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Managing Risk of Ski Resorts with Snow Options

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ABSTRACT

The main problem for the tourism businesses which operate in ski resorts is that their revenue are strictly connected to the cumulative snowfall level. The uncertainty about the snowfall due the climate changing has made this type of business highly risky, for this reason few or no investments are made every year to improve the resorts, the slopes or the lifts; continuing in this way, the resort in few years will face to a loss in competitiveness, thus less tourists, less revenue and less business.
The present work purposes to show a possible hedging strategy against the financial problems due to the scarcity of snow: the weather derivatives.
Due to the fact that in Italy there are many ski resorts situated at an altitude from 1300m to 2000m, we focus our analysis on Andalo, in Italian Alps and we obtain the estimated prices of a put snow option by applying three different methods proposed in literature.
We suggest, finally, the ideal prices for Paganella lift operator in Andalo, showing how the use of weather derivatives may be very helpful in the risk management for ski resort related to snow scarcity events.

Keywords: Ski Tourism, Management, Climate Changing, Tourism Business

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1. Introduction

Every day of our life the weather trends influence our choice: what to wear, a simple t-shirt or a heavy coat, what to bring, a sunglasses or a helpful umbrella, what to do, to leave to the beach in the week-end or stay at home because the weather forecast expects the great storm. We could continue to list much more cases in which weather condition affect our life but the evidence is one: we are really sensitive to the weather variability.
This weather sensitivity does not affect only people but also, and especially, firms that are not immune to the weather issue: the weather variability could seriously prepossess the levels of costs and revenues. For example hottest than normal winters reduce natural gas sales for residential and commercial space heating, these hottest temperatures make a big quantity of unsold gas that raise the average cost of power production and reduce the cash flow and the income of gas retailer. Cooler than normal summer certainly induce consumers to buy less ice-creams causing losses or less revenue for the ice-cream industry.
The consequences of this sensitivity to the weather conditions are such significant that the Meteorological Office in the United Kingdom estimates that 70% of UK firms may be affected by the weather (Met, 2001) and in the USA the National Research Council has projected that between 25% and 42% of total GDP (Gross Domestic Product) is vulnerable to variations in weather and the climate (National Research Council, 2003).
These data show as the weather is not only an environmental issue but also a key economic factor for a large number of sectors including energy, agriculture, tourism and any more. The awareness of the importance of meteorological factor has led to define the “weather risk” as “the uncertainty in cash flow and earnings caused by weather volatility” (Cogen, 98) or, to better define it, “it is considered “weather risks” all unforeseeable climatic events as warm, cold, rain, snow and wind, that can produce uncertainty on business results” (Colavito, 2005). With these two definitions we don't want say that a rainy day could be dangerous for the firm's life or that a windy day can ruin a company, but if the whole season, as example, in a summer destination, is cold and wet the consequence for the local business could be devastating. Therefore we can extend the definition of weather risk as “a risk that is part of everyday life, having limited economic consequences on an everyday basis but with some huge potential consequences in its accumulation or repetition.” (Barrieu and Scaillet, 2008)
The potential adverse effect due the weather risk could concern not only the revenue on sales and the costs of production but also the financial management, in particular the weather risk influences the in and out firm's cash flow. How the weather risk influence the business management is highly diversified from sector to sector and from the geographic environment in which the firm works. To better understand we can consider again a hottest summer

