Commodity Derivatives and Risk Management
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Lecture 28

Welcome to the 28th lecture on Commodity Derivatives and Risk Management. And today we will be discussing Commodity swaptions and Asian options on commodities. Please recall that in the previous session we had briefly discussed commodity swaptions. So, we will be continuing with the commodity swaptions discussion as well as we will be discussing in a greater detail all things related to Asian options on commodities. Now, let us understand what is a commodity swaptions and how commodity producers and commodity consumers use commodity swaptions to mitigate the price risk. As mentioned here, in addition to futures, forward, swaps, options, commodity consumer and producer also enter into swaptions to mitigate the commodity price risk. And swaptions are always an OTC contract which is agreed bilaterally between two parties. And swaptions are two types, one type is the pay fix swaptions and the other type is your receive fix swaptions. So, in case of a pay fix swaptions, the trader enters into an option position and pays the option premium upfront. And by paying the option premium, it has the right to enter into a commodity swap to pay a fixed price or receive a floating price on specified future date or dates. So, this is an example of a pay fix swaptions because the buyer of the option who is paying the premium has the right to pay the fixed price. Similarly, in the other case, where the swaptions is a receive fixed swaptions, the option buyer pays the upfront premium but agrees to take a swap position where it will be receiving fixed price at a later point in time and pay a floating price. Hence, it is known as your receive fix swaptions. Now, let us go to a numerical example to understand how these swaptions are actually used by commodity producers and commodity consumers. As you can see let us say a refiner which buys 10,000 barrels of crude oil once in 3 months and the refiner is anticipating hearing that the price may go up over the next 9 to 10 months. So, standing on day 0 the trader enters into an option contract please note that on day 0 the trader pays the option premium and by paying the premium it has the right to exercise something and what is that something. So, on T_1 date it will be deciding whether it will go for a swap agreement or not and if it decides to go for a swap agreement, it will be paying fixed amount which is let us say 67 dollars per barrel of for crude oil for 10,000 barrels and payment to be made on T_2, T_3 and T_4 dates. So, 3 times this payment is going to be made by this particular option buyer for 10,000 barrels of crude oil at a price of 67 dollars per barrel simultaneously because it is a swap agreement the counterparty will also be paying the floating leg, or this party will be receiving a floating leg. So, what is going to be the floating leg agreed upon on day 0 let us say both parties have agreed that the counterparty will be paying the prevailing near month WTI crude oil futures price traded at CME on

the same dates. So, whatever the future price near month WTI crude oil future price which will be prevailing on those dates that is T_2, T_3 and T_4 dates that is going to be the floating lake. Now let us go to how exactly the payment will be done at a subsequent point in time, let us understand this aspect. As I mentioned on day T_1, let us say refiners still fear that the crude oil price is going to go up. So, it exercises the option and enters into the swap contract. Now let us move to day T_2 now on day T_2 let us say if the near month WTI crude oil future price at Chicago Mercantile Exchange is greater than 67 let us say it is 69 dollars. Then the swaptions buyer, that is the party who is standing here, the buyer of the swap son will receive 20000 from the swap counterparty. So, the price difference is 2 dollars and 10000 barrels. So, 10000 barrels into 2 dollars is coming to your 20000 US dollar. Let us take the counter situation or the opposite situation let us say on day T_2 the WTI crude oil future price is less than 67 let us say it is around 62 dollars. So, in that case this particular party which has bought the option that particular party will be paying 50000 dollars to the swap counterparty and this process will be repeated again on T_3 and T_4. So, this is an example of a pay fixed option and the swaptions buyer can also enter into a receive fixed swaptions. So, another trader who is fearing that the price is going to go down that kind of a trader may be in a position to enter into a swaptions which in that case it will be a receive fixed swaptions. And coming to another very interesting dimension which we have not discussed till date with respect to commodity options that commodity options can be European option, can be American option and can be Bermudan option. So, what do we mean by a European option and American option which we have discussed greatly, but we have not discussed what exactly is a Bermudan option. Now revisiting the discussion related to the refiner, the refiner which buys 10000 barrels of crude oil once in 3 months anticipating or fearing that the price may go up in the next 9 to 10 months. So, a couple of minutes ago, we just discussed the same aspect. Now, if this is the fear of this particular refiner and if the refiner wants to enter into a swaptions which is of a European nature, he pays the option premium on day 0 and buys the right to exercise the option on T_1. Please note that this is the trader who will be paying the option premium on day 0 and he has the right to exercise the option on T_1. He cannot exercise the option anywhere between the period T_0 to T_1, in that case that particular option will be known as a European option. Similarly, American option will be the party pays the option premium of day 0, but it has the right to exercise the option on any day up to T_1. So, any day from T_0 to T_1 this particular party will be able to exercise the option in that case it will be known as an American swaptions. Now coming to the most interesting aspect which we have not discussed till date is the Bermudan option. So, in case of a Bermudan option the party will be paying premium on day 0 that is T_0, it has the right to exercise, but which date it will be exercising that will be exactly mentioned on the contract. Let us say both parties agree that this particular party which is paying the option premium will be able to exercise the option let us say on day 10, day 20 and of course, on day 30 assuming that T_1 falls on the 30th day. So, day 10 and day 20 the particular party

