**Commodity Derivatives and Risk Management**
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**Lecture 42**
# Crude Oil and Crude Oil Derivatives Price Risk Management (Cont....)

Welcome to the 42nd lecture on Commodity Derivatives and Risk Management. We will be continuing with the previous session in which we were discussing different aspects of crude oil markets and crude oil derivative price risk management. Now, let us recollect what we discussed in the previous session. Please remember that though there are 200 different varieties of crude oil produced all over the world, there are four crude oils which are known as the marker crude. So, this is North American WTI, West Texas Intermediate Crude, North Sea Brent Crude, OPEC Reference Basket, and UAE Dubai Crude. And when we talk about the price of WTI and what is the price of Brent, how exactly this spot price of WTI and Brent is arrived at we discussed in the previous session. Now, we will continue with our understanding what do we mean by the OPEC Reference Basket Crude price as well as UAE Dubai Crude price. Now coming back to the OPEC Reference Basket, OPEC is known as or short form of organization for petroleum exporting countries. And this OPEC reference market price is nothing, but the average spot price of crude oil produced by OPEC member countries. And OPEC is an intergovernmental organization which was established in the year 1960 by five members. And these five founding members are Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. And till 2016 OPEC had 13 member countries and OPEC is also known as one of the important producers' cartels. And as we discussed, the OPEC reference basket is the weighted average price of crude oil produced by the member nations and the weights are based on the production and the export volume. And these 13 members who are the members of the OPEC is mentioned here as you can see the initial or original founding members Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. After that you have Algeria, Angola, Congo, Guinea, Gabon, Libya etc. have joined the OPEC. In 2016, OPEC also formed alliance with other oil producing nations and this group is now known as the OPEC Plus. And OPEC Plus countries there are other 10 members which have joined the OPEC countries to form the OPEC Plus countries. And these OPEC Plus members collectively decide the amount of production each country is going to produce for the next year. As a producer cartel please note that as a cartel they have a common objective to ensure that the price does not go too high, or price does not go too low. So, to control the price this cartel or this group sets the total amount of production each country or each member is going to do or produce in the next year. In fact, by increasing or decreasing the production quota OPEC tries to control the crude oil price for OPEC reference basket.

So, let me show you an example of how the OPEC members set the production quota for themselves. The latest production quota which was announced on 4th June 2023 which is based on the 35th ministerial meeting of the member countries and which is in this particular meeting they agreed on the production quantity which will be starting from January 2024 to December 2024.

The source of this particular news item is mentioned here and as you can see different for different member nations the cartel, or the group has given the required production label as you can see Algeria, Angola, Congo and all that details it is very clearly mentioned which country is expected or required to produce what amount of crude oil for the next year. So, now coming to the fourth marker crude which is your UAE Dubai crude. So, this UAE Dubai crude is the light sour crude oil which is extracted from the Dubai region and Dubai crude oil price is used as a benchmark for crude oil produced in the Persian Gulf region and it is one of the most popular crude oil price benchmark for Asia in the sense majority of crude oil producers and consumers are bulk buyer if they are producing any crude oil or if they are buying crude oil they would like to price them as with respect to UAE Dubai crude. In addition to the four-marker crude this in a price reporting agency are also preparing and informing lot of index, for example Argus media prepares a index which is known as Argus sour crude index and this sour crude index is prepared based on the volume weighted average of actual transaction done for three grades of crudes. So, these three grades are known as your Mars, Poseidon and South green Kenyan. So, these are the three different varieties of crude oil price is used by the Argus media to prepare a Argus sour crude index and this index is now used extensively by many companies to price their products. For example, Saudi Arabia, Kuwait and Iraq are using this ASCII index to price their exports to mostly to the US. In fact, many crude varieties which are produced by different companies and different countries such as Arab light, Kuwait export blend, Basra light, Kirkuk all these varieties are priced against Argus sour crude index price. In addition to the Argus sour crude index Japan crude cocktail index is also used as a reference price. So, this index is an average price of crude oil imported to Japan and this index is reported by the Japanese custom department and this Japanese crude cocktail index is used to price the crude oil as well as liquefied natural gas price in Asia Pacific region. In addition to these indices, the international crude oil price for Indian basket, so this particular index which is prepared by the petroleum planning analysis sale of the Ministry of petroleum of natural gas in India. So, this basket is considered as an indicator of India's crude oil import price and this index considered the price of sour grade that is Oman and Dubai average and sweet grade that Brent dated Brent price of crude oil in the ratio of 75.62 to the 224.38. So, the prices of sour grade Oman and Dubai average as well as Brent dated Brent price ratio is used to calculate and report the international crude oil price for Indian basket. So, these are some of the indicators of popular indices or marker crude prices. In fact, in addition to that many other companies like Standard and Poor's and Platts etcetera are also offering many indices which are used

