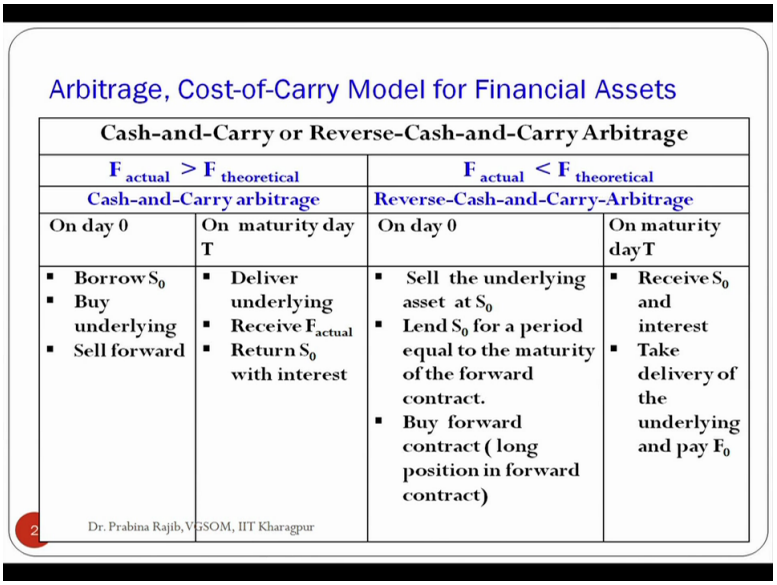
Commodity Derivatives and Risk Management.
Professor Prabina Rajib.
Vinod Gupta School of Management.
Indian Institute of Technology, Kharagpur.
Lecture-08.
Pricing and Valuation of Futures Contract (continued).

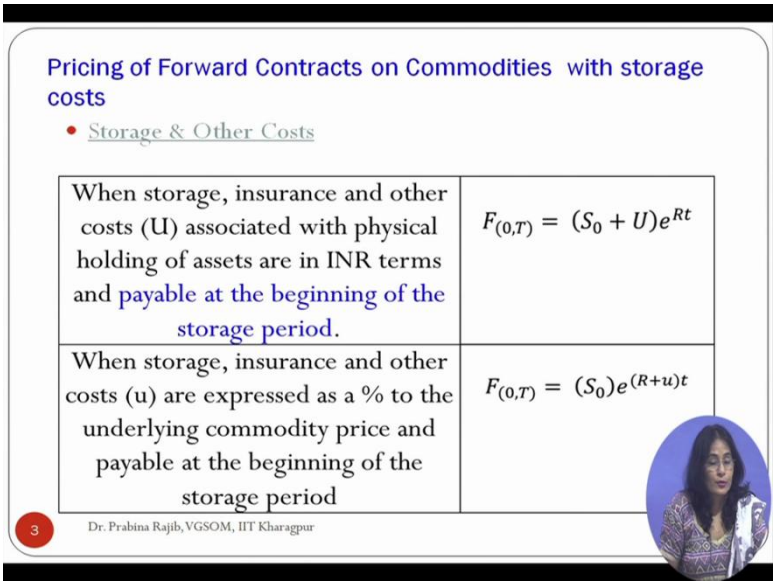
Hi all, let us continue with the discussion on our pricing and valuation of commodity derivative contracts. Now if you recall, in the last session we discussed about how the cost of carry model is used to value any derivative, futures contracts, any derivative futures contract. So we will continue with that example. We also discussed about whenever there is any deviation from the cost of model pricing, there is arbitrage opportunity in terms of cash-and-carry arbitrage and reverse cash-and-carry arbitrage.

(Refer Slide Time: 1:20)



