Commodity Derivatives and Risk Management.
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Lecture-09.
Convenience Field, Contango-Backwardation.

Welcome to the next session on commodity derivatives and risk management. Today we are we are going to discuss what is commodity basis risk. But before we go to what is the definition of basis and how basis affects the commodity, risk associated with commodity in futures investment. Let us spend a little more time understanding what we discussed last session. If you recall in the last session, we discussed about contango, about backwardation, we also discussed about the cost of carry model and if the cost of carry model does not hold true, how the traders will be able to take cash-and-carry and reverse cash-and-carry arbitrage to make, to get benefits.

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Spot and Forward/Futures Price Relationship
(Financial Vs. Commodity Underlying)

- Arbitrage model (Cost of Carry Model) holds true for pricing forward/futures contract holds
  - For financial assets such as equities, index, interest rates
  - Investment commodities like gold, silver
  - Consumption commodities without any supply constraint

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So just to summarise what we discussed in the last session, remember we discussed how this arbitrage model or cost of carry model with no arbitrage assumption holds true for pricing forward or futures contracts for financial assets, for investment commodity such as gold and silver and also consumption commodities like copper, almonds, Jeera, or you know steel, tin, and these consumption commodities without any supply constraints. So any consumption commodity which does not have a supply constant at a given point of time, that can be valued using your cost of carry model with no arbitrage assumption.

However, whenever a commodity is facing a supply constraint or at that point of time not enough of inventory are available in the market, then cost of query model does not hold true. Even if the reverse cost cash-and-carry arbitrage is possible, many traders would not be interested in exploiting this arbitrage opportunity to make profits. Let us take an example. Let us say, just before the harvest period, agriculture commodity price is ruling very high. you, you know if you are keeping track of commodity prices of late, you must have read the tomato prices at this point of time is ruling around 80 rupees a kg.

So if somebody, let us say, a tomato pulp futures contract is available for trading, had it been available for trading in Indian context, of course it is not available. So had this tomato pulp futures contract is available for trading, so if a trader would like to price this futures contract at the prevailing spot price, it would take into consideration S0 as 80 rupees and accordingly price the futures contract. However traders also know maybe within a month or 2, new arrival tomatoes will be arrived in the market and at that point of time, spot price is not going to be that high.

So considering all these factors, you can have situation when the F theoretical, that is future price calculated based on high spot price today is substantially higher than the F Actual. So that gives rise to a situation called you know, that gives rise to arbitrage opportunity which is known as your reverse cash-and-carry arbitrage. However nobody will be interested to undertake the arbitrage because the whole, the party which is holding the commodity, that party is going to get some benefit from holding that commodity.
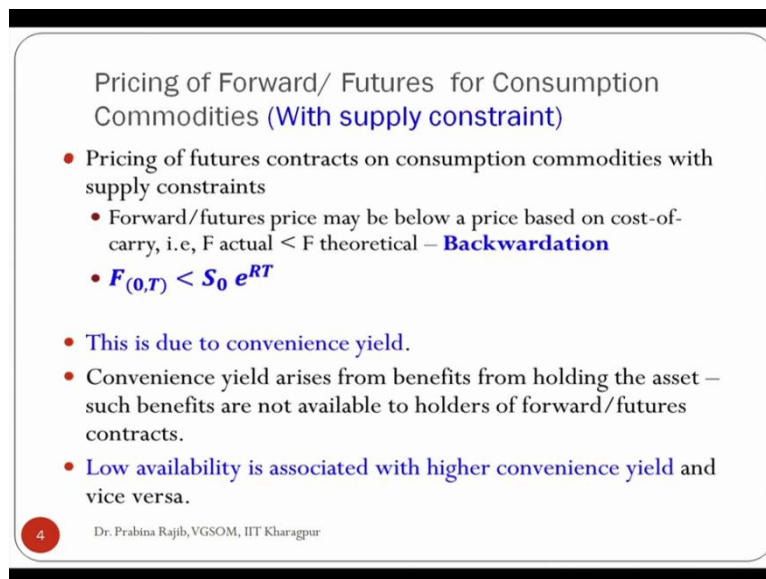
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Pricing of Forward/ Futures for Consumption Commodities (With supply constraint)

- When inventory is low and demand for commodity outstrips supply, commercial users of the commodity prefer holding physical commodity rather than holding the forward/futures contract.
  - For example, for a manufacturing company, using a commodity as raw material would prefer to hold the physical commodity, as physical inventory smoothens the production process, helps it maintaining its market shares.
  - These intangible benefits are coined as convenience yield.

