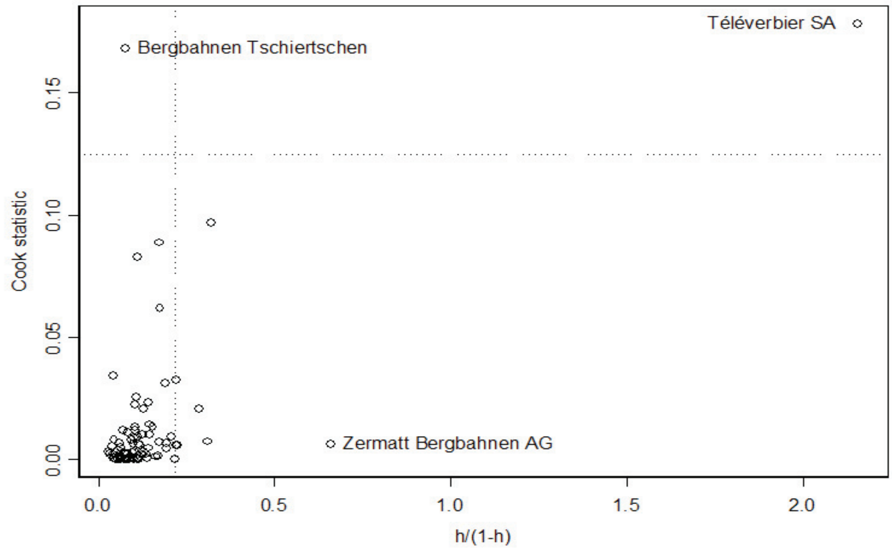



***Figure A 5.4*** *- Plot of the cook statistic versus h/(1-h) for 82 cases.*

The case Téléverbier SA is highly influential because of its high leverage and not because it is an outlier. Therefore, we consider this case to be very informative and we decide not to delete it because a high leverage in itself is not a sufficient reason for deletion (Davison 2003, p. 393-396). The case Zermatt also displays a rather high leverage. We note that the companies with the highest leverage are among the biggest companies of our sample in terms of generated EBITDA. In this sense, it is a clue for the following of the statistical analysis that we should try to concentrate our analysis on companies that are more similar in order to approximately equalize the cases' leverage. The case of the "Bergbahnen Tschiertschen" is different since the leverage is low but the influence is high. This is due to the fact that this case is an outlier. In fact, "Bergbahnen Tschiertschen" is the case with the highest (absolute) value of the residual in *figure A 5.3* (e.g. in the upper left panel of *figure A 5.3*). After having scrutinized the data, it appears that the value of the EBITDA is suspiciously small for such a company whether indicating a mistake in the data provided by the SBS or a particularly disastrous financial situation and/or some particularities in the way the EBITDA was reported. Whatever the reason for this small value of EBITDA, we decide to delete the case from our sample. This decision does not alter significantly the results obtain in the first steps (i.e. elimination of Cdays, NCdays and grant from our model). We reassess now our last model without the deleted case:

*Model 4*

```
Coefficients:
              Value Std. Error t value Pr(>|t|)
(Intercept)  3.4673  1.9917     1.7409  0.0860
log(Slopes)  0.5079  0.1592     3.1912  0.0021
 log(hbeds)  0.3151  0.0901     3.4970  0.0008
log(phbeds)  0.1091  0.1074     1.0156  0.3132
  log(WTPF)  0.8252  0.3387     2.4362  0.0173
      artkm  0.1122  0.0231     4.8610  0.0000
 I(artkm^2) -0.0016  0.0004    -3.7930  0.0003
      dist1 -0.4130  0.2060    -2.0050  0.0487
      dist2 -0.5023  0.2198    -2.2850  0.0253
Residual standard error: 1.22 on 72 degrees of freedom
Multiple R-Squared: 0.8258
```