with temperature more high than the season average. The impact of this deviation in temperature could lead completely different effects on local business: on one side there will be an increase in electricity consumption to cooling the houses and the other buildings, so the local power supplier will increase his revenue; on the other side an agriculture firm could have damage on cultivation due the excessive temperature and the dryness with the consequent lack of revenue.
Another characteristic of weather risk that we can point out from these examples is the weather risk is not, or not directly, a price risk, but is a “volume risk” that means that the variable affected by this kind of risk is the volume of business, the quantity of goods or services sale or purchase; the price is affected by the weather risk only indirectly: a change in a volume probably will lead to a change in price.
Contrary to other types of risks, the weather risk can not be influenced in any way by other factor: human control, speculation, markets dynamics, regulation and deregulation are the most common factors that can influence others risks, in example the financials risks, but any of this factors can have some effects on the weather variable. The weather variable is completely out of control. This implies that “as long as an enterprise's fortune is subject to the mercy of Mother Nature, weather risk will be a crucial part of the overall risk to be managed.” (Cao, Li and Wei, 2003).
This statement becomes crucial in the winter tourism and particularly in the ski sector which is strictly connected to the cumulative snowfall level: winter with low snow precipitation could have extremely consequences for ski industry operators not only in terms of less income and higher costs with a devastating financial effects which could lead a ski based business company to the bankruptcy, but even it can lead to the destination decline due to the scarcity or the absence of investments in the following year to improve the resorts, the slopes or the lifts. Low investments means loss in competitiveness, that determine a low appeal for the destination thus less tourists, less revenue etc. up to the fatal decline of the resort.
The present work purposes to show a possible hedging strategy against the financial problems due to the scarcity of snow: the weather derivatives. Particularly we will analyse the effects of “put snow option” as hedging strategy for Paganella 2001 Spa which is lift operator in Andalo, a little ski resort situated in the Italian oriental Alps chosen precisely because it has been affected from low cumulative snowfall in last years due the low altitude in which is located.
The paper is structured as follows. Section 2 provides the presentation of data and methodology, section 3 shows the calculation of the general prices of snow level options,; section 4 provides the tick size estimation and the specific prices estimation, and section 5 concludes.

2. Methodology and data analysis

As we have just seen revenue of all business in a ski resort are strictly influenced by the level of snow: winter with less snow causes less ski-passes sales, less arrivals in the hotels, higher costs for the artificial snow-making etc, but how the ski resort's firms can hedge this risk? Assuming that the level of snow in a region is a function of both the snowfall and temperature, in 2003 Cao, Li and Wei suggested as hedging strategy for snow-sensitive business to buy a temperature option as well a future on the cumulative snow level. This strategy results very complicated to manage and it does not ensure the hedge because the future contract could generate a pay-off not proportionally to the real loss or revenue due to the lower snow level.

Another hedging strategy for snow-sensitive business was suggested by Beyazit and Koc in 2009, it consists in buy a single derivative: a put option based on cumulative snow level in a specific period with a predetermined strike level. This strategy result easy to manage, just one contract is stipulated, and furthermore the put option guarantee a perfect hedge against scarce snowfall winters.

With put snow option the holder pay to the writer a premium P and he gains an hedge against below strike level events. Its pay-off system depends by comparison the cumulative snow index and the strike level defined in the contract. If the cumulative snow level is more than the strike level $(H_n \geq K)$ the contract does not generate any pay-off for the buyer, in this case the option cost for the buyer is just the Premium P. Differently if the cumulative snow level is less than the strike level $(H_n \leq K)$ the contract generates a pay-off for the holder made from the difference between the two degree days levels multiplied for the tick size.

To make it more clear we can give a practical example: we can assume that if the cumulative snow level during the season is below 90 cm a lift operator could incurs in some troubles, while if the snow level is above this threshold the operator will not have any financials problems. Then the business management may hedge its position buying, corresponding a premium, a snow level put option with strike level at 90 cm and a fixed tick size. At the end of the season if the snow level will be above the strike the option will be out the money or worthless thus the buyer (in our case the lift operator) will not exercise it. If instead the cumulative snow level at the end of the season will be less than the strike level, let's say 72 cm, the option will be *in the money* and it will be exercise by the buyer that will receives 18 cm times the tick size amount of cash (18 is the difference between the strike, 90cm, and the cumulative snow level, 72cm).

At this point we can define the put snow option pay-off system as follow:

$$pay - off = \theta max\{K - H_n, 0\}$$

where θ is the tick size, K is the strike level and Hn is the cumulative snow level in the contract period. How we can easy understand the pay-off snow option pay-off is function both of tick size that of the difference between strike level and cumulative snowfall. The strike level is the threshold value of the underlying index at which the contract starts to pay and normally it has a value between 50% and 100% of the used underlying variable's standard deviation and ± its average. The tick size is the amount of money that the holder of the weather derivative receives for each centimetre of snow above the strike level for the contract period defining substantially how many money will transfer at the end of the contract. As we can see in the formula 1 both the “Strike level” and the “Tick size” are fundamental to determinate the weather derivative payout structures. But what about the snow option price? How should be the premium of a weather derivative based on snow?
In literature there are more models to pricing a snow option based on a statement that the premium is function of the tick size and the expected pay-off. The differences between the models are on the evaluation of the expected pay-off.
By their article Beyazit and Koc propose three different methods to calculate the snow put option prices: the Alaton-Djehiche-Stillberger model (from now ADS model), the historical density model and the Edgeworth adjusted density model. The ADS model is based on temperature, according to it Beyazit and Koc have built the following pricing formula for the option using snow level data instead of temperature data:

$$p(t) = \theta \exp(-r(t_n - t)) E[max\{K - H_n, 0\}]$$

Where θ is the tick size, $exp(-r(tn-t))$ is the continuous discount factor which is used to discount the pay-off at the option's maturity and $E[max\{K - Hn, 0\}]$ is the expected value of the option's pay-off at the maturity. Rewriting the previous formula in terms of normal distribution and strike level we obtain the following option pricing formula:

$$p(t) = \theta \exp(-r(t_n - t))$$
$$\left((K - \mu_n)\left(\Phi(\alpha_n) - \Phi\left(-\frac{\mu_n}{\sigma_n}\right)\right) + \frac{\sigma_n}{\sqrt{2\pi}}\left(\exp\left(-\frac{\alpha_n^2}{2}\right) - \exp\left(-\frac{1}{2}\left(\frac{\mu_n}{\sigma_n}\right)^2\right)\right)\right)$$

Where $p(t)$ is the put price, σ_n and μ_n are the standard deviation and the average of cumulative snow level, Φ is cumulative distribution function for standard normal distribution, K is the strike level, r is the risk free rate and α_n is parameter of cumulative normal distribution function defined as $\alpha_n = \frac{(K-\mu_n)}{\sigma_n}$ and the cumulative snow level during the contract's period is $H_n = N \sim (\mu_n, \sigma_n^2)$. This model was used from Beyazit and Koc to have a benchmark for their suggested model: the historical densities model.

The historical densities model assume that the density of normal distribution function extracted from historical distribution of annual cumulative snow level can be calculated as a weights of the put option pay-off during the contract period and for specific strike level. The pay-off formula provided from the model is the following:

$$p(d) = \theta \exp(-r(t_n - t)) \frac{1}{\sum_{j=1}^{N} a_j(x)} \sum_{j=1}^{N} a_j(x) max\left(k - \sum_{i=1}^{D} S_i(t_n)\right)_j$$

where $p(d)$ is the put price, r is the discount rate, N is the number of observed years, D is the number of the period's days (i.e. 122 days in the December – March period), $a(x)$ is the standard normal variable density and s_j is the daily snowfall level.

Beyazit and Koc state that the results obtained from this model are higher then those obtained by the ADS model but both models are not perfect suitable for an application for a snow based option; this because contrary to temperature, the snowfall have almost always a not normal distribution. Thus due the non - normality the prices need to be modified by taking into consideration moments of distribution higher than second order. For this purpose Beyazit and Koc suggest to apply the "Generalized Edgeworth Series Expansion" in accordance with the Rubistein's (2000) approach. Using skewness and kurtosis this method is applied to modify and adjust the variable density $a(x)$, extracted from historical distribution of cumulative snow level by using first two moments, as follow:

$$f(x) = [1 + \frac{1}{6}\xi(x^3 - 3x) + \frac{1}{24}(\kappa - 3)(x^4 - 6x^2 + 3) + \frac{1}{72}\xi^2(x^6 - 15x^4 - 15)] \; a(x)$$

where ξ is the skewness and κ is the kurtosis both extracted from the historical data, x is the snow level. Once adjusted the density we can calculate the edgeworth price by the following formula where $f(x)$ are the adjusted density and all the other factor are like the formula 4:

$$p(e) = \theta \exp(-r(t_n - t)) \frac{1}{\sum_{j=1}^{N} f_j(x)} \sum_{j=1}^{N} f_j(x) max\left(k - \sum_{i=1}^{D} S_i(t_n)\right)_j$$

The prices obtained from this application should be more suitable for the snow option than the prices obtained from the other models even though the snowfall data are non normally distributed.

Anyway, as we can observe in all models the snow option prices are function of the tick size too, so we can divide the prices in two part, the general price calculated by this models using a tick size =1, which can be applied to every business of the same ski region, and the specific prices, obtained multiplying the general price for a specific tick size, evaluating in this way the specific snow option premium for a specific business. Postponing the tick size discussion to section 4 we can now analyse the meteorological data.