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So that is known as your, convenience yield, as we discussed in the previous class. Now let us go to the, as I discussed, when an inventory of a particular commodity is low and demand for that commodity is higher than the supply, commercial users of the commodity prefer holding the physical commodity rather than holding the forward or futures contract and this intangible benefit of holding the asset is known as the convenience yield.

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Pricing of Forward/ Futures for Consumption Commodities (With supply constraint)

- Pricing of futures contracts on consumption commodities with supply constraints
  - Forward/futures price may be below a price based on cost-of-carry, i.e, F actual < F theoretical – **Backwardation**
  - $F_{(0,T)} < S_0\, e^{RT}$
- This is due to convenience yield.
- Convenience yield arises from benefits from holding the asset – such benefits are not available to holders of forward/futures contracts.
- Low availability is associated with higher convenience yield and vice versa.

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And, so in case of, you know in such a situation, you can have a theoretical future price which is greater than the actual future price prevailing in the market and the situation is, this kind of the market is known as the backwardation market. And as you can see from the you know slide that is F0T, futures price or forward price prevailing today for maturity of T is less than the theoretical price as calculated by cost of carry model. Now we also know, we have also discussed that low availability of the underlying commodity is associated with higher convenience yield and vice versa.

Convenience Yield

- Cost-of-carry model is adjusted to account for convenience yield.

$$F_{(0,T)} = S_0 e^{(R + u - Y)\,T}$$

- Where
  - R = continuously compounded interest rate
  - u = present value of all costs, including storage, insurance, fumigation etc. expressed as a percentage of the underlying spot price S_0.
  - Y = convenience yield expressed as a percentage of spot price.
  - T = time to maturity in terms of years.

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How do we goead and calculate the convenience yield? As I mentioned in the previous class, convenience yield is you know not act, visible anywhere, you nobody, it is not reported like a nominal interest rate or inflation rate, this, convenience yield has to be calculated. So when we equate, the theoretical futures price with the, with the actual future price, and adjust the theoretical future price with Y, what we get is your, the convenience yield. As you can see from this equation, F 0T is equal to S0 into E to the power R plus U minus Y into T. So when we solve for 0 this equation, what we can get an indication of what is going to be the convenience yield.

Convenience Yield Calculation

- Exercise: Find out the convenience yield.
- Jeera (spot) on 30th May 2016 (for 100 kg) = Rs. 16683. On 30th May 2016, Jeera Futures maturing on 20-Jun-16 (M1) is priced at Rs. 16440 (F actual). Find out the convenience yield if storage cost per day for 100 kgs of Jeera= Rs. 0.70. Assume continuously compounded interest rate to be 10%

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That is what is the value what is the value of you know the physical holding, what kind of value is being derived by the you know holders of the asset by holding the asset. Now, I just have you know give an exercise, you can solve at your you know spare time. So you have a spot price given, you have futures price which is the actual futures price prevailing in the market, that is F Actual is given. And you have, the storage cost is also given and you have also the compounded continuously compounded interest rate is given. From here you will be able to find out what is the convenience yield.

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Now let us go to we have also in the last class we have also discussed little bit on contango and backwardation and as you know in case of a contango, the future price will be greater than the spot price and a distant delivery futures price will be greater than the less distant delivery future price like price of M 2 contract will be higher than the price of M1 contract and price of M1 contract will be higher than the spot price.

Similarly backwardation, the reverse is going to happen where you have, where you have spot being higher than the futures price and higher distant distant delivery future price is less than the less distant future price that is M1 is greater than M2. And S is greater than M1.

