Commodity Derivatives and Risk Management
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Week-06
Lecture 27
Put-Call Parity, Implied Volatility, Swaptions

Welcome to the 27th lecture on Commodity Derivatives and Risk Management. And today, we are going to discuss various aspects of put call parity, implied volatility and swaptions that is options on swaps. So, let us understand what we mean by a put call parity. Please note that commodity options have commodity futures as underlying. But please recall that a couple of sessions ago, we had extensively discussed related to the cost of carry model for commodity futures and how the actual price if it deviates from the cost of carry based model price one can do an arbitrage. So, the arbitrage could be cash and carry arbitrage and reverse cash and carry arbitrage. Now the question arises does arbitrage opportunity exist for options on future that is commodity option. The answer is yes. In fact, there exists a no arbitrage relationship between the commodity option underlying and that is known as your put call parity. So, what exactly does put call parity? The put call parity equation relationship states that the call premium plus the strike price should be equal to the put premium plus the future price. Let me repeat that the parity condition states that the call premium plus the strike price should be equal to the put premium plus the future price or we can state simply $c+X= p+F$ or $c+X-p-F=0$. And please note that this put call parity condition is only applicable to the European options. The moment commodity options become American options or any other type of option this put call parity will be changing. However, for today's discussion or for discussion in this particular lecture series, we will be focusing only on the put call parity associated with the European option. Again, if you want to read more on this particular aspect there are you know some good textbooks which are available on commodity option which elaborates which goes into the detailed discussion related to put call parity applicability in case of other kinds of options. So, as you can see the put call parity connects the call premium, put premium for a given underlying and a given maturity with underlying future price and the exercise price. Now, let us check whether the put call parity actually holds true or not, that is $c+X=p+F$. So, let us say I have taken again an option calculator, black 76 option calculator from the multi commodity exchange. I have just given randomly some numbers and let us see these are the actual price also features in the market. So, assume that this price also prevails in the market. So, what do you mean by this? 52 is the call premium as you can see 52 rupees is the call premium and what is the put premium 463 rupees is the put premium what is our x is 6500 that is your strike price is 6500 and the underlying price is 6086. So, when we are checking this

aspect in the put call parity framework as you can see the difference between the left side and the right side is only 3 rupees and this difference is too small for arbitrage opportunity because this particular equation has not taken into consideration the brokerage fee. Every time somebody will be buying and selling a call option or put option, they also have to pay a brokerage fee. So, without factoring in the brokerage fee if the put call parity difference is only 3 rupees that means, there is not enough difference for somebody to make an arbitrage profit. Of course, this particular calculation is based on an option calculator and this option calculator gives theoretical price which conform to the parity condition. In real life, if the call and put premium are mispriced and trading at a different price that will give rise to the arbitrage opportunity, and we know the arbitrage opportunities always a buy low and sell high. At the moment we are talking about arbitrage, it is a riskless strategy and people buy low and sell high. Let us take again a theoretical example let us say the call and call premium and the exercise price remains constant, but what changes is the let us say put premium is trading at 430 rupees instead of 460 rupees. If that happens as you can see c+X which will be 6552 will be greater than p+F which will come to 6516. So, the left side of the equation is going to be more than the right side of the equation. So, if that happens again following our buy low and sell high strategy what the trader will do is that their trader will undertake a buy put and a sell call and a buy futures position. So, as you can see this side is lesser than this side. So, the trader will be buying the put as well as buying the futures contract and the trader will be selling the call option. If the reverse happens if c+X is less than p+F obviously, the other side of the transaction will be done, but the logic still remains buy low and sell high. Now coming to another very interesting aspect which is related to a commodity option or for that matter of any option contract is the implied volatility. Here I am focusing on the word implied. Please note that all along many times we have discussed that the option premium both call or put premium is a function of underlying asset price, strike price or exercise price, time to maturity, risk free rate and underlying asset volatility. Please note that I have used the notation F here because we are discussing with respect to the commodity options which our commodity futures as underlined. This notation will be changed to S_0 or S when the commodity spot price will be the underlying. Now coming to your sigma, which is your historical volatility. Sigma represents historical volatility, and one needs to find out the sigma to calculate the option premium. So, we have to have a view related to f, x, t, r and sigma and sigma, we calculate from the underlying asset return volatility and that is plugged into different model to arrive at what is going to be the option premium, the call premium or put premium. But when we are talking about the implied volatility, we calculate this implied volatility in the reverse manner. So, how exactly do we calculate the implied volatility? Please note that when one uses the option premium traded in the market and back calculates the volatility, the same is known as an implied volatility. So, we do not use the sigma to calculate the

option premium. In a given day in the market, buyers and sellers are call premium put premium different people are trading the options are different premium.

