THE TEMPERATURE-BASED DERIVATIVES CONTRACTS – NEW PRODUCTS OF WEATHER RISK INDUSTRY

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Abstract:
The temperature-based derivatives contracts have appeared while the first deregulations in the utilities and the energy sectors from USA in the years 1990-2000. The transfer of the some services in the private sector has involved a better control of costs and revenues of different companies. The private investors who have turned to this area, have imposed a risk reduction management more complex than that used by any public company, in order to ensure their profits and a smaller variation of profit from one year to another. Initially, the temperature-based contracts were traded on over-the-counter market, but this type of trading has not provided a fast development of market.
A turning point in the growth of market was the launch of the first derivative exchange-traded contracts in the summer of 1999 at the Chicago Mercantile Exchange (CME).In this article, we conducted an analysis of the temperature derivative contracts having regard to their economic importance, the major implications of weather on national economies and lack of traditional insurance products for temperature's variance. From their occurrence to date, these contracts have won every field that is influenced by meteorological variables always being finding new ways to translate in derivatives contracts different components influence of the weather.

Key-words: weather derivative, HDD, CDD, temperature,

JEL Classification: G10, G20

THE INSTRUMENTS OF WEATHER DERIVATIVES MARKET

Derivatives on variations of temperature have appeared in the U.S. during the years 1990-2000 with the first deregulation in the field of energy and utility. The deregulation of power energy has created new needs for the companies from this field: in order to stabilize their earnings, these companies have needed specific products to hedge the risk caused by unexpected weather conditions.

The existing products on the financial market did not provide full coverage of risk, for which it sought new ways to offer a minimization of the weather risks to an acceptable level. One of the factors that have a notable influence on the level of energy companies' revenues is the temperature variation. This unknown factor has created a demand for insurance against that risk which was not offered by existing products on the market.

In 1996, the first contract on temperature variations was concluded between Koch Energy and Enron valid through the winter of 1997 in Milwaukee. An important factor in developing the market for contracts on temperature variation was the high temperatures caused by El Niño phenomenon during the winter of 1997-1998, which caused substantial reductions in the sales of utilities companies. Since then and until now temperature variations contracts had an upward trend. Initially, they were traded on the OTC markets (over-the-counter), but this type of trading didn't provide a fast developing market.

The importance of the weather for the economy is demonstrated not only by the launch of these derivatives, but also by the establishment of associations with preoccupation in this field.

In 1999, Weather Risk Management Association (WRMA) was founded in order to attract public and corporations' attention on risk from weather and its management, and to promote market development and improvement.

Association's contributions to market development took place in the following field: improving access to weather data; standardizing documentation of weather transactions; establishing credit standards; expanding the weather market geographically; broadening the

market's commercial scope , establishing and annual sponsorship of the benchmark survey of the weather industry in conjunction with PricewaterhouseCoopers

A turning point in the growth of the trading of contracts on the temperature variation was represented by the launch of the first derivative contracts on temperature variations in the summer of 1999 at Chicago Mercantile Exchange (CME).Between 1999 and 2003, 24.094 contracts were concluded on temperature variations and the trend was growing and extending, reaching in 2006 a total of 801.122 contracts.

After their appearance in the U.S., contracts on temperature variations and other weather components helped to develop markets in other regions of the world such as Canada, Europe and Asia.

The weather derivatives are consider financial instruments and the market of these derivatives has two facets because some of these products are used for management of risk and some of then are use for commercial trading of weather risk. (P. Barrieu, O. Scaillet, 2009).

Now, through CME and OTC markets are traded different types of contracts like: contracts for temperature variations; contracts on frost days; contracts on snowfall; contracts on rainy days; contracts on sunny days; contracts on wind intensity.

So, there are many underlying "assets" (variables) for weather contracts like temperature, snowfall, frost days, humidity, rainfall, hurricane etc., but the most used variable is the temperature. The success of temperature based contracts could be explain through the intense use of these contracts by the power companies that are among the principal actor of this market and the fact that the temperature is a more manageable variable than rain or snow that are characterized by discontinuities (Hamisultane, 2006).

Along with energy firms, such contracts allow hedging to the firms from other working areas that are also affected by weather. According to a study commissioned by WRMA, potential users of hedging instruments based on weather are working in the following areas: energy; agriculture; retail; construction; transport; others.