Now before we go to the basis part, I would like to pose a question, what happens to, the spot and futures price on the contract delivery date or the contract maturity date? The answer to this particular question is that both spot and future price must converge. If convergence does not happen, it will give rise to arbitrage opportunity. Let us take an example, simple example.

Let us say, suppose we have contract whose maturity period is 3 days. So what will be the forward price of future price? It will be S0 into E to the power R into 3 by 365 when R is a continuously compounded annual interest rate. Let us say in place of 3 days, let us make it 2 days today. So what happens to your F0T? F0T will be S0 into E to the power R into 2 by

365. And on the contract maturity date, what happens to the value? F0T will be, so on the 0th day, contract maturity day, so S0 into E to the power R into 0 by 365.

So anything multiplied by 0, anything to the power 0, so you will have F0T, in fact this becomes F0 0 will be equal to S0. So on the contact maturity date, spot and futures price must converge. So now let us see practically does it happen in real life. I have downloaded certain spot and future price data from national multi commodity exchange and let us see whether spot and future price converges or not. So I am opening a link, I want all of you to focus little bit.

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So this particular table shows the black pepper, May 2016 contract data and this data I have downloaded from NMCE data, so national multi commodity exchange, as you can see this link. And let us focus on this data, that is the futures price, futures closed price and also focus on the spot price. So I have plotted this, now please see this one. In this particular figure shows the, you know this is the contract maturity period, how the spot and future price has moved from let us say this contract matured on this particular contract matured on 5th, 3rd, 3 May 2016.

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So during this period of time if you see, here is the futures closed price is here and the spot price is here, so this particular, you know position in the graph indicates that the spot price is less than the futures price indicating a contango market. And after some point of time, the spot price has gone, you know is more than the futures price. This portion indicates the backwardation market. However if you see, this difference between spot and futures price slowly slowly narrowed down and almost converges on the contract maturity.

If we see, we go to the actual data, let us say, if you see this one, the futures price is closed at 7300 and the spot price is close to 72500. There is a price difference of 500 rupees I have to see what is the contract specifications for black pepper, probably it will be a 100 KG also. So

there is a price difference of 500 rupees for 100 KG. So this, and why still, you know why exactly it has not converged?

As you recall you know your future market have marked to market margin, futures market are also governed by the daily price limit but the spot market is not governed by the daily price limit. So this could be the reason why you have 500 rupees difference. Also one I would like to tell here is that this 500 rupees is not commensurate for doing a arbitrage. Had it been a commensurate enough, then some, some trader must have you know taken the benefit of arbitrage.