to price or the varieties of crude oil. Now, coming back to understanding what influences the crude oil price. In fact, this is one of the most difficult aspect one can think of there are hundreds and thousands of factors which influence the crude oil price, but for the sake of discussion we will be only discussing only few important factors which have a bearing on the crude oil price. Please note that the crude oil prices have strong correlation with the geopolitical activities and majority of crude oil reserves are located in regions which experience frequent political upheaval. So, that is one of the reasons why we get to see the crude oil price fluctuating significantly. And more importantly please note that USA, Russia, and Saudi Arabia which are the three important dominant crude oil production countries which about these three countries control about 42 percent of the global production of the crude oil and the political relationship between or among these three countries significantly affect the oil prices, crude oil prices. Crude oil price is also significantly influenced by the supply and demand condition for like any commodity. And here it is also very important to understand that crude oil supply as well as consumption is relatively inelastic in the short term. So, crude oil supply cannot be reduced very quickly, similarly crude oil consumption in the sense the refined product consumptions cannot be reduced all of a sudden. So, crude oil supply as well as the demand both are relatively inelastic in the short term. Now, though the supply is inelastic OPEC also influences the world oil prices as OPEC traditionally has been known as a swing producer. So, what is the meaning of a swing producer? So, swing producer is a company or an organization which is capable of increasing or reducing the supply of any commodity with minimal cost. So, swing producer is producers are also able to influence price. So, a producer which will be treated as a swing producer if they wish will be able to increase the production of the commodity or will be able to reduce the production of the commodity. So, if a particular set of companies or entities are able are in a position to increase or reduce production, they will be able to influence the price. So, OPEC as a swing producer OPEC role has been quite significant in terms of influencing the price of the crude oil. And among the OPEC member countries like Saudi Arabia which is the largest producer many a times this particular country also has voluntarily reduced the crude oil output to increase the crude price. So, the action of the OPEC and the OPEC members also influence the crude oil price significantly. In addition to the demand supply situation the US dollar strengthening of US dollar also impacts the crude oil price significantly. We will be discussing how exactly the US dollar is calculated and how the strengthening of the US dollar affects the crude oil price in the next couple of minutes. Now, in addition to this aspect financialization of crude oil is also a significant contributor to the crude oil price, increasing of crude oil price. In fact, when we are talking about the word financialization of crude oil, so financialization indicates that the trading activity of financial investors such as swap dealer, hedge funds and commodity index traders are affecting the volatility and price of crude oil significantly. In addition to the financialization of crude oil supply of renewable energy is also emerging as an

