Commodity Derivatives and Risk Management
Prof. Prabina Rajib
Vinod Gupta School of Management
Indian Institute of Technology, Kharagpur
Week-10
Lecture 46
Weather Derivatives

Welcome to the 46th lecture on Commodity Derivatives and Risk Management. Today we will be discussing various aspects related to weather derivatives, derivative contract based on rainfall, snowfall, temperature and even hurricane. But before we proceed to the discussion related to weather derivatives, I would like to take a couple of minutes on discussing the natural gas calendar spread and how a hedge fund named Amaranth advisor incurred 6.6 billion dollars. In fact, in the previous session I discussed this aspect, but not in greater detail. So, I thought that let me revisit that discussion related to natural gas calendar spread and then we proceed to today's agenda of weather derivatives. Please note that the hedge fund whose name was Amaranth Advisors, this particular hedge fund was founded in the year 2000 and in the year 2006 it incurred a 6.6 billion dollars loss by entering into the natural gas calendar spread futures contract. Now, one of the traders, his name is Mr. Brianne Hunter, was working for the Amaranth advisors and in the year 2005 around July August 2005 this trader made a profit of 1 billion dollars profit for the company by entering into long futures contract. As you can see sometime around May 2005 Mr. Brianne Hunter took a long futures position on a March April 2006 natural gas spread. And what was his expectation that during this period of time the natural gas spread futures contract is going to widen. Hence it he bought the contract or took a long futures position. And true to his expectation the natural gas futures contract widened because around August 2005 Hurricane Katrina and Hurricane Rita caused major damage to the oil pipelines and rigs in the Gulf of Mexico. And basically, the natural gas price for the month of March increased significantly as compared to the April 2006 contract thus leading to a widening of the spread. And by September 2005 the spread had widened, and Mr. Hunter made a profit of 1 billion dollars for the hedge fund. In fact, Mr. Hunter wanted to repeat the same strategy in the year 2006. So, around May 2006 again he took long futures position in March April 2007 calendar spread position. And he also got some information related to a greater number of hurricanes affecting the USA for 2006 summer season. And the National Hurricane Center of USA took long futures position also predicted the that similar hurricanes may going to occur in the month of October August to October 2006. And thinking that similar kind of profit he will be making he entered into long futures position. And not only he entered into the long futures position, the quantity of the contract he took was significantly higher. But unfortunately, the calendar spread did not widen the calendar spread in fact, failed down and that is the cause of this

particular company or Mr. Brian Hunter incurred about 6.6 billion dollars loss. And the company came to and came to stop company stopped its operation by September 2006. So, this is what the case related to the impact of entering into the natural gas calendar spread which is also popularly known as a widow maker spread. With this now let us come to another interesting aspect related to how countries are mitigating crude oil price risk by creating something called a strategic petroleum reserve. Please note that crude oil price natural gas price fluctuates significantly and for that companies which are in the business of producing crude oil or companies which are in crude oil refinery selling refined product they enter into various kind of a futures option contract to mitigate the risk. Now, countries also face a significant amount of risk when the crude oil price increases. In this context an international body called International Energy Agency or IEA requires its member countries to maintain 90 days of crude oil inventory 90 days of import requirement of the crude oil inventory and refined products. So, all member countries of IEA have to maintain an inventory of 90 days of import requirement. As you can see, different member countries have different number of days of crude oil inventory. Of course, this is not the complete list, the complete list related to the member countries and how many number of days of inventory is available at this particular web link. In this context, please note that member countries mostly create underground storage locations to store crude oil for emergency purposes. Please note that even though these storage units are known as strategic petroleum reserves normally they do not store petroleum products or gasoline or diesel product, it is the crude oil which gets stored in these petroleum reserves. Because refined products cannot be stored over a long period of time because of quality degradation. However, crude oil can be stored for about 40 50 years without any kind of quality degradation. So, all over the world the strategic petroleum reserves maintained by different countries have crude oil reserves. In this context, Indian government has created a specific unit which is known as Indian strategic petroleum reserve limited (ISPRL), it is a special undertaking by the government of India. And this particular institution or this particular organization has been entrusted with managing the India's sovereign crude. And as part of India’s sovereign crude oil management program ISPRL manages facilities at three location that is Vizag, Mangalore and Padur of Karnataka. And currently it is storing about 13 million tons of crude oil, and it is equivalent to 9 to 10 days of India's current import requirement of the crude oil. Now going forward ISPRL is planning to construct underground storage facilities at two new locations, Chandikhol, Odisha and Padur Karnataka under phase two. And in fact, these underground storage locations are engineering marvels and as part of one of my case study development exercises I got the opportunity to visit one of these underground crude oil storages. It was an unbelievable experience for me. And in fact, you can get lot of information related to this underground crude oil storage facility, the construction, the construction cost, how the crude oil is stored and how the crude oil is taken out from those underground storage if the necessity arises all this information, you will be able to