is also has the right to exercise, in that case it will be known as a Bermudan option. And though we were discussing the Bermudan option in the context of swaptions, please note that Bermudan option is also applicable to any option which is agreed upon in the OTC market and this is definitely applicable for swaptions. Though I may be discussing this concept of Bermudan option with respect to swaptions, this Bermudan option has a relevance to any option which is agreed between both parties in an OTC market. With this, we come to one discussion end of discussion related to the swaptions but let us move to the very another interesting aspect of a commodity option which is known as an Asian option. Asian options are also known as an average price commodity option. Please note that an option is a European option or a American option or a Bermudan option depending on whether the long position can exercise the option only on a expiry date or any day up to the expiry or on specific days. So, couple of minutes ago we discussed this aspect related to European and American and Bermudan option. Now coming to Asian option, Asian option is an average price option and the same has nothing to do with the option exercise date. Please note that the European, American and Bermudan option category is depending upon when the long position holder will be able to exercise the option. But in case of an Asian option, the Asian option is related to the average price option, and it has nothing to do with the option exercise date. Please note that in case of an Asian option the exercise price will be compared with the average price of the underlying asset during the life of the contract to decide whether it would be an in the money option or an out of money option. Please note we have discussed also this aspect significantly in the earlier session, when we were talking about a European long-call position holder will benefit when the underlying asset price is greater than the exercise price. So, the benefit we represent as Max $[S_T - X,0]$. Now, if this particular option would have been an Asian in nature as you can see this formula will be changing little bit and what is the change in the formula, instead of writing S_T, we would write $S_{Average.}$ So, S_T represents the underlying asset price on the contract maturity date, but $S_{Average}$ represents the average of the underlying asset price during the life of the contract. Similarly, in case of a European put, the payoff is governed by Max $[X- S_T,0]$, in case of an Asian long put this formula will change it will be Max $[X- S_{Average},0]$. Now why this particular way of representing the underlying asset price in case of an average price option or Asian price option because the demand for commodities is fairly continuous and market participants tend to produce and sell as well as buy and consume commodity on an ongoing basis. Please note that physical market operation for commodity ah producers and consumer they are regularly producing commodities they are regularly selling commodities. So, buying derivative contracts where the exercise price is compared with a single t price on the on the contract expiry date price does not really help them to mitigate the risk in the best possible manner. So, many commodity producers and consumers prefer Asian options as their physical market buying and selling activity happens regularly rather than on specific dates. And please note that for the first time Asian options were offered by