The data used in this work have been provided from “Ufficio Previsioni e Pianificazione - Dipartimento Protezione Civile e Infrastrutture - provincia Autonoma di Trento”, the reference meteorological station is 11AN at an altitude of 1005m in Andalo. The snow level measurement starts in November and ends in next April, the data are registered every day by military personnel belonging to the “Alpini” corps in “meteomont” division or by the “meteomont” operators belonging to the “Corpo Forestale dello Stato” and cover a range of years from 1982 to 2012. The following chart n. 1 shows the monthly snowfall trend from November 1982 to April 2012, blue line, and the monthly snowfall average, red line.

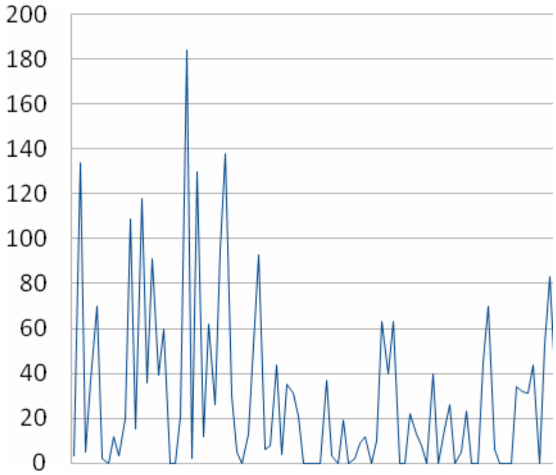

Fig.1 : Cumulative monthly snowfall from November 1982 to April 2012 and its average. Source: “Ufficio Previsioni e Pianificazione - Dipartimento Protezione Civile e Infrastrutture - provincia Autonoma di Trento”

The sample is made by 184 observations with a range from 0 (51 months are registered with 0 cm of new snow) to 184 cm registered on January 1985, the monthly snowfall average calculated on the basis of 184 months is 25.09 cm, while the average calculated on the basis of the snowy months (133 months) is 34.82 cm. The monthly snowfall analysis could be better understood by next table highlighting the monthly snowfall average, the monthly snowfall maximum and the frequency of months with no snow precipitation:

	Monthly Average	Max	Freq. 0 Snowfall
November	11.88 cm	118 cm	20
December	34.45 cm	134 cm	6
January	40.55 cm	184 cm	2

February	30.35 cm	138 cm	1
March	28.80 cm	130 cm	3
April	4.48 cm	50 cm	19

Tab.1: Monthly snowfall Average, monthly snowfall maximum and frequency of month with no snow precipitation

As we can clearly see in the tab n.1 the most snowy month is January with mean of 40.55 cm of snow precipitation, followed by December and February, respectively with 34.45 cm and 30.35 cm of snow. November for twenty years has registered 0 cm of snowfall while April has registered the same snow level for 19 years, respectively the 64% and 61% of the observed years. From this analysis we can establish that November and April are not significant and for this reason to determine the cumulative annual snow level we will exclude this two months while using only December, January, February and March.
The next chart shows the cumulative annual snow level from 1982 to 2012 calculate as mentioned above, conventionally every year level includes previous year December and its January, February, March and April (i.e. the level 246 cm of 1982 is made from December 1981 and from January to April of 1982).