get it at this particular website. In fact, in a very smart move ISPRL filled the strategic petroleum reserve locations during April-May 2020 during the COVID period of time when the crude oil price had gone down at that point in time ISPRL filled in all these storage location underground storage locations at a crude oil price of probably 22 dollars per barrel. So, it is a very positive initiative by the government of India as well as the ISPRL. In this context I would also want you to read a very interesting article which is titled as why Singapore is putting its oil back into the ground. So, Singapore is also creating a massive mega storage unit to store underground crude oil and more details about that particular initiative is mentioned at this this weblink. So, with this we come to an end with all discussion related to crude oil. Please recall from the session 40-41 onwards till this session we have extensively dealt with how different companies crude oil production companies refinery companies are using futures options swaps calendar spreads etcetera to mitigate price risk associated with these products. With this now let us move to today's agenda of weather derivatives. All of us understand the risk or impact of weather in our life. In fact, companies involved in agricultural, energy, aviation, construction, mining, event management, tourism etcetera face significant amount of revenue risk due to adverse weather conditions. In fact, beer sales in India drop significantly if summer is mild. Similarly, hydro electricity companies generate lower revenue or generate lower electricity if rainfall is low. Mining companies halt mining operation when there is heavy rainfall leading to flooding of mines. And the impact of weather risk is increasingly becoming very significant because of global warming leading to extreme weather patterns. And the right-side block shows the different business sectors, and which are the weather variable which affect the business sector and the business risk associated with the weather conditions. For example, let us take the example of a different tourism industry. When there is a significant amount of rainfall or snowfall there is there can be a drop in traffic and sales if the summer is not cool enough. Similarly, there could be a drop in traffic in ski resorts if there is insufficient snowfall. So, higher snowfall could be a risk for some set of companies and lower snowfall could be risk for another set of companies. So, this particular table shows the impact of weather-related variables on the business risk faced by different companies. Coming back to some more examples of weather risk as I mentioned in the previous slide that beer sales go down if the summer is not hot enough. So, this is again an interesting article related to2023 May month there is a significant amount of decline in beer sales because the summer was not hot enough. And I am sure all of you will recall the massive flood of2016 which happened in Chennai and as part of this particular massive flood insurance company had to pay a claim of 4800 crore in the year 2016. And predominantly most of the insurance payment was done for motor insurance related claims as well as many companies had entered into corporate all risk policy. And one of these important aspects of corporate all risk policy is that if there is a production interruption happens then the insurance company will be making the short fall. So, the motor insurance claim as well as

production interruption claim constituted about 4800 crore and insurance company had to pay this amount of money to Indian companies and Indian individuals. In this context, please note that India ranks among the top three nations which has experienced most natural disaster during period 2000 to 2019 and more than 100 crore people have been affected due to the natural disaster in these 20 years. And this particular image I have taken from the India today and the detail related to the image source and the interesting article related to the natural disaster in different countries is taken from this web link. Now coming to the discussion related to weather insurance versus weather derivative. Please recall our objective is to understand more on weather derivatives, but it is very important to understand what is the difference between weather insurance product as well as weather derivative products. Please note that weather insurance covers risk associated with high risk and low probability events. Very low probability means once in a while this kind of event will be occurring and once this event happens then the risk or the loss is going to be very high. So, weather insurance covers risk associated with high risk and low probability events and insurance payment is capped by the sum insured. So, if somebody is buying let us say insurance for the home the insurance company will come to do the inspection and find out or finalize the total sum insured. And if anything happens then the maximum payment will be capped by the sum insured. Now also another very interesting principle which is associated with the weather insurance which is known as your indemnity principle of the insurance. This indicates that the policies to guarantee to restore the insured to the position he or she was in before the uncertain incident or event that caused a loss for the insured. What this basically means that if I have taken an insurance of my home and total let us say some insurance is for 40 lakhs and there is a fire and the insurance company will be coming and doing an assessment of it and they realize or they find that the total loss is going to be the5 lakh or 6 lakh rupees the insurance company is going to pay me only 5 lakh or 6 lakh rupees not more than that. They will be making sure that my house is in condition before the fire is restored. So, that is the principle related to indemnity principle of insurance. Now coming to weather risk please note that weather risk does not only emanate from catastrophic events like earthquakes, tornadoes, rainfall, flood, excessive snowfall etcetera. Many times, weather risk emanates from ordinary variation in climatic conditions. For example, small changes in temperature, rainfall, humidity snowfall can affect the business risk of a particular company. And weather derivatives are used to hedge the weather risks that are non-catastrophic in nature these are high probability and low risk events. Let me repeat here weather derivatives are used to hedge weather risk that are non-catastrophic in nature which are high probability and low risk events. While weather insurance covers events or risk which are high risk, but low probability events. And weather derivatives help companies to mitigate volumetric risk and what is the meaning of volumetric risk, the risk associated with decline in sales or production volume. Now, let us look at the risk associated with let us understand little more on what do we mean by a volumetric risk.