The diagnostic plots for the new regression do not give rise to new commentaries. The striking element of the last regression is the fact that the coefficient of the variable log(phbeds) is not significantly different from zero. This seems to indicate that the inaccuracy of the phbeds variable may be very serious even if the value is given by the FSO. As mentioned in the main body of the text, phbeds gives the value of the beds available in different kinds of accommodation: rented holiday houses and apartments, youth hostels and group accommodations (without the beds in the mountain huts). For the rented holiday houses and apartments, the inaccuracy may become serious and come from different sources. First, there is no clear definition of what is a rented holiday house and apartment and therefore very different kinds of beds can be put together in the phbeds variable. In particular, the notion of rented holiday house and apartment does depend neither on the period nor on the duration during which the holiday house or apartment is rented. Another point is that this statistic totally or partially includes Bed and Breakfast establishments in some communes and does not include this kind of lodging in others communes. Also, the value for the phbeds variable is based on the tourism statistics for the tourist year 2002/03 (i.e. running from November 2002 to October 2003) whereas our financial data mainly concern the winter season 2003/04. This is a problem since the number of rented beds in the "holiday houses and apartments" has the reputation to be variable from one year to the other. Even more problematic is the fact that there are some doubts about the reliability of the data given by the FSO for the tourist year 2002/03. For instance, the value of the rented beds in the holiday houses and apartments for the valaisan communes are generally the same that those available in the “Inventaire final du Tourisme 2000”. On the contrary, no serious measurement errors are really expected with the number of beds in the youth hostels and in the group accommodations. Indeed, it is not to fear that this value changes a lot from one year to the other. Moreover, these beds are much more homogenous than those described as rented in the holiday houses and apartments (i.e. they are professional beds which are rented during the holiday periods). In this context, one possibility would be to split phbed into two variables so as to try to isolate the measurement errors. The first of this variable would represent the number of beds in the youth hostels and group accommodations (ygbeds) whereas the second variable would represent the number of beds in the rented holiday houses and apartments (habeds). However, ygbeds is not found to be significant when replacing the variable phbed in the model. A possible attitude would then simply be to remove log(phbeds) from model 4 and make estimations and predictions based on this new model. The results are shown below.

*Model 5*

```
Coefficients:
              Value Std. Error t value Pr(>|t|)
(Intercept)  3.2859  1.9841     1.6562  0.1020
log(Slopes)  0.5266  0.1581     3.3304  0.0014
 log(hbeds)  0.3669  0.0742     4.9438  0.0000
  log(WTPF)  0.9123  0.3277     2.7838  0.0068
      artkm  0.1107  0.0230     4.8042  0.0000
 I(artkm^2) -0.0016  0.0004    -3.7080  0.0004
      dist1 -0.3708  0.2018    -1.8376  0.0702
      dist2 -0.5114  0.2197    -2.3280  0.0227
Residual standard error: 1.221 on 73 degrees of freedom
Multiple R-Squared: 0.8233
```

All the results presented in subsection 2.4.1 of chapter 2 are based on this last model as well as the results of the related subsections in this appendix (i.e. subsections A 5.3 and A 5.4).

## A 5.3 Interpreting coefficients

Without considering at this stages any endogeneity problems (i.e. assuming that $E(\varepsilon_j|x_j)=0$), model 5 can be stated as follows:

$$E(\log EBITDA_j|x_j) = \beta_0 + \beta_1 \log WTPF_j + \beta_2 \log Slopes_j + \beta_3 \log hbeds_j + \beta_4 dist1_j + \beta_5 dist2_j + \beta_6 artkm_j + \beta_7 artkm_j^2 \quad \text{(A 5.7)}$$

Where

$$x_j^T = (1, \log WTPF_j, \log Slopes_j, \log hbeds_j, dist1_j, dist2_j, artkm_j, artkm_j^2)$$

Therefore, we can interpret the parameters associated to the artificial snow in the following manner:

$$\frac{\partial E(\log EBITDA_j|x_j)}{\partial artkm_j} = \beta_6 + 2\beta_7 artkm_j \quad \text{(A 5.8)}$$

Which is generally not the same as[4]:

$$\frac{\partial \log E(EBITDA_j|x_j)}{\partial artkm_j} = \frac{1}{E(EBITDA_j|x_j)} \frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j} \quad \text{(A 5.9)}$$

This is this last partial derivative that carries an interesting interpretation since it gives the percentage change in EBITDA given a marginal increase in the length of the ski slopes equipped with snowmaking facilities. According to several sources, it is however possible to make the following approximation:

[4] In fact, if $E(\varepsilon_j|x_j)=0$ but $\varepsilon_j$ and $x_j$ are not independent then the two partial derivatives are generally different. For the most part, little is lost by treating the two definitions of semielasticities as the same when y>0 (Wooldridge 2001, p.17).