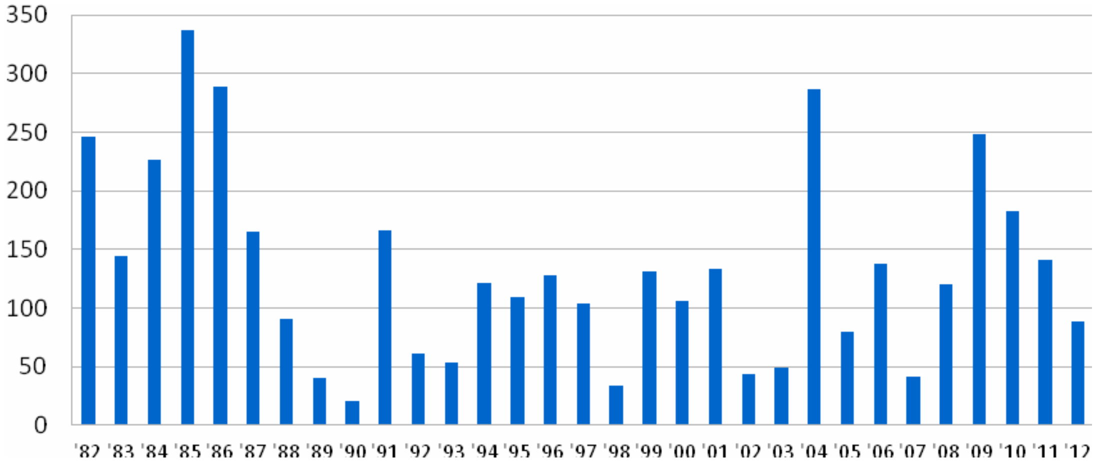

Fig 2: Cumulative annual snowfall from 1997 to 2012 and its average (red line) Source: personal elaboration on data from "Ufficio Previsioni e Pianificazione - Dipartimento Protezione Civile e Infrastrutture - provincia Autonoma di Trento"

As we can observe the annual cumulative snow times series created in this way is quite variable with a range from 21 cm registered in the 1990 to 356 cm registered in the 1985; it presents an average of about 133 cm per year, represented by the red line in the chart 2, the standard deviation is 82,47 cm, the kurtosis is 0.106 and the skewness is 0.849.

3. General price estimation

One studied the pricing methodology and the data analysis we can go ahead with the estimation of the prices. In this section we will estimate the general prices, which are the same for every business in the same resort, and in the further we'll use these general prices to calculate the specific prices for a specific business. In order to establish the correct price we should keep on mind two considerations: the first is that one of the most price influential factor in the models is the strike level (K in all the equations). The strike level should represent the snowfall threshold under which the business interested to stipulate a snow option could incur in some financials problems. For this two reasons is very important that the strike level should be as appropriate as possible.

In this work we have assumed that the strike level should be calculated according to which said in previous section; we have assumed that strike level range should be from 92cm (average – ½ standard deviation = 133cm – 41cm) and 215cm (average + standard deviation = 133cm + 82cm). To simplify we have used different levels from 100cm to 200cm in increments of 10cm remaining really close to the range calculated above.

The second consideration is that the prices calculated by this way are nothing other than the error margin for the snow option seller or, in other words, a kind of warranty against an adverse snowfall level. To better understand this notion we can give a practical example: we can image that the buyer buy a snow option with snowfall strike level at 100cm from the seller at price of $11\cdot\theta$. The price $11\cdot\theta$ indicates that the seller obtain, as a snow option price, 11 times the amount of cash which he should pay to the buyer if the option will be in the money at the end of the contract. Thus until the cumulative snow level will be equal to the strike level minus the general price (in this case 100cm – 11cm = 89cm) the snow option seller will not incur in a negative balance. In fact if the cumulative snow level is more the 89cm, let's say 91cm, the seller will give back to the buyer $9\cdot\theta$ but he still gains 11-9 = $2\cdot\theta$; if the snow level is equal to the strike level minus the general price, in our case 89cm, the seller will give back $11\cdot\theta$ to the buyer obtaining a null balance; on the contrary he will incur in a negative balance just in the case in which the cumulative snow level will be less than the strike level minus the general price, in our example if the snowfall will be 87cm the seller will give back to the buyer $13\cdot\theta$ losing $2\cdot\theta$ more than the $11\cdot\theta$ obtained as a option price.

Quoted the importance of the strike level and what are the prices in practice we can go ahead with the results obtained by the application of the three models to the precipitation data of Andalo.

The result can be summarise in next chart:

Strike level	Alaton-Djehiche-Stillberger prices	Historical density prices	Edgeworth adjusted density prices
100	11.6955986352	12.0173772158	12.0170992263
110	14.8062460489	15.2181566039	15.2178407731
120	18.3778030102	19.228290232	19.2279465453
130	22.4226422218	24.1689876053	24.1686296595
140	26.94639392	30.3175975546	30.3172436373
150	31.9477007695	37.2694344662	37.2690966253
160	37.4182771298	44.3988665813	44.398547431
170	43.3432683997	51.9015115083	51.9012150482
180	49.7018845929	59.8600857949	59.8598168978
190	56.468263328	68.0796898549	68.0794495299
200	63.6125028692	76.4111638178	76.4109524974

Tab. 2 : Snow option prices calculated by Alaton-Djehiche-Stillberger model, Historical density model and Edgeworth adjusted density model at different strike levels.