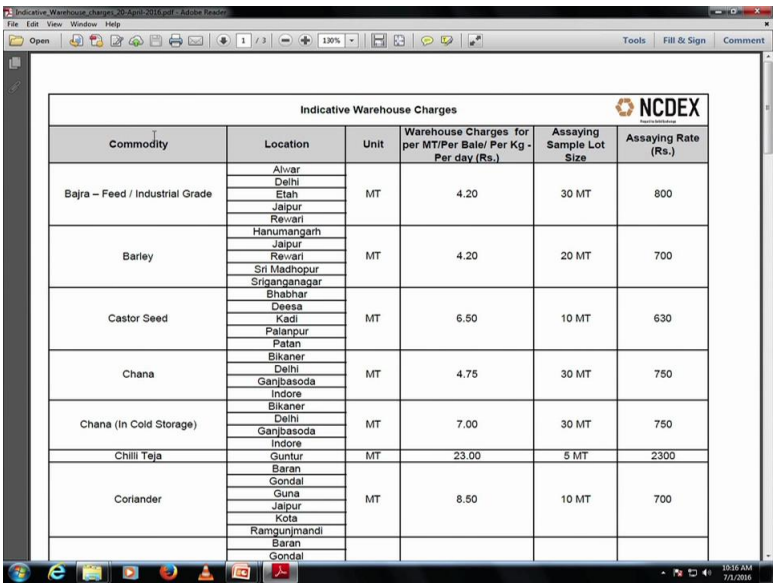
Now let us take an example of a commodity underlying and to check how this cash-and-carry arbitrage and reverse cash-and-carry arbitrage can be executed in a real-life situation. So this is just a summarisation, you know, we discussed this aspect in detail in the previous session. So with, you know, if the actual price is greater than the theoretical price, we will undertake cash-and-carry arbitrage. And if actual price is less than the article price, we will undertake the reverse cash-and-carry arbitrage.

(Refer Slide Time: 1:45)



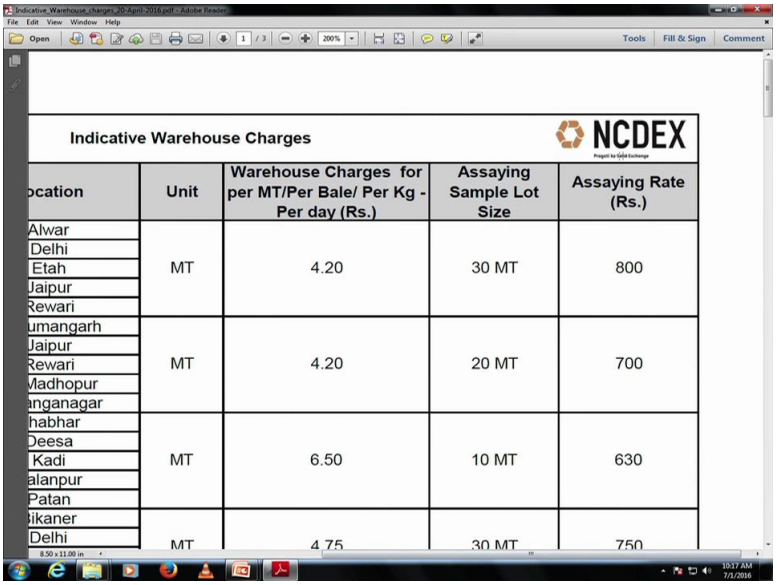
Now let us take an example of a commodity contract. In case of a commodity underlying, we are storage costs associated with, you know storing a particular commodity besides the cost of buying the commodity. So along with the S0, we have to add the present value of the storage cost to find out the cash, cost of carry model based forward or future price. Now how, where do we get this storage cost?

(Refer Slide Time: 2:21)



Indicative Warehouse Charges — NCDEX

Commodity	Location	Unit	Warehouse Charges for per MT/Per Bale/ Per Kg - Per day (Rs.)	Assaying Sample Lot Size	Assaying Rate (Rs.)
Bajra – Feed / Industrial Grade	Alwar, Delhi, Etah, Jaipur, Rewari	MT	4.20	30 MT	800
Barley	Hanumangarh, Jaipur, Rewari, Sri Madhopur, Sriganganagar	MT	4.20	20 MT	700
Castor Seed	Bhabhar, Deesa, Kadi, Palanpur, Patan	MT	6.50	10 MT	630
Chana	Bikaner, Delhi, Ganjbasoda, Indore	MT	4.75	30 MT	750
Chana (In Cold Storage)	Bikaner, Delhi, Ganjbasoda, Indore	MT	7.00	30 MT	750
Chilli Teja	Guntur	MT	23.00	5 MT	2300
Coriander	Baran, Gondal, Guna, Jaipur, Kota, Ramgunjmandi	MT	8.50	10 MT	700
	Baran, Gondal				