important factor which is influencing the crude oil price. Renewable energy sources such as solar and wind could see a decline in the world reliance in oil. So, if there is a significant amount of production of renewable energy one can expect crude oil prices to go down. Now, let us understand what exactly the US dollar index is and how the US dollar index influences the crude oil price. So, the US dollar index which is popularly known as USDX. So, these USDX tracks the US dollar's relative strength against a basket of 6 foreign currencies. And the index is calculated as a weighted average of US dollar exchange rate which is normalized by an indexing factor. So, the indexing factor is 50.14348112 honestly speaking I do not know the basis behind which this particular number has been arrived nevertheless today let us understand how exactly this US dollar index is calculated. And US dollar index considers the exchange rate between US dollar and the 6 other currencies basically Euro USD, USD JPY that is Japanese yen, Great Britain pound USD, USD Canadian dollar, USD Swedish kronor, and USD Swiss franc. So, these are the 6 different currency pair, exchange rate is used to calculate the US dollar index and the formula for calculation of this index is given here. And please note that in this index Euro and USD index has a Euro USD exchange rate has 57.6 percent weightage, Japanese yen and USD has about 13.6 percent weightage and other 4 currencies have in total amount of weightage is clearly mentioned. And as you can see here the index weight is negative which is 57.60 percent negative here as well as 11.90 percent negative here. And this negative weight is because of the fact that Euro USD and GBP USD is quoted in a different manner as compared to any other exchange rate. Please note that the interbank market USD is the base currency for all currencies except for Euro GBP. Let me repeat that in the case of a interbank market the US dollar is used as a base currency for all currency except Euro and Great Britain pound. Now, in the case of all other currencies the price of foreign currency for 1 unit of the US dollar is expressed. So, the normal norm or in the case of a interbank market, will always be the price of a foreign currency for 1 unit of USD will be quoted. For example, here when we are seeing let us say USD CAD 1.35 means it is 1.35 Canadian dollar is equivalent to 1 US dollar. But for the Euro as well as Great Britain pound the quotation is other way around. So, for Euro USD rate price of USD per 1 unit of Euro is expressed. So, that is the precise reason why you can see the index weights are negative for Euro USD and GBP USD. And this particular table I have just taken some values with respect to the different currency pairs, that is exchange rate values and based on this particular formula and I have calculated the dollar US dollar index for that particular day stands at 102.74. So, what is the meaning or how do we go about interpreting this US dollar index? And please note that the US dollar index has a base value of 100 and this supposes the index stands for index value is 110. So, it indicates that the US dollar has appreciated 10 percent versus the basket of currencies over time. So, from the base period to the date in which the index is being calculated suppose that day index is 110 that means, we can assume that during this period the US dollar has appreciated 10 percent versus the 6 other currency pairs. Now,

coming back to why US dollar will be negatively influencing the crude oil price, please note that higher index is associated with the lower crude oil price because when the US dollar appreciate index goes up and US dollar appreciation means that the other currency is depreciating and when the other currency is depreciating the foreign countries are paying more in domestic currency terms to buy the same unit of crude oil. So, in that case the crude oil becomes much more expensive hence the price of the crude oil goes down. So, crude oil price is negatively correlated or should be negatively correlated with the US dollar index value. Now, this particular slide shows the details related to the marker crude oil price and the inventory of crude oil as well as the relationship between US dollar index and crude oil price. This first block shows the USD spot price for the WTI crude oil as well as Brent crude oil, OPEC daily spot price as well as Dubai for this spot price. So, the four marker crude spot prices are plotted for the last five years this data which I have downloaded from the Bloomberg website, Bloomberg station available at IIT Kharagpur. So, as you can see these prices are almost nearly identical with very little variation of course, during 2020, April 2020 which is a period coinciding with the COVID WTI crude oil price went negative. So, we will be discussing in detail why it went negative except for WTI and in fact, all other four crude oil prices almost move in a similar manner and have a very little price difference. And this block, the second block indicates the WTI spot price with the WTI inventory. As you can see this particular chart shows the price movement of WTI spot price which is in the line chart and the WTI inventory and WTI inventory at the Cushing Oklahoma warehouse which this detail is again published by the Department of Energy USA and this detail is related to the monthly data this is not the daily data monthly data of crude oil inventory available at Cushing Oklahoma. As you can see whenever there is a higher inventory crude oil WTI crude oil price goes down and here this is the period which is coinciding with the peak amount of WTI inventory at Cushing Oklahoma and the same period is coinciding with the lowest price of the WTI crude oil. And this index again shows the relationship between the US dollar index and WTI crude oil price and this WTI crude oil price is nothing, but the generic first futures contract price. That means, it is the future price in the near month future price which again I have downloaded from the Bloomberg and US dollar index and WTI generic first futures contract as you can see the relationship between these two important aspects of a crude oil. Now, coming back to what are the derivative contracts which are available on crude oil and output from the crude oil. So, when I am using the word output from the crude oil I mean the refinery products such as jet fuel petrol diesel etcetera and when I am using the word derivative means these are related to your futures and option contract which are available at different commodity exchanges which can be used by companies to mitigate the price risk. In fact, almost all commodity exchanges offer derivative contracts on variety of crude oil and crude oil output such as diesel natural gas aviation turbine fuel heating oil Naphtha etcetera. And there are endless types of futures options spread contracts are available in these exchanges to meet the needs of the hedges and