Recall we discuss also last class, the, you know the price difference has to be substantially higher for a trader to buy and sell in both market and factor in the borrowing and lending rates. So all these things taken into consideration is, probably 5 and it is not commensurate enough for taking a arbitrage benefits. Now let us go to another contract.
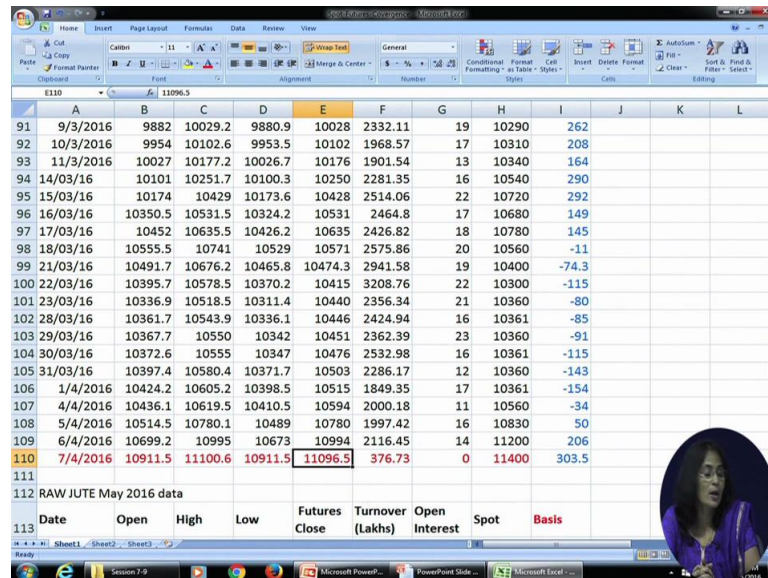
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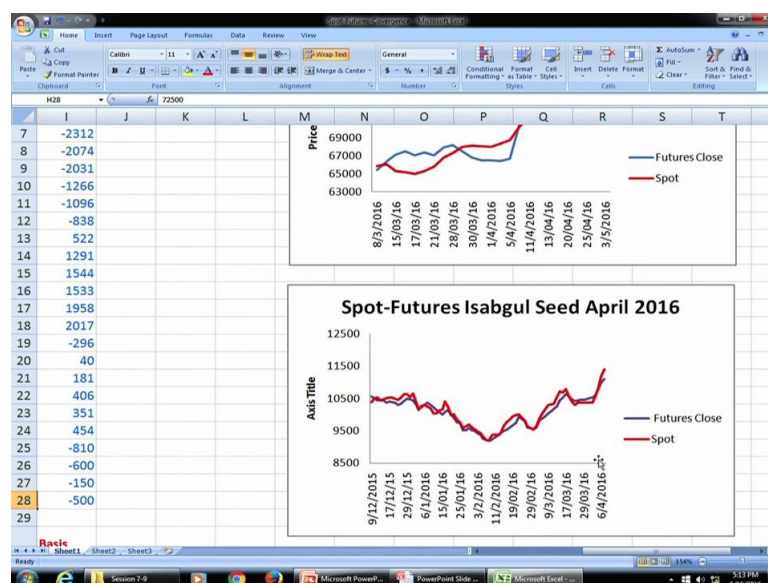
This is this is a, this contract is the spot futures for Isabgol seeds. And you know I am sure all of you know why, how you know the, what is and is a Isabgol seed, it is a diuretic and it is you know it is it is in many Ayurvedic medicines. So you have a spot futures price relationship. So this is sometimes, this particular, this is very close, the spot futures price is very close to each other and some point of time, you know both prices are exhibiting contango or backwardation market.

Another interesting pic, you know combinations, this is the spot futures price between, spot futures relationship between the raw jute, for raw jute. And if you can see the spot is always less than the futures price indicating that this particular commodity has remained as a contango market throughout the life of this contract, that is May 2016 contract. However, again coming back to the closing price.

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The closing price is 11,000 futures closing price is 11,096.5 and the spot closing is 11,400, the same logic what I explained for black pepper is applicable here. So even if there seems to be a almost 204 rupees price difference but this is not commensurate enough for traders to take arbitrage.

So after this discussion, what we are concluding, we are concluding is that on the contract maturity date, spot and future price converge. Even if there is some minor differences are there, but for all practical purposes, we can say that the spot and futures price is, you know spot futures price converges on the contract maturity date. If convergence does not happen, it will lead to an arbitrage benefits, let me give a very simple example how arbitrage benefits can happen, let us take.

So let us say on suppose, on the morning of the, on the morning trading time of the futures contract maturity a contract is trading at let us say rupees 700. And on the, at the same time,

the spot price is let us say 900. A spot price is, so futures contract, on the contract maturity date in the morning, suppose the exchange opened at 10 o'clock in the morning and around that time the future contract delivery for the same contract maturing on the same day is quoting at rupees 700 and the spot price is rupees 900.

So how, how a trader can make arbitrage benefit? As you know the trader can, arbitrage benefits can be done only by buy low and sell high. So what we can do, he can take a long futures contract, take long futures contract at 700 rupees simultaneously sell a, sell the commodities in the spot market, in spot market. So he will receive 9 900 rupees from the spot market by selling the commodity in the spot market.

He will pay 700 rupees by end of the day, by you know, by end of the day he will be spending 700 rupees and within the delivery period he will have the underlying commodities, so making a net profit of 200 rupees from this price difference. Similarly vice versa, suppose the futures contract is trading at 700 but the spot price is trading at let us say 500. And so what the trader can do, the trader can do a short futures and simultaneously take a long position in the underlying asset markets.