Through the weather derivatives, we can affirm like Rayner that the companies from different fields "have attempted to domesticate weather, climate change and their consequences for millennia" and weather derivatives are an indirect form of commoditization of nature.(Rayner, 2003).

Table 1. Correlation sector-climate risk

Sector	**Main climate-related risks to hedge**
Energy	Temperature
Agriculture	Temperature, precipitation, frost
Agribusiness	Sun, Temperature, Decrease in consumption due to climate
Distribution	General meteo conditions
Tourism	Snow, Sun, Temperature
Health	Very cold winters, very hot summers
Transportation	Wind, Rain, Snow, Frost, Icing
Building and construction	Wind, Rain, Snow, Frost, Icing

Source: A primer on Weather Derivatives, Pauline Barrieu and Olivier Scaillet, 2009

In addition, "…weather derivatives may re-shape forms of economic and environmental governance and do so in ways not conducive to the future production of sustainable ecologies and economies" (Pollard, 2009).

METHODOLOGY FOR THE CALCULATION OF CONTRACTS ON TEMPERATURE VARIATION

The first contracts have been directed to hedge temperature variation risks of utility companies, in this way establishing the use of the degrees Celsius (Fahrenheit U.S.) as a measure of agreement. It was also established that a temperature of 18˚ C (65˚ F) requires no heating or cooling of housing and spaces for human activity, although in warmer climates it can be used a higher values. Based on these premises there have been issued two new concepts:

- HDD (Heating Degree Day) for the days when heating is required for human activities. HDD index is generally used during the cold season when temperatures drop below 18˚ C
- CDD (Cooling Degree Day) for days when cooling is required for human activities. CDD index is used in the hot season when temperatures exceed 18˚ C

To obtain the HDD or CDD, the average of maximum and minimum temperature recorded at a meteorological station or in a certain city is calculated by the formula:

$$T_i = \frac{T_{i\,min} + T_{i\,max}}{2} \quad (1)$$

where:
T_i - the average temperature recorded on the day I;
$T_{i\,min}$ - the minimum temperature recorded on the day I;
$T_{i\,max}$ - maximum temperature recorded on the day I;

The average temperature at a particular station, calculated above, is used to calculate the HDD or CDD according to the following formula:

-for HDD

$$HDD_i = \max(0, T - T_i) \quad (2)$$

where:
HDDi - heating degree day on day i;
T - temperature of 18 ˚ C (65 ˚ F);
T_i - the average temperature recorded on the day I;

-for CDD

$$CDD_i = \max(T_i - T, 0) \quad (3)$$

where:
CDD_i – cooling degree day on day i ;
T - temperature of 18 ˚ C (65 ˚ F);
T_i - the average temperature recorded on the day I;

The daily values of HDD or CDD are added up in order to get the HDD or CDD value for total contract period, according to the following formula:

$$HDD_t = \sum_{i=1}^{n} HDD_i \quad (4)$$

$$CDD_t = \sum_{i=1}^{n} CDD_i \quad (5)$$

where:
HDD_t /CDD_t– total amount of daily values ;(HDDi / CDDi) which can be calculated on a week, a month or a season.

Exemple

Transfuel Company is active in the field of providing fuel for thermal power producer CET. According to studies conducted by risk management department, it was established that, if the temperature will be higher than -5 ˚ C in December and January, the unit will register a drop in profits.

The following are known:

- For the unit to achieve a satisfactory return is required to deliver an average of 380 tons of oil daily at a price of 1.720 u.m. / tone ;
- This need is met when the daily outside temperature is at the level of -5 ˚ C;
- A rise of temperature determines a drop in fuel needs;
- And a temperature drop drives the increase in demand for fuel.

To ensure against risk, the unit decided to conclude a contract on temperature variations. A contract on temperature variations can be made specifying the following seven parameters (Zeng,2000):

1. Type of contract.
2. Contract period.
3. Official station from which weather data are obtained.
4. Definition of the Index (W) on which the contract is based.
5. Threshold exercise (S) for W.
6. Tick (k) or linear or binary payment scheme to pay constant (P0).
7. Premium.