Banker's trust of Tokyo in the year 1987, may be from that point in on point onwards this particular type of option is known as an Asian option. And please note that the Asian options are mostly European in nature, and they are exercised on the date of the contract expiry based on the average price of the underlying asset. Now, let us take a numerical example to understand the true detail of Asian options. As you can see the right-side panel explains the difference between an average price option and a European option. So, let us say one particular trader has access to enter into an average price option, Asian option or a European option. Let us say the contract expiry is for 5 days, we are taking let us say 4 different cases. So, in each of these cases please note that on day 1, the share price or underlying asset price is 7 rupees and on day 5 the exercise price on day 5 the commodity or the underlying asset price is 12 rupees. In all these 4 cases on day 1 the price is 7 and day 5 the price is 12, but in between the prices have gone up and gone down. So, as you can see you have this is just a simple line chart which indicates the movement of the underlying asset price over the 5 days. Now, if a trader would have taken a European option in all these 4 cases S_T is 12, S_T is your price corresponding to the contract maturity date in this case is the 5th day. So, in all these 4 cases the S_T is your 12, but if this particular trader would have been taking a contract which would be an Asian option, please see the underlying asset price is not going to be 12 rupees, but it is going to be the arithmetic average of all 5 days price. In this case it is coming to 13 rupees, 8.8 rupees, 12 rupees and 6.8 rupees. So, please note that this is an example of an Asian option which is considered arithmetic average of the prices to decide what is going to be the underlying asset price. Some Asian options can be based on the geometric mean prices for example, underlying asset price for the for the first case if the Asian option would have been a geometric mean-based price it would have been a multiplication of 7 into 12 into 14 into 20 into 12 to the power square root of 5 which is equal to your 12.31. Now please note that this average price option or Asian price option cannot be valued using your typical Black Scholes option pricing model because a Black Scholes option pricing model does not accommodate different kind of an underlying asset price. So, normally a Monte Carlo simulation is done to generate the price path for the underlying asset and those price path the average of those prices are considered for exercising the option or considered whether an option is going to be in the money or out of money option. In this context, I have done a simple simulation of this average price commodity option. So, let me show this one to all of you using excel. Before I proceed to the excel file let us assume that the current price of the underlying futures commodity is 100 rupees, why have I mentioning the word underlying futures because commodity options have the futures as underlying. The same logic could be applicable to any underlying asset, let us say annual standard deviation of the return of the future price is 31 percent and average daily return is 0.16 percent. And what is our objective? Our objective is to generate or simulate the daily price for the next 5 days as one instance and replicate the same process for the next 50 instances. Please note that I have only used 50 instances.