As we can easily observe that the prices increase with the strike level for all three models because greater will be the strike level greater will be the likelihood that the cumulative snow level registered will be under the strike level making the option “in the money” at the end of the contract. Another result that we can easily highlight is that the ADS model has the prices less than the other two. Both of this results, the price increasing and the ADS prices less than the others, are as we expected, but the prices in the third column are really unexpected: they are really similar to the historical density prices and the differences are actually negative. The Edgeworth adjusted density prices in fact are slightly lower (on average of 0.0013%) than the historical density prices. This "discount" could be explained analysing the cumulative snow level distribution: in fact despite what we have said before it would seem that the data are normally distributed. The similitude between Edgeworth adjusted density prices and historical density prices indicates that the Edgeworth adjustment appears to be unnecessary in our case study, due this from now we will use the Historical density prices.

4. Tick size and specific prices estimation

The prices calculated in the previous section are the generalized prices that can be used by any business in the Andalo ski resort that multiplying his generalized prices for the specific tick size θ can calculated his specific price. As we have already said the tick size should be equal at the impact that every cm of snow has on the business revenues, for this reason it is very important do not underestimate this parameter; a wrong estimation may render the snow option not useful for the buyer.
For our study we would have liked to estimate the tick size as best as possible and with this purpose we have contacted the Paganella 2001 S.p.a. that has provided us the Annual Report (with balance sheet, profit and loss account and the integrative notes by the administration council) from the last 11 seasons from 2001 winter; while the volume of sold ski-passes is provided by the "Consorzio ski-pass Paganella Dolomiti" which is the consortium that manage the ski-pass sales and the revenue distributions between Paganella 2001 S.p.A. and "Valle Bianca" the lift company operating in near and ski-linked village Fai della Paganella.
Unfortunately notwithstanding the large mole of material studied and analysed we cannot estimate perfectly the Paganella 2001's θ because in the Reports, especially in the profit and loss accounts, it's very difficult to find the the items of expenditure due only to the lack of snow. To be more clear we can consider the cost of snow-making system: in winters with few snowfall the company of course use more electric energy and more hours of labours work to overcame the lack of snow making it artificially but, analysing the legal accounting documentation, it is impossible to establish how much of the total expenditure in electric power and in human resource is imputable to the snow-making operation. To do it we should analyse the every day accounting and even in this case the work would be very complex and it would require a long time, in-fact in a telephone interview with an administration officer of Paganella 2001 S.p.A. we became aware that only last year a different electricity meter was set up exclusively for the snow-making machine with the aim of understand the effective expenditure for this operation. However using the available data we can do some considerations about the influence of snow on Paganella 2001's revenues.