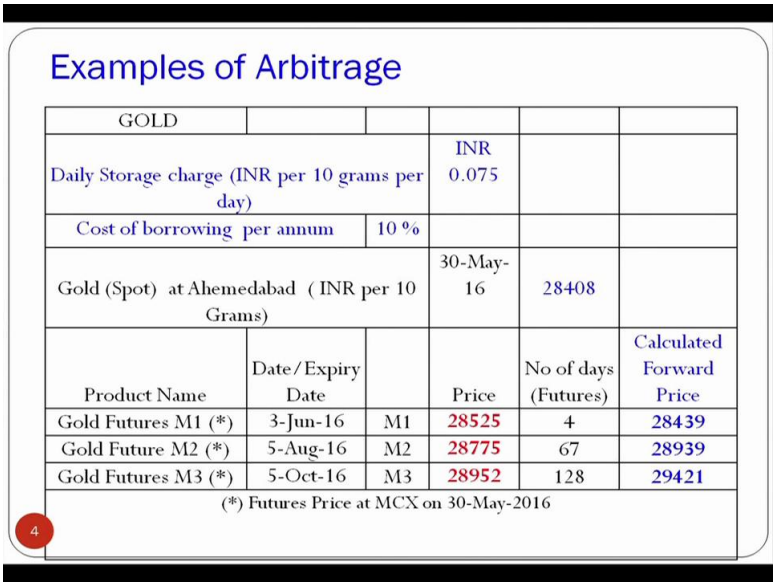
Indicative Warehouse Charges

NCDEX

ocation	Unit	Warehouse Charges for per MT/Per Bale/ Per Kg - Per day (Rs.)	Assaying Sample Lot Size	Assaying Rate (Rs.)
Alwar Delhi Etah Jaipur Rewari	MT	4.20	30 MT	800
umangarh Jaipur Rewari Madhopur nganagar	MT	4.20	20 MT	700
habhar Deesa Kadi alanpur Patan	MT	6.50	10 MT	630
ikaner Delhi	MT	4.75	30 MT	750

So the storage cost is again exchanges inform us what is the storage cost. So this is a typical example of, you know, it is in this letting us know what is the storage cost. This particular document I have downloaded from national commodity derivative exchange website. So if you see this Bajra which is stored in Alwar warehouse, it costs around 4.20 rupees per day for 1 metric ton of storage. And besides this you also have you know another cost which is assaying rate, quality assessment rate which costs about 800 rupees for 30 metric tons.

(Refer Slide Time: 3:25)



Examples of Arbitrage

GOLD					
Daily Storage charge (INR per 10 grams per day)			INR 0.075		
Cost of borrowing per annum		10 %			
Gold (Spot) at Ahemedabad (INR per 10 Grams)			30-May-16	28408	
Product Name	Date/Expiry Date		Price	No of days (Futures)	Calculated Forward Price
Gold Futures M1 (*)	3-Jun-16	M1	28525	4	28439
Gold Future M2 (*)	5-Aug-16	M2	28775	67	28939
Gold Futures M3 (*)	5-Oct-16	M3	28952	128	29421
(*) Futures Price at MCX on 30-May-2016					

4

So from time to time exchanges inform us what is the cost of storage and this has to be incorporated into the forward price modelling. Now let us take an example, let us take this example of gold and we will work out how cash-and-carry and reverse cash-and-carry

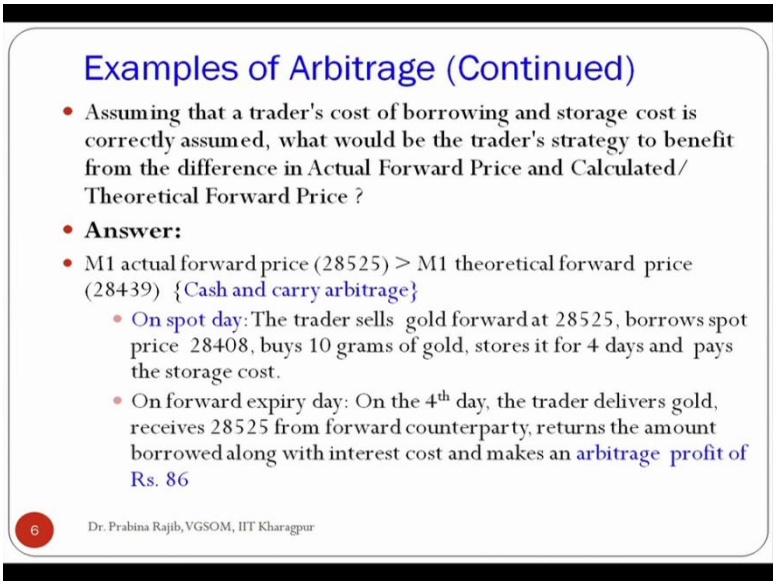
arbitrage can be taken in this context. Let us say a spot price on 30 May 2016, the spot price atmedabad gold is 28,408 rupees. And what is the storage charge? Storage charge comes to 7.5 paise per 10 gram per day and what is the cost of borrowing? Cost of borrowing I have assumed to 10 percent for continuously compounded rate.