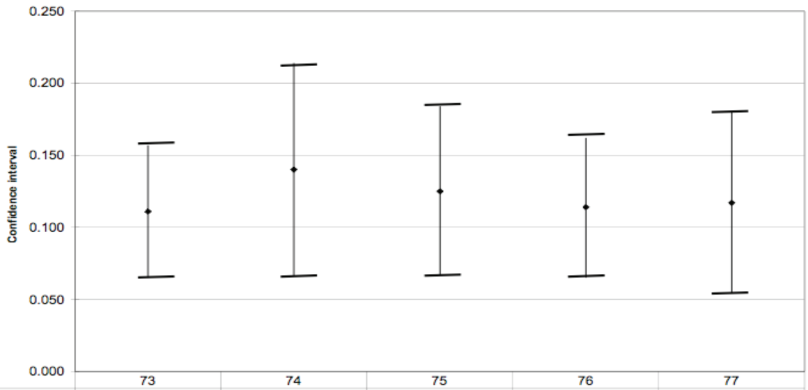
$$\frac{\partial E(\log EBITDA_j | x_j)}{\partial artkm_j} = \beta_6 + 2\beta_7 artkm_j \approx \frac{1}{E(EBITDA_j | x_j)} \frac{\partial E(EBITDA_j | x_j)}{\partial artkm_j} \quad \text{(A 5.10)}$$

Therefore, we interpret $\beta_6+2\beta_7 artkm_j$ as giving the percentage change in EBITDA for a marginal increase in artkm for any given value of artkm. The results are summarized in *table A 5.3*.

| Existing kilometers (artkm) | Confidence interval | Point estimate |
|---|---|---|
| 0 | [6.5%, 15.7%] | 11.1% |
| 10 | [4.8%, 11%] | 7.9% |
| 20 | [2.8%, 6.6%] | 4.7% |
| 30 | [-0.4%, 3.4%] | 1.5% |
| 40 | [-4.8%, 1.4%] | -1.7% |

***Table A 5.3*** *- Confidence intervals and point estimates for the partial effect of additional investments in snowmaking on the EBITDA.*

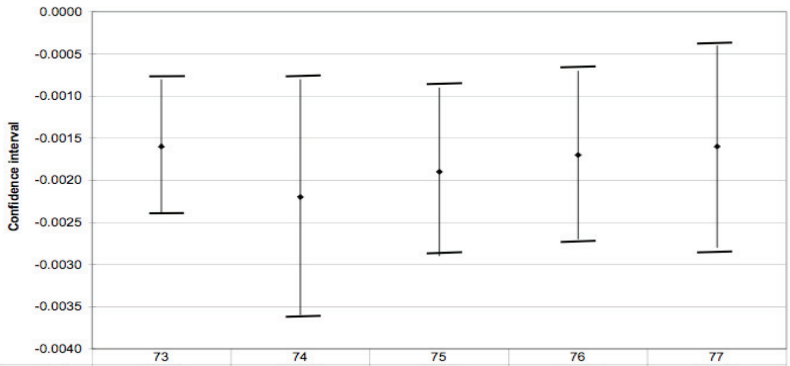
A troubling aspect of the model is that four cases must have been omitted from the regression because they display negative EBITDA. In order to analyse the effects of these deletions on the value and the standard error of the estimates of $\beta_6$ and $\beta_7$, we can try to reintroduce gradually these four cases in our sample by adding a positive offset to the values of the dependent variable. The results are presented in *figures A 5.6* and *A 5.7*.




| | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|
| Lower limit | 0.065 | 0.066 | 0.067 | 0.065 | 0.054 |
| Upper limit | 0.157 | 0.214 | 0.184 | 0.162 | 0.180 |
| ◆ Point estimate | 0.111 | 0.140 | 0.125 | 0.114 | 0.117 |

Degrees of freedom

***Figure A 5.5*** *- 95% confidence intervals for the coefficient associated to the variable artkm.*




| | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|
| Lower limit | -0.0024 | -0.0036 | -0.0029 | -0.0027 | -0.0028 |
| Upper limit | -0.0008 | -0.0008 | -0.0009 | -0.0007 | -0.0004 |
| ◆ Point estimate | -0.0016 | -0.0022 | -0.0019 | -0.0017 | -0.0016 |

Degrees of freedom

***Figure A 5.6*** *- 95% confidence intervals for the coefficient associated to the variable artkm^2.*

At each step of the process, it is worth noting that the objective function minimized by the WLS estimates changes in two ways. On the one hand, an additional element is added to the sum of squares because of the new case. On the other hand, the value of the dependent variable is changed for all cases. Strictly speaking, we do not therefore analyse the pure effect of adding one additional case on the weighted least square estimates. This being said, *figure A 5.6* shows clear evidence that the EBITDA increases with the first kilometer of investment in snowmaking facilities. Considering all the confidence intervals, this increase ranges approximately from 5% to 20% of the EBITDA. Furthermore, the point estimates are all lying in the range between 11% and 14%. Looking at *figure A 5.7*, we can see that the upper limit of all the confidence intervals is always negative. This is again evidence that the net operating gains of snowmaking investments decrease as the level of snowmaking investments increases. The point estimates vary from a value of -0.0022 to a value of -0.0016.

## A 5.4 Predictions

In this part, we will try to give some details about the way we make our “predictions”. We are interested in determining what would be the financial consequences if all the companies of our sample were to equip one additional km of slopes with snowmaking facilities. By doing so, we would like to determine what the potential was during the financial year 2003/04 for cash flow and net income improvements through snowmaking investments.

By looking at the estimates derived in section A 5.2, we note first that this additional investment can possibly worsen the operating results of the companies because the estimate of $\beta_7$ is negative. Indeed, any additional investments in snowmaking facilities for companies with more than 34.6 km of equipped ski slopes will reduce their operating results whatever their size. For these companies, additional investments will therefore neither enhance the cash flow nor the net income. For the other companies, we determine some threshold values of the mean function from which it is worth investing in snowmaking according to some predefined criteria. We employ two kinds of criteria. The first one is related to the cash flow and the second one to the net income. In the first case, we compute the minimum value of the mean function so that the cash flow is not deteriorated when taking into account the financial costs (FC) associated to the snowmaking investments. We also do compute a second kind of minimum value. It is the value of the mean function for which there is a balance between the operating gains and the financial and depreciation costs (FC+DC) associated to the snowmaking investments. To compute these values, we must first derive the financial and depreciation costs of a one kilometer investment in snowmaking. In order to compute the interest payments, we make the hypothesis that 25% of the financing is ensured through bank loans and that the variable mortgage rate is equal to 5%. With investment costs taken to be equal to 1 Mio CHF, this leads to interest payments of 12’500 CHF (for the first year). Depreciation costs are computed on the basis of the same investment costs with a (straight line) depreciation to be spread over 25 years. With these hypotheses, the yearly depreciation cost is equal to 40’000 CHF.

From the previous section, we note that:

$$\frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j} \approx (\beta_6 + 2\beta_7 artkm_j) E(EBITDA_j|x_j) \quad \text{(A 5.11)}$$

We would like to determine the minimum values of the mean function such that:

$$\left.\begin{aligned} &\frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j} - FC \geq 0 \\ &E(EBITDA_j|x_j)_{FC,artkm_j} \geq \frac{FC}{(\beta_6 + 2\beta_7 artkm_j)} \end{aligned}\right\} \quad \text{(A 5.12)} \quad \text{Cash flow constraint}$$

$$\frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j} - (FC + DC) \geq 0$$