For the presented case study the parameters are:

1. Contract: Purchase of European style put option;
2. January 2010;
3. Weather recording station;
4. The contract is based on HDD index calculated during the above mentioned
5. period;
6. Threshold exercise HDD 713 ;
7. Tick: 1˚HDD=2000 m.u.;
8. Premium = 50000 m.u..;

Table 2. Temperature values in January

Temp:	**01.01**	**02.01**	**03.01**	**04.01**	**05.01**	**06.01**	**07.01**	**08.01**	**09.01**	**10.01**	**11.01**	**12.01**	**13.01**	**14.01**	**15.01**	
MAX	0.00	-1.66	-3.90	-6.67	-10.00	-4.44	-2.79	-1.66	-4.44	-6.12	-7.22	-6.67	-5.00	-2.22	-1.66	
MIN	-4.44	-5.00	-7.22	-11.11	-14.44	-12.22	-8.33	-7.22	-6.68	-9.44	-9.44	-11.11	-12.78	-6.66	-5.00	
AVG	-2.22	-3.33	-5.56	-8.89	-12.22	-8.33	-5.56	-4.44	-5.56	-7.78	-8.33	-8.89	-8.89	-4.44	-3.33	
Temp:	**16.01**	**17.01**	**18.01**	**19.01**	**20.01**	**21.01**	**22.01**	**23.01**	**24.01**	**25.01**	**26.01**	**27.01**	**28.01**	**29.01**	**30.01**	**31.01**
MAX	0.78	1.67	1.67	1.11	0.88	5.00	8.89	5.00	3.89	4.44	3.33	6.67	5.00	5.00	5.56	2.78
MIN	-3.00	-6.11	-1.67	-1.11	-3.10	-2.78	-2.23	0.56	-1.67	-4.44	-3.33	-2.23	-2.78	-5.00	-5.56	-7.22
AVG	-1.11	-2.22	0.00	0.00	-1.11	1.11	3.33	2.22	1.11	0.00	0.00	2.22	1.11	0.00	0.00	-2.22

Table 3. Daily HDD

	01.01	**02.01**	**03.01**	**04.01**	**05.01**	**06.01**	**07.01**	**08.01**	**09.01**	**10.01**	**11.01**	**12.01**	**13.01**	**14.01**	**15.01**	**16.01**
t˚C	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
t_i˚C	-2.22	-3.33	-5.56	-8.89	-12.2	-8.33	-5.56	-4.44	-5.56	-7.78	-8.33	-8.89	-8.89	-4.44	-3.33	-1.11
HDD_i	20.22	21.33	23.56	26.89	30.22	26.33	23.56	22.44	23.56	25.78	26.33	26.89	26.89	22.44	21.33	19.11

	17.01	**18.01**	**19.01**	**20.01**	**21.01**	**22.01**	**23.01**	**24.01**	**25.01**	**26.01**	**27.01**	**28.01**	**29.01**	**30.01**	**31.01**	**HDD_T**
t˚C	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	
t_i˚C	-2.22	0	0	-1.11	1.11	3.33	2.22	1.11	0	0	2.22	1.11	0	0	-2.22	
HDD_i	20.22	18	18	19.11	16.89	14.67	15.78	16.89	18	18	15.78	16.89	18	18	20.22	651.33

In Table 2 the average temperature is calculated using formula (1), in Table 3 the daily HDD values are calculated using formula (2) and for the HDD_T formula (4) is used.

To get cash flow of the contract, we compare the obtained HDD_T value with the threshold exercise value:

- HDD_T>S –heating degrees value was higher than the exercise threshold stipulated in the contract and the only cash flow is the premium paid (50000 m.u.). The company recorded a profit drop equivalent to the premium paid, in turn it recorded a higher income related to a general increase of fuel consumption due to low temperatures recorded.

- HDD_t<S –heating degrees value was lower than the exercise threshold stipulated in the contract and the cash flow received by the firm is calculated as $k \times (S - HDD_T)$, which in our case becomes 2000×(713-651)= 124000 m.u..
- From this value we deduct the initial paid premium 124000-50000=74000 m.u. and we obtain the value by which the return is increased.

In (Fig.1.) it can be seen the evolution chart of the contracts' return and payment for different values of HDD_t. The chart shows that if the value of HDD_t is lower than the threshold, meaning that the average temperature of the month was not below -5°C,
the contract generates payments correlated with the HDD_t value.
If the value of the HDD_t is higher than the threshold the contract will not register any payments except the premium.