Now, if we plug this premium into the calculator and we know what the f is, we know what the x is, we know what the t is, we know r and we find out what is going to be the corresponding sigma. So, call and put premium we take it from the market that we model into the option calculator, and we back calculate what is going to be the applicable volatility. So, that is measured as your implied volatility and implied volatility is the volatility implied by the known option price. Let us take this example again this is an implied volatility calculator, I have just taken some random values, underlying asset price is 100 rupees, strike price is 90 rupees, days to expiry is 60 rupees, prevailing interest rate is 5 percent and there are some other component which is available and please note that we are not giving the volatility what we are giving is the we are giving the price let us say this particular option is trading in the market at 11 rupees and when we are back calculating this particular option calculator is giving us the volatility assumed by this price which is 19.58 percent. So, as I explained by inputting the same price of 11 rupees option price into the model one gets the implied volatility of 19.58 percent. So, what does exactly 19.58 percent implied volatility means? That means, this particular trader who has paid or received 11 rupees for call option premium for all these underlying conditions this particular trader is expecting the underlying asset volatility to be 19.58 percent within the next 60 days and why are you using the word next 60 days, because the date to expiration which we have taken into consideration in this particular calculation is a 60. So, let me repeat 19.58 percent of implied volatility means that the trader is expecting the underlying asset volatility to be 19.5 percent within the next 60 days. So, this is the concept of implied volatility. Now, let us come to understand what you mean by implied volatility index. Implied volatility index is the index of this calculated volatility values. So, I have taken just again a hypothetical example for calculating the implied volatility index. Let us understand what the meaning of this particular table is and from here why how one can calculate the implied volatility index. Please note that this is again a hypothetical example this is not based on the real-life data. So, on a given day the F_0 the underlying asset price is 100 rupees we have various combination of x you ranging from let us say 80 rupees to 120 rupees and in a number of days of the expiry of this particular option contract is 60 days and r remains constant that is 5 percent and we can have either a call option or put option and please note that based on these parameters suppose this particular option is trading call premium is trading at 11 rupees in the market. So, implied volatility is going to be 19.58 percent. Similarly for different combination of this strike price, as you can see, the call premium or put premium is different. This is what people are buying selling in the market. Please recall we had discussed about open high low close values of the option premium. So, at a given moment different options premium are paid and received by long call and short call position holder. So, from that market price we are inputting into the model and calculating the implied volatility. As you can see,

these are your implied volatility based on these parameters. Now, if somebody uses this implied volatility and creates an index out of it that is going to be called as an implied volatility index for that particular commodity for that given maturity. So, let us say we have the these are the total number of call and put options trading and these are the different price point, we calculated the implied volatility for each combination of call and put for each for different strike prices and we create an index out of these values, we will be getting an implied volatility index. And please note that the implied volatility index is regularly being calculated and reported by different commodity exchanges. One of the leading commodity exchanges which has popularized this implied volatility index concept is the Chicago Mercantile Exchange. This CME is calculating and reporting implied volatility indexes for many commodities, and these are known as CVOL indexes. And what CME quotes in their website they mention that using their proprietary simple variance methodology that assigns equal weighting to strikes across the entire implied volatility curve the CVOL index produces a more representative measure of the market expectation of 30 day forward risk. So, as you can see this implied volatility index helps one in getting a market expectation, what market is pricing, what market is thinking about the volatility which is going to be prevailing in the next number of days. Here I have mentioned 60 because it is a hypothetical example, but CME when it calculates the CVOL index it takes the 30 days forward options having a 30-day maturity and hence it calculates the C-vol index which gives an indication of what is going to be the 30 day forward volatility. As we just now discussed this implied volatility index is also known as the fear gauge and implied volatility is a major of expected future bounciness of the underlying as opposed to the realized volatility which is a major of what has already happened. Please remember or please understand that in case of a Black Scholes option pricing model, we calculate the sigma from the historical prices, using the historical prices we find out the asset return and the standard deviation of that return series is plugged into the Black Scholes option pricing model or Black 76 model to arrive at the call premium or put premium. But in case of implied volatility, we are doing the other way around. So, implied volatility is a measure of expected bounciness of the underlying as opposed to the realized volatility which is a measure of what has already happened. And this is a quote unquote from the CME website and see please note that a CME calculates and reports commodity implied volatility index for many commodities such as wheat, corn, soybean, gold, silver, crude oil etcetera. And like CME, Bloomberg also calculates the implied volatility index for many commodities depending upon the traded option prices. Please note that as a data provider Bloomberg has access to the options traded at different exchanges. So, CME only calculates and reports the volatility index for all those commodity options which are traded at CME platform, but Bloomberg being a data provider has access to the option trading data for other commodity exchanges. So, Bloomberg also calculates the implied volatility index for many commodities. Please note that the methodology for calculation of implied volatility may vary slightly sometimes