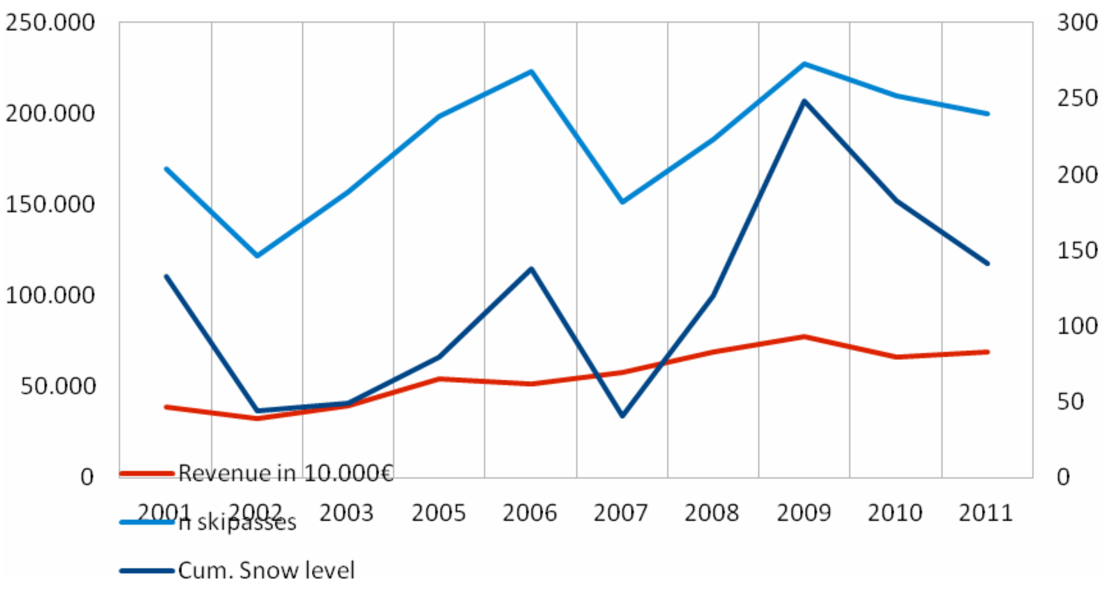

Fig 3: cumulative snow level, revenue and sold ski-passes trends

If we look the trend of cumulative snowfall level, the trend of the volume of sold ski-passes and the revenue trend from 2001 to 2011, we can observe the snow level trend and the sold ski-passes trend have the same course, even if the distance from the two curves is not always the same: this two observations lead us to affirm that the snow level influences the ski-passes sales but after a certain level this influence result be less important. We can do another observation looking the revenue trend: this trend seems don not follow the trend of snow level and it present an almost constant increasing course. We can say that this revenue trend is above all due the ski-pass price inflation, secondly due the efficiency of the snow-making system and probably in last part to the snow level (the higher registered revenue is in 2009 with about 7billion € and the maximum cumulative snow level in this period 248cm).
But, as we said at begins of this paragraphs the difficult is impute the correct weight to this three different influencing factors.
For time reasons we leave this aim to further studies and here we are forced to estimate the tick size by dividing the annual revenue for the cumulative snow level obtaining the weigh of every centimetre of snow for every year on revenue, thus by adding the results for every years and dividing for the number of years we will obtain the average value that we can use as our tick size θ, even if we know that this method is surely not perfect (in this way the years with less snow are the years in which the single centimetre generate more revenue than the winter with more snow!).

The results of this calculation lead us to determinate a value of the tick size as θ = 56.540€, for simplicity we fix the theta for the numerical example of next paragraph at 55.000€. With the tick size calculation now we have now all the element to give a practical example of the utility of the weather derivatives. Let's image that the snow option seller, a bank or a insurance company, can provide to Paganella S.p.A. three different snow option summarised in following table:

Strike level	General Prices	Premiums
100cm	12	660.000
150cm	37	2.035.000
200cm	76	4.180.000

Tab 3 : Details of three contracts

The general prices are calculate using the historical density model and they are round off to the nearest integer number, the premiums (the specific prices) are calculated multiplying the general prices for the specific tick size theta which is set at 55.000€ as quoted previously.
According to the expectation greater is the strike level greater is the price, and greater should be the pay-off of the snow option. But if we looking the next chart we can clearly see that the maximum net pay-offs (as net pay-off we mean the snow option pay-off minus the premium) are relatively closed.