speculators alike. In fact, compared to gold the number of different types of futures options spread contracts available at the exchanges mind boggling it is at CME probably about 50 to 60 different option contracts different types of futures contracts are available. In addition to the exchange traded option contracts many companies which are in the you know whole value chain aspect of crude oil they enter into bilateral for bilateral contracts and option contracts and swap contracts to mitigate the price risk associated with crude oil and other refined product. So, the right-side block which I have taken which is from the reliance annual report 2022 as you can see this reliance clearly mentions what is the extent of commodity risk exposure commodity derivative contracts, they have entered in the OTC market as well as the exchange market and as compared to the total exposure. So, this clearly indicates that companies use this derivative contract to mitigate the crude oil and other refined product risk. In addition to the reliance annual report, I have also taken a snapshot of the commodity price risk management from a shell company which is for the year 2022. As you can see, the company very clearly mentions that company enters into price risk management by entering into oil natural gas and power underlines for oil natural gas and power these are swaps and options and future contracts. Now, coming back to airlines which are one of the significant users of derivative contracts related to jet fuel please note that the jet fuel is jet fuel consists of one of the major expenses related to airline companies and all over the world airlines report about 20 to 25 percent of the total operating cost comes from the cost of jet fuel and it is one of the largest single most operating expense item for airline companies. And this table shows the southwest airlines company's annual report and these views related to the jet fuel hedging practices. As the company mentions jet fuel company intends to buy jet fuel at the lowest possible price and to reduce the volatility in operating expenses through its fuel hedging program and jet fuel is not widely traded in organized futures exchanges for a longer maturity. Hence, the company enters into a cross currency hedge cross hedge not cross currency hedge company enters into cross hedge related to WTI crude oil, Brent crude oil and refined products such as heating oil and gasoline contracts. And very interestingly the company also mentions the different types of derivative contracts the company enters into. For example, the southwest airline company mentions that they enter into they take call options they take collar structure which is basically entering into call option as well as put option. This aspect we have very clearly discussed in the previous session with respect to the gold that how gold mining company companies use collar structure to mitigate the risk or take a position with respect to zero cost hedging. The company also enters into call spread and put spread and the company also enters into fixed price swap agreement in its portfolio. So, these are some of the interesting aspects with respect to the southwest airline companies annual report and as I also shared the snap snapshots of reliance annual report and shell annual report. It is very obvious that companies who are in the business or value chain partner in the crude oil they enter into derivative contracts to mitigate the crude oil price risk and not only crude oil price risk

also the price risk associated with products refined products which are generated from the crude oil. This lets us understand one of the very interesting and very unique aspects of the crude oil market is the futures price turning negative which happened during the COVID pandemic period.

So, let us understand what causes the negative crude oil price, negative crude oil future price and what are its ramifications. Please note that a near impossible event happened on April 2020 during the COVID pandemic and this during this period of time WTI May 2020 futures contract that is West Texas intermediate May 2020 futures contract which are listed at traded at NYMEX CME this particular contract was you know normally this particular contract was expiring on 24th April 2020. As this contract was a delivery-based contract long futures position holders were required to receive the crude oil from the short futures position upon expiry. Please keep an eye on the expiry date which is the 24th of April 2020. And as part of the contract settlement long futures position holders are supposed to receive crude oil from the short futures position holder during the expiry. And at that point in time there was no refinery was doing any kind of a processing because there was no demand for petrol, diesel and aviation turbine fuel as any form of travel had practically come to a halt and crude oil storage tanks were nearly full at Cushing USA. So, companies were producing crude oil and there was hardly any refining activity was happening because there was no demand for the refined product such as petrol, diesel, and aviation turbine fuel. And in that process crude oil storage tanks at Cushing Oklahoma were operating nearly full capacity. And the crude oil inventory increased by 23 million barrels during the month of April 2020, and which picked about 65 million barrels of in storage which was about 83 percent of the total working capacity available at Cushing USA. And long futures position holders were not in a position to receive oil. Please note that the contract expired on 24th April. On 18th April this May 2020 contract which was expiring on 24th April that closed at a price of 18.17 dollars as you can see from the right-side block as you can see from the right side block the May 2020 contract which was expiring on 21st April. So, that particular contract on 18th April closed at a price of 18.27 dollars. And on 20th April, which was the Monday on that day you had this May 2020 futures contract, which was expiring on 21st April, throughout the day the future price fell to the negative of 40.32. So, it is unheard of that the price of a particular commodity going down to going below 0. So, on that day the price of the futures contract went negative by 40.32 before closing at a negative of 37.63. So, this settlement this particular futures contract settles at 37.63 US dollar negative value. On 21st April, on the contract maturity date the price fell to the day low of 39.44 before settling at 10.1 before settling at a positive of 10.01 dollar. Now, because of the price there was no inventory and no space to store the inventory of the crude oil. So, the long futures position holder was not in a position to receive crude oil. So, what they were doing they were interested to close the long position at any cost they were even willing to pay a price to the counterparty. So, that they can square up their long position. So, that is

