Weather Derivatives

Weather derivatives are of very recent origin. One of the first weather derivatives contracts to be transacted was between Consolidated Edision (ConEd) Corporation of New York and Aquila Energy (AE) of USA. The New York based power distribution company, ConEd used to purchase electricity from AE. Anticipating a cooler August (Cooler summer) in 1996, ConEd brought in a weather clause whereby AE would pay discount to ConEd if August is cooler than expected.

To measure whether August is cooler or not both parties agreed to use the Cooling Degree Days (CDDs) measured in New York City's Central Park weather station. Both parties agreed that if actual CDD was 11-20% below the expected value of 320, ConEd would receive cash discount. This contract paved way for hedging weather related risk – many energy companies realized that a greater portion of energy demand governed by weather conditions. Not that the companies realized this all of a sudden, this contract made companies aware that weather related risk could be hedged.

In another case, Koch Energy of USA was anticipating decline in power off-take due to El-Nino effect in 1997. It transacted weather option contract based on Heating Degree Days (HDD) index with Enron Corporation. From 1998 onwards, weather derivatives in Over the Counter (OTC) market started growing. In 1999, Chicago Mercantile Exchange (CME) started offering exchange traded futures and options contracts on weather derivatives. Since then, the weather derivatives contract market is growing robustly.

Please read some more about this online.

Exchange traded weather derivative contract at CME

1. *Temperature based derivatives contracts:*

Contracts based on temperature have either *Heating Degree Days (HDDs)* or *Cooling Degree Days (CDDs)* as the underlying.

HDD is a quantitative measure to indicate whether a specific day's temperature at a specific location is cool enough so that buildings require heating. Similarly, CDD also indicates whether it is hot enough requiring air conditioning/cooling

In a given day if the average temperature is less (higher) than base temperature, it is counted as one HDD (CDD). Base temperatures are pre-specified for a geographical region based on climate condition. Weather contracts during winter months are related to HDD while these for summer months are related to CDD.

For HDD calculation, suppose the base temperature is 65^0F at a place X. On a given day the highest and lowest temperature at X is 50^0F and 30^0F, respectively. Hence the average temperature is 40^0F. As the average temperature is less than the base temperature of 65^0F, then it would be considered as a heating degree day with the HDD value of 25 (65^0F - 40^0F). The CDD is also calculated in a similar manner. If a given day's average temperature is 70^0F, with

base temperature at 65^0F, then it would be counted as one CDD with CDD value of 5. On the other hand, if the average temperature is 60^0F, then the value of CDD is zero.

HDD and CDD can be represented as:

HDD = max (0, base temperature - T_i)

CDD = max (0, T_i - Base temperature)

where $T_i = \frac{T_{max}+T_{min}}{2}$

CME weather derivatives based on temperature calculated over a week/ a month or over season. A weekly HDD or CDD index value is simply the sum of all daily HDD or CDD in a week.

Example:

Data given below shows the average temperature for 7 days at a given place. Calculate both HDD and CDD for a week with base temperature of 65^0F.

Day of the week	Mon.	Tues.	Wed.	Thu.	Fri.	Sat.	Sunday
Average temp(T_i)	69	66	60	59	61	58	56

Solution:

HDD value	0	0	5	6	4	7	9

Cumulative HDD value for the week = 31

Now, CDD calculation:

Day of the week	Mon.	Tues.	Wed.	Thu.	Fri.	Sat.	Sunday
Average temp(T_i)	82	79	75	70	65	63	61
CDD value	17	14	10	5	0	0	0

Cumulative HDD value for the week = 46

Weather contracts is winter months are tied to HDD while weather contracts in summer months are CDD. Some of the interesting features of CDD/HDD contract is as follows: At CME, USA-based CDD contracts are available for May, June, July, August and September.

The HDD contracts are available for November, December, January, February and March

CDD/HDD Monthly Futures'

CDD/HDD futures contract specifications at CME are standardized. Contract size is USD 20 times the respective CME degree days (HDD/CDD) index. It indicates that if a trader takes a position in contract with HDD/CDD value of 1000, the trader's contract value is USD 20,000.

Example

A wheat farmer from Minneapolis knows that a warmer winter is good for wheat production. The farmer is happy if there is less number of HDDs in the month of December 2018. Less number of HDDs indicates warmer winter, and hence, less HDD value. But the farmer fears that winter may be severe. Hence on 8th October 2018, the wheat farmer takes a long futures position in Minneapolis December 2018 HDD contract (100 units) with each unit trading at 625. The contract expired on 31st December 2018 with a settlement value of 690. Calculate whether the farmer has lot of gained in the contract.

Solution:

The HDD value of 690 is the sum of daily HDD values for the month of Decembeber 2018. On 1st January 2019, the farmer will receive the income of USD 130,000 (USD 20 * (690 – 625) * 100 contracts}

The farmer has gained in the contract and may have lost in wheat production due to colder winter.