some exchanges may use only in the money option, some exchanges may use only out of money options, or some exchanges only use at the money options to calculate the implied volatility index. The methodology may vary, but the concept of implied volatility remains the same. So, Bloomberg as I mentioned Bloomberg also calculates the implied volatility index for many commodities depending upon the traded option prices. So, this this particular slide shows the Bloomberg implied volatility index values for the last 5 years. This data which I have downloaded from the Bloomberg database which we at IIT Kharagpur as a researcher or teacher we have access to it. So, let's understand this implied volatility index for gold, wheat and crude oil. As you can see crude oil volatility increased to 128.89 percent on 21st April 2021 coinciding with the COVID period. On average, as you can see, the volatility index for crude oil option remains in the range bound to 20 to 30 percent maximum, but during this period of time it peaked on 21st April 2020 and went up to the range of 128.89. So, as you can see the market was getting very jittery. The market was expecting significant amount of price volatility because of the COVID related uncertainty, and the implied volatility index increased to 128.89 percent for the crude oil. Similarly, for gold the implied volatility index picked on 18th March 2020 of course, that is over a period of the last 5 years. So, gold picked gold volatility index reached a peak of 37.41 percent on 18th March 2022. So, again a period coinciding with your COVID related uncertainty. On average, as you can see the implied volatility for crude oil implied volatility options is much higher compared to the gold implied volatility. Gold implied volatility ranges within 15 to 20 percent maximum as you can see, but here if as you can see that implied volatility for crude oil ranges between 20 to 50 percent on normal. Of course, during COVID period it increased or spiked significantly, but when we are comparing the implied volatility in general or average values as you can see crude oil volatility implied volatility is much higher as compared to the gold volatility. And interestingly I had also downloaded the implied volatility for the wheat as you can see implied volatility remained range bound for within 40 percent for wheat for most of the year and this particular day which is coinciding on your 4th April 2020 it peaked a 60.58 percent which was not coinciding exactly it was after the Russia's invasion of the Ukraine. Russia and Ukraine are the largest producer of the wheat in the world, two largest producers of the wheat in the world and when Russia's invasion of Ukraine happened market became very jittery and that got reflected in the implied volatility of 60.58 percent. Now, the question is why we are discussing this implied volatility with respect to commodity option. Please note that the higher the implied volatility, the higher is the risk associated with the underlying asset price or underlying a commodity's future price. Please note that many large export and import houses which are basically large exporter and importer of commodity related export and import houses they have started using the implied volatility index to gauge the underlying asset price movement in the near term. So, implied volatility is a volatility which says what is going to be the volatility maybe 30 days ahead or 60 days ahead is a forward-looking volatility

figure compared to the historical volatility where we have whatever has happened. So, that is not much of a use to this export or import houses. So, this export and import houses have started using the implied volatility index to get a view of what is going to be the underlying asset price movement at least in the 30 to 60 days. In fact, many traders have also started using the implied volatility to determine the future price level and consequently find out whether an option is going to be in the money or out of money option. So, today if as a trader somebody is interested to take a long call or long put or short call some short put position their decision to pay the premium is governed by whether this particular option is going to be in the money or out of money by the time the expiry happens. So, implied volatility gives a is being used as a very robust and it is strong indicator of what is going to be the risk associated with the underlying asset price movement and kind of a gives an indication to this trader whether their options are going to be in the money or out of money options. So, volatility index is being used by many sophisticated traders to take them to get a view on the underlying asset price movement. Now, let us come to another very important interesting aspect related to commodity price risk management. Please note that since the beginning of this particular lecture series, we have discussed about forwards, futures, swaps, options etcetera as a mechanism by which commodity consumer and producer mitigate the price risk. Now, in addition to this futures, options, swaps and forward contracts, commodity producers and consumers can also enter into swaptions contracts to mitigate the commodity price risk. Please note that the swaptions are OTC contracts or bilateral contracts. These are not standardized exchange traded contracts as we saw being listed and traded in various commodity exchanges. Swaps and bilateral contracts both parties enter into an agreement and take a swaptions contract. So, what exactly is a swaptions contract? Swaptions contracts are basically options on swaps. It is very easy to understand from the name swap and are options on swap contracts and this can be two types this swap, and contract can be receiving fixed swap and or a pay fixed swap and how exactly this swap and contract works. Let us say a trader enters into an option position on a day 0 and pays the option premium upfront. So, the trader enters into an option contract and pays the option premium upfront and by paying the option premium we know that the buyer of the option or the party which is paying the option premium has the right to do something and what in this case what is that right? The right is to enter into a commodity swap to pay a fixed price or receive a floating price on a specified future date or dates. So, this will be an example of a pay fixed swaptions. In other type the trader enters into an option position pays the upfront option premium and by paying the upfront option premium takes the right or gains a right and that right is to enter into commodity swap to receive the fixed price or pay a floating price on a specified future date or dates. So, this is an example of a receive fixed swaptions. With this we will be winding up today's lecture session. We will be continuing with the remaining part of the swaps on commodities and other types of options contracts which commodity producers and consumers take to mitigate various

kinds of price risk. So, let me summarize what we discussed today. We discussed how put call parity as a no arbitrage relationship holds true in case of commodity if no arbitrage condition of put call parity gets violated traders can enter into arbitrage position by buying low and selling high. We also discussed what is the concept of implied volatility and how one can calculate or how commodity exchanges are calculating commodity implied volatility index on different commodities and how this implied volatility index is being used by commodity producers and commodity consumers to get a forward-looking view about the future price. And we also just briefly discussed swaptions and commodities and we will be revisiting the swaptions on and commodity in greater detail in the subsequent lecture. Again, I look forward to interacting with all of you in the next lecture session and thank you all of you.