The same calculation or same logic can be used for 1000 instance or 50000 instance. So, there is no limit to generating all these different alternative price paths. And to generate day 1 price or next 5 days price I have used this particular formula which is your price on day t with day 1 let us say price on day 1 is going to be price on day 0 into 1 plus norm inf it is a function norm inf is a function in a excel file. Then rand is an also or random number generator in an excel file and I have also considered the daily return and daily return volatility. Please note that here what we have mentioned is the standard deviation of return of 31 percent which is annualized return. So, when I am forecasting, or we are going to generate a price for one day ahead we have to consider the daily return and daily return volatility. As you can see Norm inf is an excel function which provides the inverse of the normal cumulative distribution for the specified mean and the standard deviation. And why are we using this Norm inf function because we are assuming that the underlying asset return is normally distributed. And the rand function generates a random number between 0 and 1. With this let me take you through the simulation detail and please note that this particular file will also be available the excel file also will be available for to each of you those who will be doing this particular course as part of the NPTEL. So, as you can see day 0 price is 100 rupees daily average return is 0.16 percent and annualized standard deviation is 31 percent and standard deviation of daily this, 31 percent divided by square root of 252 is giving me this number. Please note that these are all hypothetical number this is not actual number in real life when somebody will be simulating the price path for Asian option, they have to consider the actual deep actual price average daily return and the actual standard deviation return standard deviation. As you can see based on this formula, please note that each of these cells has a formula the formula which I have already discussed and as you can see like let me just rerun this one. So, every time I am rerunning it is generating different combination of the price path. So, let me rerun here. So, in this case P 1 is one combination of the price path for 5 days. So, day 0 price is 100. So, the next one it could be 97.37, 101.68, 100.93, 100.15 and day 5 price is going to be 99.52 and based on all these 5 days price that is day 1 to day 5 this is the asset the average price this is a simple average price of the last 5 day. So, this is one instance which I am explaining the similar you know has been similar exercise has been done for only 50 instances. So, let me repeat this one more time. So, this is an example of a Monte Carlo simulation being used to generate the price path for average price option or Asian option. Now, let us go back to our discussion. So, as you can see this is again a snapshot of the picture which I have taken from the excel file. So, this particular picture is showing that 50 combination of the price path and these 3 pictures are showing the comparison of exercise to prevail on the fifth day for European option versus average of the 5 days for the Asian option. So, if somebody has entered into a long call or long put or short call or short put option using Asian option what is going to be the S average which will be considered for the option vis-a-vis somebody who has entered into a European option which will be considering only the fifth day price for deciding whether

an option is going to be in the money or out of money option. So, as you can see these are again 3 random snapshots which I have taken from the excel file and as you can see the blue line shows the fifth day price combination. So, these are your fifth day combination prices and the orange line is the average price of all 5 days and as you can see that in every combination the dispersion or the volatility of the average prices much smaller compared to the volatility associated with the fifth day price. So, the fifth day price shows greater volatility compared to the average prices. Hence, Asian options are generally less expensive than the corresponding European options as the uncertainty about underlying prices is lower when averaged. So, whenever a trader has an option to enter into a normal European option, the option premium will be much higher compared to an Asian option of course, everything else remaining constant the option expiry, underlying asset volatility, risk free rate etcetera. If all these factors remain constant, then Asian option will be selling at a much cheaper rate as compared to a any other option of European in nature. Now coming to does really exchanges offer this kind of an option if there is a need for the consumer commodity producer or commodity consumer. Please note that I did mention that commodity producers and commodity consumers normal physical activity make them interested in taking an average price option.

So, in line with that many commodity exchanges offer exchange traded average price option these are not bilateral contract these are exchange traded average price option. So, some of the sample list of average price options from the Chicago Mercantile Exchange. So, these are as you can see this in a 6 to 7 list indicates the list of average price options. Again, please note this is not a comprehensive list. I have just taken a snapshot of the average price options available at Chicago Mercantile Exchange. Similarly, London Metal Exchange also offer contracts which are known as popularly known as TAPOS or Traded Average Price Options. As you can see from this again this particular snapshot is the contract specification which I have taken from the London Metal Exchange. So, as this detail is given here, and this is an example of contract specification of the Traded Average Price Option. Like any contract specification there will be lot of information, but what I want you to pay attention is the last line which is your option style in this case is an Asian mentioned. It is not American or European or Bermudan, but it is mentioned as an Asian, Asian means it is an average price option. So, with this we come to our end of today's discussion related to different types of options being available in OTC market as well as exchange traded platform for commodity producers and consumers to hedge the risk. Commodity swaptions are OTC contracts bilaterally agreed upon. However, exchange traded average price option or average price options can both be bilateral contracts as well as exchange traded contracts and many exchanges offer these Asian options as exchange traded contracts. Because there is a strong need from commodity producers and consumers to take invest in these options to mitigate the price risk. So, with this we come to an end to all things what we are supposed to discuss with respect to options. In the subsequent lecture session, we will be starting with the different

commodities related individual commodity related contract specification pricing and so on so forth. So, with this I greatly look forward to interacting with all of you in the next session. Thank you all of you.