So it is a very very important understanding that what we are discussing at this point is that spot and futures price must converge and most of the times spot and futures price converges, converges on the contract maturity, otherwise it will lead to an arbitrage benefits. With this let us start our discussion on what is a commodity basis. When I am saying basis, it is B-A-S-I-S, it is spelt as BASIS. And if you recall, in some earlier sessions we had discussed that in case of a forward contracts, there are significant amount of counterparty risk.

However in case of a futures contract, that is no counterparty risk. In lieu of counterparty risk, what futures traders face is the basis risk. So what is this basis risks and how it manifests itself, we will be discussing in detail. But before that let us understand what do we mean by basis. So basis is defined as the difference between the spot price and the future price.

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So let us, this is, how we define, if you see the screen. That is basis on a day T, on a any day, I basis on Day T, that this BT is defined as spot price minus the futures price. And as you know in case of a contango markets, futures price is more than the spot price, so going by that logic you will have a negative basis in a contango market and a positive basis in a backwardation market. And basis also normally goes down as the delivery approaches and as spot and future price converge towards each other, the difference, the basis narrows down and it comes to 0 on the contract, almost 0 on the contract maturity date.

So this is the definition of basis, now let us understand how this basis poses a risk to the commodity futures holder.

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So what is the basis risk? Basis risk is the risk that arises from hedging a contract that does not expire on the same date as the underlying exposure. So, if you recall or if you know futures contract has standardised and any day as a consumer of a commodity or a producer of commodity, my physical operation would require me to take delivery or mail delivery on a specific date.

However futures contract may not mature on the same date. So this is one of the important reasons why basis risk arises. Let me again repeat, the basis risk arises from hedging with a contract that does not expire on the same date as the underlying exposure. Let us again revisit what we have discussed about our understanding on hedging. So who is a short Hedger? Short Hedger is a party who is long on asset or owns the asset and is fearing that the price is going to go up, sorry the price is going to go down in future.

So it, it is interested to mitigate that price risk by entering into a forward contract, sorry a futures contract for selling at a later date. So long asset party who is owning the asset, he has a fear of price going down and he mitigate that risk by entering into a short futures position and that is why he is known as a short Hedger. Vice versa a party who is going to buy the underlying at a later date and is fearing that the price is going to go up unless he or she does, does does something, that party will be mitigating the risk.

That party will be mitigating the risk by entering into a long futures contracts. Now let say let us take an example. Let us say a soya oil producer who is crushing soya bean and produces refined soya oil and as per its business requirements it intends to sell the 1st a lot of soya oil it will be crushing on 10th June 2016. So it fears that by 10 June 2016 soya oil prices going to go down, hands on the spot date, so standing on 22 April, the soya oil producer is, you know forming a price expectations regarding the future price.

And he is getting an indication he is feeling that soya oil price may go down and he would like to mitigate that risk by entering into a futures contract. and which futures contract it will take? Let us say futures contracts which is maturing on June, that is M 2 futures contract, maturity date is 20th June. And if, suppose the you know soya oil producer, you know instead of going to a futures, instead of buying futures contract or instead of entering into a short futures contract, he could have his hedged this risk by entering into a forward contract.

Let us assume that both forward contract and futures contract are available at 870. So if this, so all producer would have gone for, gone for futures forward contract, he would have definitely sold the underlying at 870 rupees on the 10 June 2016 irrespective of the prevailing spot price at that date. So by entering into a forward contract, the short Hedger, sorry the soya, soya oil producer would be you know, would be sure of getting 870 rupees.

Of course we are ignoring the counterparty risk, that is the forward contract, the counterparty, we are assuming that the counterparty is going to abide by his side of the contract. So if, the producer would have gone for you know, a forward contract, he would have been sure to get

870. Now instead of going for forward contract, let us say that, you know the producer chooses to go into the futures contract.

Now how the relationship between the spot price and the prevailing future price is going to impact its profitability, that we are going to discuss in our next session in detail. Now let me summarise what we discussed in this session. We discussed little bit on our understanding of what is a contango market, what is a backwardation market and also we spent some time on understanding how the spot and futures price must converge or why it must converge on the contract maturity date.

And we have just started with our understanding on a basis risk. So I will be meeting you in the next next session with more details on basis risk. Thank you all of you.