(A 5.13) Net income constraint

$$E(EBITDA_j|x_j)_{NI,artkm_j} \geq \frac{FC + DC}{(\beta_6 + 2\beta_7 artkm_j)}$$

Using the values given above for the financial and the depreciation costs along with the weighted least square estimates of $\beta_6$ and $\beta_7$, we have deduced these threshold values and collected them in *table A 5.4*.

| Existing kilometers (artkm) | Estimates of threshold values for | |
|---|---|---|
| | ***Cash Flow enhancing*** $E(EBITDA_j\|x_j)_{FC,artkm_j}$ | ***Net Income enhancing*** $E(EBITDA_j\|x_j)_{NI,artkm_j}$ |
| 0 | 112'918 | 474'255 |
| 5 | 131'996 | 554'382 |
| 10 | 158'831 | 667'090 |
| 15 | 199'362 | 837'321 |
| 20 | 267'666 | 1'124'197 |
| 25 | 407'166 | 1'710'098 |
| 30 | 850'340 | 3'571'429 |

***Table A 5.4*** *- Threshold values for determining the economic advisability of additional investments in snowmaking.*

For each company of our sample, we can then compare the fitted value of its EBITDA (i.e. the estimate of $E(EBITDA_j|x_j)$) to the values displayed in the preceding table and define whether additional investment in snowmaking will enhance its cash flow resp. its net income or not. Equivalently, we could have computed the estimated value of $\frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j}$ for each case and then have compared it with FC or (FC+DC). The results are given in *table A 5.5* (for a sample of 81 companies).

| EBITDA enhancing | Cash flow enhancing | Net income enhancing |
|---|---|---|
| 97.5% | 86.4% | 61.7% |

***Table A 5.5*** *- Figures giving the percentage of our sample's companies for whom additional snowmaking investments will increase 1/the EBITDA, 2/the cash flow and 3/the net income.*

These results must be looked at with caution for at least two reasons. On the one hand, the interest of this prediction depends on the adequacy of the chosen model for our particular set of data. On the other hand, these results are derived from point estimates thereby not taking into account the inherent variability of the estimates. Building confidence interval for $\frac{\partial E(EBITDA_j|x_j)}{\partial artkm_j}$ would have probably involved finding the distribution of $(\hat{\beta}_6 + 2\hat{\beta}_7 artkm_j)\hat{y}_j$ which seems nonetheless rather difficult to obtain.

## A 5.5 Bibliography

**Cook R D and Weisberg S** 1999 Applied regression including computing and graphics. John Wiley & Sons, Inc.

**Davison A C** 2003 Statistical models. Cambridge: Cambridge university press.

**Kutner M H Li W Nachtsheim C J and Neter J** 2005 Applied linear statistical models. McGraw-Hill Companies, Inc.

**Wooldridge J M** 2001 Econometric analysis of cross section and panel data. Cambridge: MIT Press.

# Appendix 6: DEA models

## A 6.1 The CCR model

In this section, we present the mathematical description of the input-oriented CCR model. As for the two other models that are presented in this appendix, the CCR model is formulated as a linear program problem. Since the other models are expansions of this model, it is useful to present it first. The multiplier form of the linear program problem is the following:

$$\max_{v,u} uy_0 \quad \text{(A 6.1)}$$

$$vx_0 = 1 \quad \text{(A 6.2)}$$

$$-vX + uY \leq 0 \quad \text{(A 6.3)}$$

$$v \geq 0 \quad , \; u \geq 0 \quad \text{(A 6.4)}$$

The dual problem which is also called the envelopment form of the linear program problem is expressed as:

$$\min_{\theta,\lambda} \theta \quad \text{(A 6.5)}$$

$$\theta x_0 - X\lambda \geq 0 \quad \text{(A 6.6)}$$

$$Y\lambda \geq y_0 \quad \text{(A 6.7)}$$

$$\lambda \geq 0 \quad \text{(A 6.8)}$$

The dual problem is solved using a two-stage procedure. In the first stage, $\theta$ is minimized so that $\theta^*$ is obtained. In the second stage, the sum of the input excesses and output shortfalls are maximized while keeping $\theta$ equal to $\theta^*$. This second stage is expressed mathematically in the following equations:

$$\max_{\lambda, s^-, s^+} \omega = es^- + es^+ \quad \text{(A 6.9)}$$

$$s^- = \theta^* x_0 - X\lambda \quad \text{(A 6.10)}$$

$$s^+ = Y\lambda - y_0 \quad \text{(A 6.11)}$$

$$\lambda \geq 0,\ s^- \geq 0,\ s^+ \geq 0 \quad \text{(A 6.12)}$$

Where $e = (1,...,1)$ (a vector of ones)

## A 6.2 The BCC model

The CCR model implies constant returns to scale of activities. An early modification of the CCR model was proposed in order to allow for variable returns to scale frontiers. The latter property is obtained by modifying the envelopment and multiplier forms of the (input-oriented) CCR model in the following way:

$$\min_{\theta_B, \lambda} \theta_B \quad \text{(A 6.13)}$$

$$\theta_B x_0 - X\lambda \geq 0 \quad \text{(A 6.14)}$$

$$Y\lambda \geq y_0 \quad \text{(A 6.15)}$$

$$e\lambda = 1 \quad \text{(A 6.16)}$$

$$\lambda \geq 0 \quad \text{(A 6.17)}$$

Where $\theta_B$ is a scalar.

The multiplier form of the BCC model is expressed as:

$$\max_{v,u,u_0} z = uy_0 - u_0 \quad \text{(A 6.18)}$$

$$vx_0 = 1 \quad \text{(A 6.19)}$$

$$-vX + uY - u_0 e \leq 0 \quad \text{(A 6.20)}$$

$$v \geq 0,\ u \geq 0,\ u_0 \text{ free in sign,} \quad \text{(A 6.21)}$$

Where $v$ and $u$ are vectors and $z$ and $u_0$ are scalars and the latter, being « free in sign », may be positive or negative (or zero).

Note that the two-stage procedure used to solve the envelopment form of the BCC model is similar to the CCR case.

## A 6.3 The Non-Discretionary Variable (NDSC) Model

The input-oriented non-discretionary variable model is presented below. It is solved using the same two-stage procedure as for the CCR and BCC models (the symbol ε in equation A 6.22 means that the slack variables are to be maximized at a second stage). However, we have to note that the second stage maximizes the sum of discretionary input excesses and output shortfalls. Indeed, note how the slack variables associated to the non-discretionary variables are omitted from the objective in equation A 6.22. For the envelopment form, the variable returns to scale version of this model is obtained by adding equation A 6.16 to the equations A 6.22 to A 6.25.

$$\min \theta - \varepsilon\left(\sum_{i \in D} s_i^- + \sum_{r=1}^{s} s_r^+\right) \quad \text{(A 6.22)}$$

subject to:

$$\theta x_{i0} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^-,\ i \in D \quad \text{(A 6.23)}$$

$$x_{i0} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^-,\ i \in ND \quad \text{(A 6.24)}$$

$$y_{r0} = \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+,\ r = 1,\ldots,s \quad \text{(A 6.25)}$$

Where all variables (except $\theta$) are constrained to be nonnegative.

The multiplier form of the NDSC model is expressed as:

$$\max_{v,u} \sum_{r=1}^{s} u_r y_{r0} - \sum_{i \in ND} v_i x_{i0} \quad \text{(A 6.26)}$$

subject to

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i \in ND} v_i x_{ij} - \sum_{i \in D} v_i x_{ij} \leq 0,\ j = 1,\ldots,n \quad \text{(A 6.27)}$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1 \quad \text{(A 6.28)}$$

$$v_i \geq \varepsilon,\ i \in D, v_i \geq 0,\ i \in ND, u_r \geq \varepsilon,\ r = 1,\ldots,s \quad \text{(A 6.29)}$$

## A 6.4 Bibliography

**Banker R D Charnes A and Cooper W W** 1984 Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis *Management Science 30(9) 1078-1092.*

**Cooper W W Seiford L M and Tone K** 2007 Data Envelopment Analysis: a comprehensive text with models, applications, references and DEA-Solver software. New York: Springer.