the precise reason why the crude oil future price went negative on 20th April 2020. Here also I would like to draw your attention to the fact that negative WTI crude oil future price did not actually indicate that crude oil has become had become worthless at that point in time. It was more to do with an aberration induced due to the COVID pandemic and more to do with the lack of storage facility. So, the aberration related to the COVID pandemic as well as lack of storage facility led to a negative crude oil future price. And this is something of a unique event in the life of any futures contract. In fact, the negative crude oil price at NYMEX WTI futures contract created an unprecedented situation for multi commodity exchange of India. Please note that the multi commodity exchange April 2020 contract expires on 20th April. So, the day the NYMEX WTI futures contract went negative on the same day April 2020 contract of multi commodity exchange crude oil futures contract was also maturing. Please note that as per the contract specification of multi commodity the multi commodity exchange the final settlement price will be reported in this manner. So, as you can see in the quote unquote the near month contract settlement price will be done at NYMEX WTI crude oil contract converted to rupee terms based on UST INR reference rate. So, the final settlement price will be based on the price prevailing at the NYMEX WTI futures contract. So, in this context please note that on 17th April for the contract which is maturing on 20th April 2020 the contract closed at 1436 rupees. But on 20th April 2020 the contract there was some trading in the contract, but the exchange was forced to close it at 1 because it was not possible for the exchange to allow traders to give negative price because the system the information technology IT system of the multi commodity exchange did not allow or did not permit traders to enter the negative price. So, on 20th April 2020 the MCX system did not allow negative price order entry. So, MCX did an interim settlement of 1 rupee. Subsequently about 2 to 3 days later MCX considered a negative price of 2884 as a settlement price. And when this happened a few brokerages house have filed a case against multi commodity exchange indicating how can the settlement price will be negative. So, I do not know exactly the outcome of this case, but at it was a major news in terms of that many brokerage houses have filed case against the multi commodity exchange. But going by the newspaper reports as per the multi commodity exchanges multi commodity exchange website information. So, if the contract term sets that the price is going to be based on the NYMEX WTI crude oil contract. So, the contract will be settled based on the actual price of the NYMEX WTI crude oil contract considering the fact that on that day NYMEX WTI crude oil contract settled at a negative. Obviously, the multi commodity exchange went about setting the negative price for settling the 20th of April contract. In this context I would also like to draw your attention that on 8th April Chicago Mercantile Exchange issued an advisory to everybody on the negative price because they were anticipating that price may go negative. In this context I would also want all of you to go through this detail the link related to the actual advisory is mentioned here. And the advisory goes about that the CME clearing has tested a plan to support the possibility of negative