On the other hand, for instance, if the contract settles at 603, then the farmer pays USD 44000 to his counterparty. Lesser HDD value means a warmer winter. The farmer may have got a good produce. Below table shows the HDD values with ups and downs

Long HDD Futures Pay-off

	HDD settlement value	Actual climate condition	Cash settlement	Payment/Receipt
Farmer takes Long Futures (100 contracts) at 625. Fears a Colder winter i.e. higher HDD	690	Colder winter	Receives cash	USD 20*(690-625)*100 contracts = USD 130,000
	603	Warmer Winter	Pays cash	USD 20*(625-603)*100 contracts = USD 44,000

Example:

An electricity distribution company in New York area would be happy with higher HDD (cooler days requiring heating) but fears that winter will be warmer. In other words, the company is anticipating lower HDD value. The company takes short futures position (750 contracts) on 12 November 2018 on New York December 2019. HDD contracts trades at 712. Calculate the pay-off of the company when the HDD's settlement prices are 695 for warmer winter and 739 to colder winter. '

Note: two values are assumed for representation of short position on HDD contracts

Solution:

Short HDD futures pay-off

	HDD settlement value	Actual climate condition	Cash settlement	Payment/Receipt
Electricity company takes Short Futures (750 contracts) at 712. Fears a warmer winter, i.e. Lower HDD	695	Colder winter	Receives cash	USD 20*(712-695)*750 contracts = USD 255,000
	739	Warmer Winter	Pays cash	USD 20*(739-712)*750 contracts = USD 405,000

Example:

Suppose in April 2018, a major beachwear seller in Los Angeles area fears that during May 2018, the peak tourist season, sales may not be high as the summer would not be hot enough. The company fears a cooler summer i.e., less CDD. To mitigate the risk associated with loss of sales revenue, it takes short futures contract. On 4th April 2018, the company takes a short futures position (250 contracts) in Los Angeles May 2018 at 1012. Calculate the payoff of the company when the CDD settles at 1025 for hotter summer and 987 for colder summer respectively.

	HDD settlement value	Actual climate condition	Cash settlement	Payment/Receipt
Beachwear company takes Short Futures (250 contracts) at 1012. Fears a colder summer, i.e., lower CDD	1025	Hotter summer	Pays cash	USD 20*(1025 - 1012)*250 contracts = USD 65,000
	987	Colder summer	Receives cash	USD 20*(1012-987)*250 contracts = USD 125,000

Futures on Rainfall Index

Futures contracts on rainfall provides an opportunity to customers to hedge risk associated with excess of scanty rainfall. Rainfall index at a particular location forms the underlying. For example, CME reports rainfall index for several cities of USA. The index value is calculated based on daily rainfall recorded at a particular weather station. In US, the rainfall index on a city like Chicago is measured by the amount of rainfall received at Chicago O'Hare International Airport. Similarly, the rainfall index for Los Angles is measured at USC campus.

Rainfall index is measured in inches. Rainfall index for a day is the sum total of daily rainfall received at a particular location between 12.01 a.m. and 12.00 midnight – total rainfall received during 24 hours.

Monthly rainfall index value is the sum total of daily rainfall during a calendar month.

At CME, *8 monthly rainfall futures contracts* from March to October are available. In case of *seasonal rainfall futures*, the index value is the sum total of monthly rainfall for all months in the season. For *seasonal strip rainfall futures*, traders can trade rainfall futures for minimum two months and maximum eight consecutive calendar months starting from March to October. At CME, the size of rainfall index is USD 500 times the respective CME Rainfall Index.

Scanty rainfall or drought conditions affect agricultural production in a major way, and so as the excess rainfall. If a farmer is anticipating scanty rainfall, the farmer can take short futures position. If rainfall is scanty, the farmer benefits from the futures position.

Example:

Soybean crop takes 6 months from plating to harvest. The sowing season starts in May and crop is harvested in the month of October and November. However, rainfall in the month of August (pod setting period) is crucial for good production. The farmer is expecting a lesser rainfall than that is required for good production. During June 2018, the farmer took a short futures position on August Rainfall Index at 3 inches. On 1 September 2018, the August rainfall index stood at 3.57 inches or 1.65 inches. Find out the profit or loss of the farmer.

Solution:

Soybean farmer took short rainfall futures at 2 inches

Rainfall index value = 3.57inches

Profit = USD 500* (3 inches – 3.57 inches) = - USD 285

Rainfall index value = 1.65 inches

Profit = USD 500 * (3 inches – 1.65 inches) = USD 675.

Note: Besides agriculture, tourism, outdoor event management companies, cricketing and many outdoor sports events, mining industries use rainfall derivatives contracts.

MCX and Rainfall Index

India's derivatives market on weather parameters is at nascent stage. MCX stock exchange publishes the rainfall index at three places in India – Mumbai (Colaba), Indore and Jaipur. Rainfall index at these three cities are known as Raindex MUM, Raindex IDR and RaindexJAI respectively. MCX calculates the normal index value for these places from historical annual cumulative rainfall values. The normal index values are 1950, 950 and 350 inches of rain for Raindex MUM, RaindexIDR and RaindexJAI, respectively. These historical values have been collected from the *Indian Meteorological Department (IMD).*

Daily rainfall data at these places are collected and benchmarked against index value. MCX uses a cap on maximum daily rainfall to reduce the impact on index on days of unprecedented rainfall on a single day.