**Fried H O Knox Lovell C A and Schmidt S S eds.** 1993 The measurement of productive efficiency: techniques and applications. Oxford: Oxford University Press.

# CURRICULUM VITAE


## Camille Gonseth

**Assistant doctorant,** Laboratoire de recherches en économie et management de l'environnement
**Candidat pour un post-doctorat**

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## INFORMATIONS PERSONNELLES

Né le 26 mai 1978
Nationalité suisse
Célibataire

| | | |
|---|---|---|
| Français | – | *langue maternelle* |
| Italien | – | parlé & écrit très bien |
| Anglais | – | parlé & écrit bien |
| Allemand | – | connaissances |
| Russe | – | connaissances élémentaires |

## FORMATION & EXPERIENCE

| | |
|---|---|
| 2004 → | **Doctorant**, *titre de la thèse: « Adapting ski area operations to a warmer climate in the Swiss Alps through snowmaking investments and efficiency improvements»* (directeur de thèse: Prof. Philippe Thalmann)<br>Laboratoire de recherches en économie et management de l'environnement (REME), Ecole Polytechnique Fédérale de Lausanne, Suisse |
| 2004 - 2005 | **Certificat Study Center Gerzensee**, *spécialisation en économétrie et microéconomie dans le cadre du « Swiss Program for Beginning Doctoral Students in Economics 2004 ».*<br>Centre de formation de la Banque Nationale Suisse, Gerzensee, Suisse |
| 2003 → | **Assistant** en économie politique dans le cadre du programme d'enseignement SHS (cours du Prof. Philippe Thalmann)<br>Laboratoire de recherches en économie et management de l'environnement (REME), Ecole Polytechnique Fédérale de Lausanne, Suisse |
| 1996 – 2002 | **Diplôme d'ingénieur EPFL du génie rural**, *mention Environnement*<br>Ecole Polytechnique Fédérale de Lausanne, Suisse |
| 1996 | **Maturité Fédérale type C (scientifique)**<br>Ecole Internationale de Genève – La Châtaigneraie, Suisse |

## PUBLICATIONS

**« Do snowmaking investments improve the financial situation of ski area operation companies in the perspective of climate change ?»**, Article à paraître en 2008 dans les actes publiés par *Innsbruck University Press* de la conférence internationale « Managing Alpine Future ».

« **Swiss Climate Policy : Combining VAs with other instruments under the menace of a $CO_2$ tax »** (avec A. Baranzini et P.Thalmann). Dans A.Baranzini & P.Thalmann (éds), « **Volontary Approaches in Climate Policy »**, Edward Elgar, Cheltenham (UK), pp.249-276, juin 2004

## SEMINAIRES & CONFERENCES

**International Conference on Managing Alpine Future: Strategies for Sustainability in Times of Change**, Innsbruck, Autriche, 15-17 octobre 2007. Titre de l'intervention : *Do snowmaking investments improve the financial situation opf ski lift companies in the perspective of climate change ?*

**International Conference on Climate Change Impacts on Tourism**, Lisbonne, Portugal, 7-8 septembre 2007. Titre de l'intervention : *Do snowmaking investments improve the financial situation opf ski lift companies in the perspective of climate change ?*

**Joint OECD and Wengen 2006 International and Interdisciplinary Workshop: Adaptation to the Impacts of Climatic Change in the European Alps**, Wengen, Suisse, 4-6 octobre 2006. Titre de l'intervention : *The choices of the Swiss ski lift companies towards artificial snow cover use : A statistical analysis*

## INFORMATIQUE

| | |
|---|---|
| *Système d'exploitation* | Microsoft Office |
| *Programmes & logiciels* | LaTeX, Splus, EViews6, Stata10, MatLab |

## DIVERS

| | |
|---|---|
| *Intérêts* | Culture de la Russie et des pays scandinaves, Islande médiévale, protection de l'environnement |
| *Temps libres* | Lecture, sorties culturelles, tennis, randonnées en montagne, voyages |