Please note that the volumetric risk is different than the price risk. Let us understand how volumetric risk is different than price risk. Now let us say a crude oil producer is fearing decline in crude oil price, this particular producer can enter into crude oil futures contract. And if his fear really materializes and crude oil price goes down the company will benefit from the futures market while it will incur loss in the spot market or vice versa. That is if crude oil price increases it will benefit in the spot market while incurring loss from the futures market. Now, the risk associated with commodity price variation is very easy to measure in that sense let us say the crude oil production company will be able to identify if crude oil price falls by let us say 5 dollars per barrel a company will incur let us say x rupees as loss. So, it is pretty simple or straight forward to understand the impact of decline in crude oil price on the company's profitability or company's revenue. However, it is very difficult to identify or quantify what would be the impact of weather on sales volume. There is no direct one to one relationship between for example, let us say temperature increases and let us if temperature increases significantly let us say a movie hall owner will expect a smaller number of people to come and see the movies. The company knows that the top line or the revenue will go down, but how many people will exactly not come to see the movie that is very difficult to quantify. So, quantification of impact of weather-related parameters on company's business or sales volume is not so, straight forward. However, a company which is interested to enter into the weather derivative contract has to do some kind of a quantification method before it decides to enter into derivative contract. So, going forward we will understand this aspect in greater detail. Now, let us come to what are the weather derivative contracts which are listed and traded in different commodity exchanges. Now, let us understand the first contract which is a contract on temperature. Please note that whatever I am going to discuss in this particular session has more to do with commodity exchanges in the international context in the sense these contracts are not available for trading in Indian exchanges. So, most of the weather derivative contracts are traded at Chicago Mercantile Exchange or CME. Now, let us understand what are the futures contract related to temperature are, which are available for trading at CME. These two futures contracts are known as heating degree day contract or a cooling degree day contract that is HDD or CDD. So, what exactly is a HDD contract or a CDD contract let us understand and then we will go and discuss how the futures contract on this HDD and CDD are created and traded. Now, for example, let us understand a day will be treated as a heating degree day. Please note that a day will be treated as a heating degree day if it is cold enough to start the room heating. So, HDD contracts will be available for winter months. So, heating degree days means if days are cold enough and people will be starting their room heaters then it will be known as a heating degree day. Similarly, a day will be treated as a cooling degree day if it is hot enough to start the air conditioning. And please note that HDD futures contract at CME is available for winter months which are basically November, December, January, February, March and CDD futures at CME that is cooling degree day futures contract at

Chicago Mercantile Exchange are available for summer months starting from April to October. And how exactly this CDD or the HDD are calculated let us understand this. The formula for HDD that that is heating degree day on a given day will be max of 0 minus the base temperature and temperature on a given day. Ti stands for i stands for a day, t stands for a given day. And how exactly this Ti value is calculated Ti is an average of days high temperature and the low temperature. As you can see T max T min divided by 2 is going to give us the Ti for a given day. And the HDD value for a given day is going to be max of max of 0 minus the base temperature minus Ti. So, in case of an HDD contract and CDD contract at CME the base temperature is set at 65-degree Fahrenheit. This is a fixed component this does not change. So, this 65-degree Fahrenheit remains constant and depending upon the actual days temperature for a given day the HDD value will be calculated and similarly CDD value will be calculated. And please note that these are your underlying or the spot values for HDD and CDD. And we have a futures contract for HDD and CDD available. For example, the future contract on CDD every contract unit is equivalent to 20 times of CME degree days. And price quotation people who will be buying and selling the futures contract on CDD or HDD they will be quoting in USD per index points. And these contracts are by default financially settled because nobody can deliver the underlying asset which is basically HDD or CDD here. So, all temperature contracts by default are financially settled and the months available are April to October. Of course, this is the snapshot which I have taken from the CME, and it relates to the CDD contract hence the months available are your summer months. For HDD contracts your winter months ranging from November to March will be there. How do we go about calculating the futures contract related to CDD? So, CDD is your cooling degree days is max of 0 minus temperature on a given day minus that base temperature which is your 65-degree Fahrenheit. Now, let us say let us understand what is going to be the week 1 CDD value and week 2 CDD value. So, as you can see week 1 let us say Monday to Sunday the average daily average temperatures are mentioned in Fahrenheit degree. And based on this formula the CDD value is going to be some days there will be positive value of 17 and someday it is going to be 0 it minimum it will be 0 and for this week 1 sum total of the CDD value is going to be 50. So, this is the sum summation of 17, 14, 10, 5 and 4 this is going to be the CDD value for the week is going to be 50. Similarly, another week let us compare same we will be considering the daily temperature for another week starting from Monday to Sunday again the daily average temperatures will be compared with the 65-degree Fahrenheit of base temperature to arrive at the CDD value. So, as you can see for the second week the CDD value is 16 and this value of 50 for the first week the value is 50 and as you can see week 1 will be much hotter compared to week 2. You can see the temperatures as you see the temperatures are normally much higher compared to the actual temperatures on the week 2. So, that is the reason why you will have the CDD value for week 1 is going to be much higher compared to CDD value for the week 2. So, basically week 2 is going to be a cooler

summer month as compared to week 1. Now, we will be continuing with how exactly different hedgers will be entering into CDD and HDD futures contract in the next session. So, I am eagerly looking forward to interacting with all of you in the next session.