options underlying and enable markets to continue to function normally. If any WTI crude oil future price sells in any month to a label below 8 dollar per barrel CME clearing will move to a Bachelier model of WTI crude oil crude oil option contract. Please note that we have discussed that black 76 model is normally used for valuing the option contracts exchange traded option contracts which have futures as the underlying and because the future prices are going negative, or the CME was anticipating that future price may go into the negative direction. So, the CME shifted from the black 76 model to the Bachelier model of valuing the option contracts. With this let us understand how exactly the commodity WTI futures curve has moved in the interim period as you can see the red line is the WTI forward curve WTI futures forward curve on the 20th of April 2020 and as you can see this is a negative price and the near month price was negative, and the next month price was positive. So, you can see a significant difference, and, in any case, this was a contango market. Contango market means the far month future price is more than the near month future price, but as you can see over the period of time since the last you know couple of years the market has turned to backwardation and as you can see the near month future prices are much higher compared to the far month future prices. So, the market has turned into the backwardation. Now, this is a very peculiar situation with respect to crude oil which shows the volatility associated with the crude oil price. Sometimes it is contango, sometimes it is backwardation, but please recall in case of a gold market it was always in a contango. We had taken also some snapshots of the forward curve gold forward curve and that remained in contango for almost all those days, but in case of a in case of crude oil the forward curve shifts from contango to backwardation and vice versa depending upon whether there is crude oil is available plenty or there is some supply constraint with respect to the crude oil. As I mentioned the market has gone back to backwardation since 20th April 2020 as one can see the backward date forward curve in recent times. In this context let us also understand a trade which is known as a crude oil contract contango trade extensively used by trade by traders. So, it is basically a cash and carry arbitrage trade. So, what happens in a contango trade is that if the actual future price is more than the theoretical future price that gives rise to an arbitrage benefit which is known as your cash and carry arbitrage. In fact, this aspect we have discussed in the initial part of our lecture in terms of when we were discussing the concept related to how one will be one how one can go about pricing a futures contract. So, when one would be able to do a contango trade, a contango trade happens when the actual market price future price is greater than the theoretical price. So, now, let us take this as a small example let us say spot price on a given day is 71.25 barrel and let us say 3-month future price is 73.4. So, these two prices are available to any trader. Now, the number of months as mentioned is 3 months and the storage cost per month per barrel of crude oil let us say 25 cents. So, total storage cost comes to about 75 cents for 1 barrel of crude oil for 3 months. And let us say a particular trader has a cost of borrowing continuous compounded cost of borrowing is 4 percent. So, based on this cost

of based on the cost of carry based future price this comes to your 72.02. Basically, the future price is nothing, but the spot price plus the present value of the storage cost into the cost of carry. So, based on this the theoretical future price is coming to 72.02. And when one is comparing the theoretical future price with the actual future price, the actual future price is 73.4, but theoretically it should be trading around 72.02. So, one would be able to undertake the cash and carry arbitrage and if they do a cash and carry arbitrage after 3 months one will be able to get about 1376 US dollars per 1000 barrels of contract. Now, whenever this kind of a situation happens traders undertake a contango trade. So, what basically they do traders buy the crude oil in the physical market and store the crude oil. So, traders would buy the physical crude oil at the spot price and store the oil in this case for 3 months and simultaneously enter into sale simultaneously enter into sorting the futures contract or take a sale position in the futures contract. And in this context when this price difference is significant a lot of people will be entering into the contango trade, and this is pretty much happening in the USA. So, it is very often discussed with respect to crude oil. And in this context, I would also like to highlight that the storage rental for crude oil also exhibits significant volatility. Please note that during April 2020 when the crude oil storage facility at Cushing Oklahoma had gone down the storage rental for crude oil also had gone up significantly higher. So, the storage rental for crude oil also exhibits significant volatility. Now, to mitigate the risk associated with the storage rental, Chicago Mercantile Exchange has also introduced an interesting futures contract which is for mitigating the storage price risk. Please note that this futures contract is not for mitigating any other type of risk, it is for mitigating the storage price risk. So, if storage rental is increasing or one somebody who is interested in storing crude oil for some time and is fearing that the crude oil storage rental is going to increase this particular party can enter into a futures contract. And this storage futures contract is known as LOOP crude oil storage futures. I want all of you to again please pay attention to the word storage futures. So, the details related to the contract specification are mentioned here and LOOP stands for Louisiana offshore oil port. The storage futures contract is a physically settled contract on the contract expiry the short futures holder will provide a capacity allocation contract to the long futures position holder and that capacity allocation contract gives the long futures position holder the legal right to store crude oil for a calendar month at the loop LLC storage facility in Louisiana. So, this is also again a very innovative futures contract which is available to crude oil producers and crude oil traders to mitigate the risk associated with the storage rental. So, with this we will come to an end of our discussion related to negative crude oil price as well as a crude oil contango trade and the loop crude oil storage futures. In the next session we will be continuing with the discussion related to innovative derivative contracts offered by different exchanges as well as certain interesting and innovative derivative contracts available to crude oil value chain partners in the OTC market. With this we will come to an end of today’s session. Again, I eagerly look forward to interacting with all of you in the next session. Thank you all of you.