WEATHER DERIVATIVES: THE MOST COMMON PRICING AND VALUATION METHODS

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Abstract*: In recent years , weather derivatives have become a common tool in risk management for sectors as: agriculture, energy, sports, etc. This is based on the fact that there is no unique way to determine the value and price solutions that would be generally approved by all market-participant. Not as in the case of the Black-Scholes formula for options on non-dividend-paying stocks, thus weather derivatives valuation being the source for a constant debate between academics and practitioners. One looks for fair and truly correct prices that include all factors, while the others search every-day applicable solutions that help transactionning. To be honest... this is somehow like alchemy. This paper's purpose is the examination of statistical characteristics of weather data, data clearing and filling techniques. The study will be referring to temperatures because that is the best analyzed phenomenon, being the most common. This was also heavily influenced by energy companies and energetic interests, because the degree days were of interest ever before weather derivatives were put for sale. The main ideas are explaining what ways of pricing and valuation are put into perspective for this financial instrument, taking into consideration that the Black-Scholes Model is not suitable, mainly cause the lack of historically correlated and uniforms data. Also here, we will present the pros and cons that we found for each method. The methods are: the Burn analysis, the index value simulation method (IVSM), the daily simulation method (DSM). On the hole, this paper wants to shed light the weather derivatives pricing methods that are a mix of insurance pricing method and standard financial modeling methods. At the end we will prospect the discounting problem, by means of the Consumption based Capital Asset Pricing Model (CCAPM). This is all done empirically due to the fact that on the Romanian market these products are not yet used for either insurance or investment purposes.*

Keywords: weather derivatives, pricing, valuation, burn analysis, DSM, IVSM

JEL classification: G22, G24

Weather derivatives are financial "means" that can be used by companies or/and individuals as part of a risk management strategy to lower risk of adverse or unexpected weather conditions. The difference from other derivatives is that the underlying asset (represented by rain/ temperature/ snow) has no direct value to price the weather derivative on [The use of the black-scholes model in the field of weather derivatives, Horia Mircea Botoș, Cristina Ciumas, UBB Cluj, IC. EMQFB 2012, Tg Mures].

It is natural to assume a mean-reverting model for the weather. As with interest rates, it is unlikely that the weather next year will be 10 times higher than the weather this year.

The most important difference between interest rate derivative models and models for weather derivatives is the calibration process. Interest rate derivative models are calibrated to the market prices of liquid instruments, while weather derivative models are calibrated to past data. So far, an mature, active and liquid market does not yet exist for weather derivatives. On the other hand, we have a wealth of historical weather data. We are determining the parameters for which the probability of having generated the observed data is maximal.
The most common methods put forward for a efficient process of pricing and valuating weather derivatives are: the Burn analysis, the index value simulation method (IVSM), the daily simulation method (DSM).
Description of these methods will show that the mix origin of weather derivatives, of insurance and financial instrument, manifests its self even in pricing. This puts into perspective the frequent use of the Consumption based Capital Asset Pricing Model (CCAPM), when addressing them.

Temperature statistical characteristics

In my studies until this point an action that seemed logical but rarely took place is *natural* hedging. But when it comes to weather this imply the question if risk can be better foreseen by a diversification and spread of the geographical coverage of the business. In a try to record correct and adequate features of temperature, many papers and companies study correlations between cities and/or countries. Such a paper is the one of Cao and Wei in 2004, and the result were impressing. They stated that by widening the geographical coverage, the risk diversification is very low, almost null, when it weather phenomena's. Cao and Wei computed the numbers for the USA, and Ferrer Garcia and Sturzenegger for Europe, the result being the same. As an example the correlation of temperatures in New York and Philadelphia is of 0.9853, thus showing that only 2.9% of temperatures changes in New York are correlated with changes taking place in Philadelphia. There study show that the lowers correlation was of 0.8443, between New York and Dallas that was still high. The same study in Europe had similar results. Correlations between countries in Italy, Napoli- Milano was of 0.9536. General correlations between temperatures in France and the Swiss was of 0.99, while between Switzerland and Great Britain were 0.9671. A later study show that the correlation between New York and London was 0.9531. The conclusion arising from these figures is that temperature diversification can't be internationalized, this it is recommended that's markets the use of weather derivatives.

Given the basic temperature properties registered at different location and intervals (times), explains the use of the DSM, that incorporates an adequate track of these processes:

a) Warming trend: Meteorological research shows that it is possible that climatic trends to be cooler or warmer over time. Weather stations, generally register just warming trend because of constant city expansion. This phenomena is called "the heat island effect" and caused by the heat-storing properties of construction materials. This means that CDD[Cooling degree days] levels will rise over time, while the HDD[Heating degree days] level will decrees. The more energy-efficient are the building materials, the closer the two values will be.

b) Seasons: Temperatures have a sinusoidal grafts, caused by the seasonal variations . This is visible without any data processing by just looking at the data

c) Heteroscedasticity : temperature has a stochastic volatility, which is more visible in winter then in summer.

d) Auto-correlation: temperature patterns are strongly auto-correlated. For short lags the correlation is near to 1, afterwards decreasing visibly. This auto-correlation is significant and visible for lags of 365 units or multiples of it.

All the point made until now show that the historical data describe future outcomes are at the basis of the process of valuation and pricing for weather derivatives, but this can cause problems for the dealer when data sets are incomplete or display errors.

Temperature data sets can be obtain from a large variety of providers, but we would recommend the ones obtain from the national meteorological institutes. This because the data is more objectively recorded and the institutes are incorruptible in their recordings. Raw data sets are more affordable and easier to be put into research structures, while the cleaned data are expensive and ,some times, less relevant because of their alterations. The data cleaning methods for weather data are not made public, but the standard methods put into practice on the raw data also provides relevant information.

Scientist have put into perspective that the Principal Component Analysis (PCA) outperforms other techniques, the Fallback Methodology being the second method recommended. But practitioners, and also Chicago Merchant Exchange , prefer the Fallback method (results are also easier to be come across when there are values missing).

The Black Scholes Model

There are a lot of reasons why the Black Scholes model does not work. Firstly, weather underlying factor are not tradable or storable, thus a riskless portfolio cannot be built. Another motive why the BlackScholes equation fails there is heteroscedastic nature of weather and , we must take into account that, be indexes are summations of previous are actual weather outcomes. The degree days indexes are an accumulation of average daily temperatures, making them similar to Asian derivatives.

More details about this subject can be seen in one of the authors previous works.

The Burn analysis

This method is sometimes referred as actuarial pricing. The model starts from the assumption that future temperatures can be predicted using just historical series of recorded temperatures. Computing security paid in the past and averaging pay offs in the last years, the buyer can estimate the expected profits at maturity. To presume that future gains can be determined from past performances, we need a lengthy data set, the problem being that this is susceptible to frequent errors. Cao and Wei demonstrated in one of their studies that payoffs almost quadruple switching the data set from 10 to 20 years. This reassess the question: who do we determine the right historical length. Hard to answer.