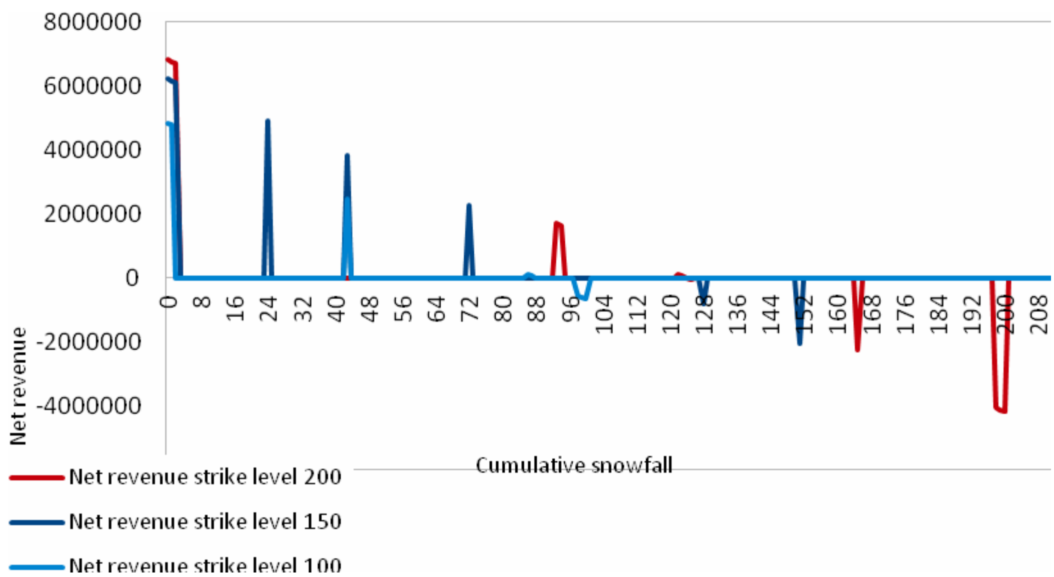

Fig. 4.3: Pay-off of three contracts.

As we can see the theoretical maximum pay-off (if the cumulative snow level at the end of the period is 0cm) for the 100cm strike level contract is 4.840.000€, for the 150cm contract is 6.215.000€ and for the 200cm contract is 6.820.000€.
Imagining a more realistic scenario at the end of the contract we can suppose that instead of 0cm at the end of the contract's period there is a cumulative snow level at 30cm, as indicate by the dotted line in the figure, in this case the

pay-off for the contract are 3.850.000 for the 100cm contract, 4.565.000 for the 150cm contract and 5.170.000 for the 200cm contract.
The 200cm contract seems to be the less useful respect to the other two, this because the 200cm strike level is really far away from the cumulative snowfall average 133cm and it result be more risky for the snow option seller and thus more expensive with a premium (more the € 4 million that is really close to the revenue annual average of the company which is around 5,4 million €).
The 150cm contract present a really good level of net revenue with 4.565.000 but his premium is too high to be used in reality, pay a premium of about 2millon€ it means use the 37% of the revenue average just to buy the snow options e this will be unacceptable for a correct administration.
Personally we thinking that the Paganella 2001's CEO should choose the 100cm contract as part of his hedge strategy against the meteorological risk because this contract can provide a relatively high net pay-off (the pay-off that the company would obtain with a cumulative snow level at 30cm will be higher than the 2002's revenue and really close to the revenues of 2001 and 2003) comparing with the lower premium of 660.000.

With this hudge pay-off Paganella 2001 would be hedge its position against the snow scarcity in a great way: in-fact if in 2002, with a winter with only 21cm of snow, the ceo would had bought a snow option like this, he would increase the business revenue of 120% from about 3,2million to about 7 million!!! Just with only one contract he would change the fortunes of his administrated business obtaining new liquidity to make new investment, and so keeping his resort always on the top in the competitiveness battle.

Conclusions

This paper has tried to give an overview on weather derivatives and a practical application of the three different pricing models. The evidence from this example is clear: if are used correctly, the weather derivatives could be a key factor in the fight against the meteorological uncertainty. Applying a correct hedging strategy against the meteorological risk could make the difference between a tragic loss and a successful triumph.
Of course there are a lot of margins for improvement, in fact reading the Paganella 2001's Annual Reports often we have found negative evaluation of the snow trend in the season from the management notwithstanding the registered cumulative snow level was relatively high, this incongruity was due to temperature above the average that dissolved the snow really quickly. A further research field could be finding a new model to pricing snow options that taking into account not only the cumulative snow level, but also the daily temperature and the level of snow on the ground.

Another improving could be done considering the climate change that is happening: it could be really interesting to create a model that takes note of this changing and which will be based not on historical data but on future forecast.
Furthermore the tick size estimation in this work is unfortunately too much approximative, but is the best we can do with the general data available to us, surely another research line could and must be a deep accounting analysis to correctly estimate the value of the tick size theta maybe creating a framework to standardize this estimation. Of course the theta estimation would be more simple in little resort without a snow-making system, that generates of course more costs but in the other hand it generates revenue even without natural snow, making thus very difficult to understand the weight on every centimetre of snow on revenue. As well as is more easy the theta estimation in this little ski resort, the snow option seems to be more useful because it represents the only tools able to hedge the business from the weather risk.
Hopefully within short time, maybe lead by a new managerial class and enthusiastic tourism operators, the weather derivatives, and in particular the snow option, will be diffuse in every ski resort, helping the operators to improve and to protect our winter tourism and our mountains.

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