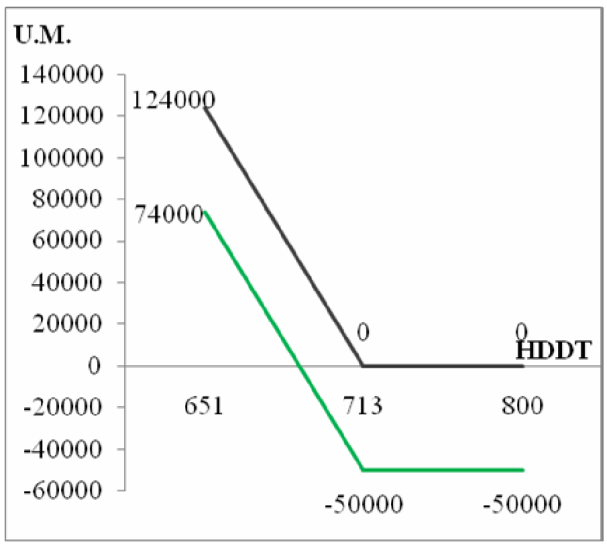

Figure 1. Return and payment

In order to offer more opportunities to companies and investors, on CME weather market are available three types of derivatives contracts: monthly contracts; seasonal contracts and seasonal strip contracts.

CONCLUSIONS

Weather is the major topic in all discussions. At the first sight, weather is an environmental issue but taking in account its economic implications, it is an important key economic factor.

The weather risk can affect the entire economy of a country, but the most sensitive sector is the energy industries. The main player on this weather risk market are energy companies like Aquila Energy, Hess Energy, British Gas, financial institutions, insurance companies and hedge funds.

Because of economic implications of weather risk, there are many preoccupations in financial field regarding the hedging of weather risk. The results consist in the launch of many financial instruments or products like exchange traded derivatives contracts.

The success of these derivatives contracts is due to their characteristics and differences from the traditional insurance products:

- they are standardized contracts traded on the exchange;
- in order to receive the money, there is no need to prove the damages;
- they cover small variations of variables like temperature that can cause huge losses for the companies.

In addition, the contracts are based on some indices that do not depend on actions of market participants (so, there is little moral hazard) and the payoffs of these contracts are based on indices that are publicly available and objectively measured (Vedenov, Barnett 2004).

The weather indices are flexible and ease to construct, but the main problem of weather derivatives is the spatial variability of the weather that is source of basis risk - the weather risk is a geographical risk that can not be controlled. (Barrieu, Scaillet, 2009)

These financial products could be used not only for hedging purpose but also for speculative purpose by different types of individual or institutional investors because their returns are not highly correlated with the returns of traditional securities like bonds or shares. So, the weather derivatives contracts are excellent diversification vehicles for investors and these instruments "can improve the risk-return trade-off in asset allocation decision" (Cao, Li, Wei, 2004).

In addition, through the purchase and the sale of these contracts by financial investors, we assist to the weather risk transfer on the capital market.

The specialists consider that the development of weather derivatives market depend, in some extend, on the meteorological science and its capacity "to measure, forecast and render, in a commodity form, knowledge of different atmospheric components." (Rayner, 2003). So, the weather derivatives are an indirect for of commodification of nature and the weather indices are a commodity within the weather derivatives market.

The implications of the existence of these derivatives contracts are important. For example, in many countries, the public authorities are interested in order to adopt and strengthen new crop insurance program because the traditional agricultural insurance schemes are affected by problems like asymmetric information and systemic risk. (Stoppa, Hess, 2003). For these reasons, in countries like Canada, USA, innovative insurance program, based on weather derivatives, have been tested and developed.

Despite the success of these derivatives contracts on the financial market, the quantitative and qualitative development of this market will be different from other segments because of some aspects:

- the underlying asset (weather) is not traded on the spot market, so, some arbitrage or speculative strategies are not available for this „commodity";
- the liquidity of the weather derivative market has been improved, but the level is not very high as we can observe on other traditional financial market because the weather is location specific and non-standardized commodity;
- the financial derivatives are useful for price hedging and weather derivatives are used for quantity hedging.

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