And I have calculated the forward price or forward price for 3 maturity period, that is 4 days 67 days and 128 days respectively. And why have I chosen this? I have chosen this, these 3 days coinciding with the maturity period of 3 contracts which are traded at MCX exchange. So M1 contract which is maturing on 3 June 2016 has a maturity period of 4 days. So by using the cost of carry model and the storage cost what we are getting as a theoretical forward price is 28,439 as our theoretical forward price for M1 contract.

And similarly the forward price calculated forward price, theoretical forward price for other 2 contracts are 28,939 and 29,421 respectively. And what is the market price F Actual, actual price prevailing at MCX, is 28,525 for the rear month contract 28,775 for the next month contract. Now let us take an example, now let us take this, you know, we compare these 2 sets of prices to know whether arbitrage is possible or not. Let us compare the 1st price, 1st set of price, that is a theoretical price vis-a-vis the actual price.

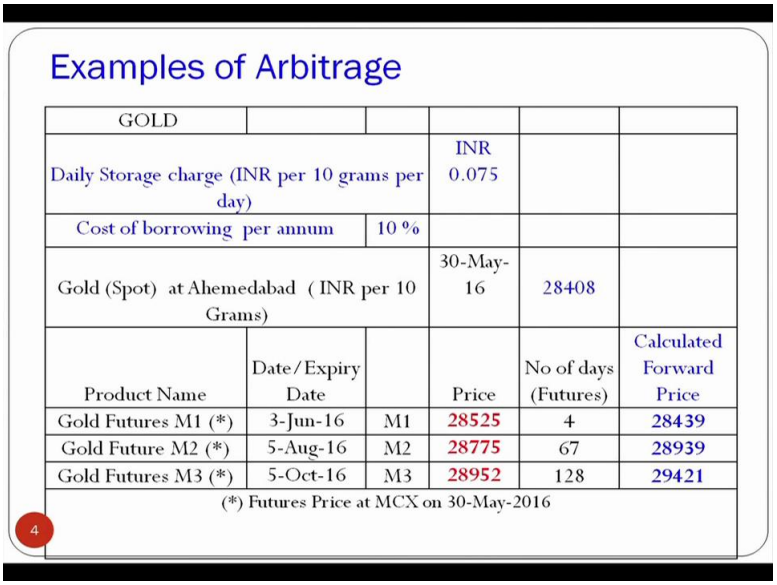
So what is the theoretical price? Theoretical price is 28,439 and actual price is 28,525. So F Actual is greater than F theoretical. So we will be able to undertake cash-and-carry arbitrage. So what is going to our cash-and-carry arbitrage strategy? We will borrow cash, we will buy gold and simultaneously enter into contract to sale forward, sell futures contract.

(Refer Slide Time: 6:22)



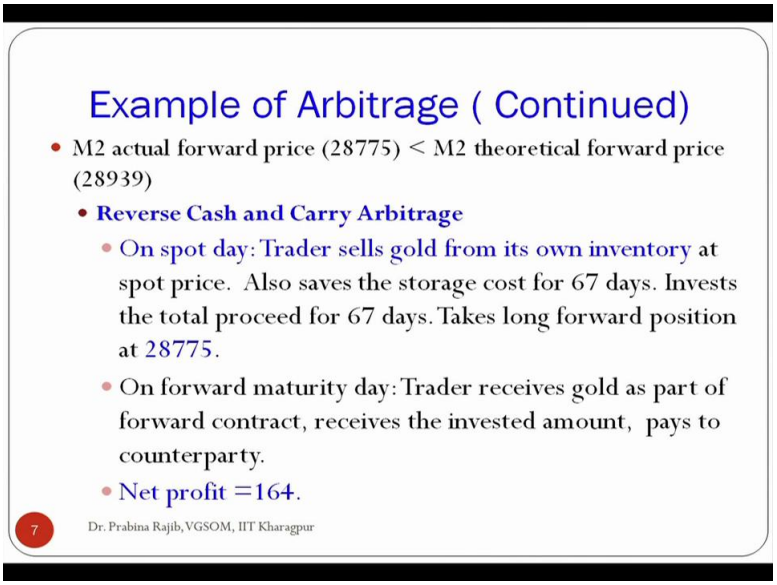
So this is the question, my question to all of you. So, so answering to the, you know, to the discussion that what is going to be the arbitrage profit when the trader is going to undertake cash-and-carry arbitrage? It shows that the cash-and-carry arbitrage to be 86 rupees. So the calculation of, is given here. So on spot day, the trader, you know borrows 28,408 rupees, buys 10 grams of gold and stores it for 4 days and pays the storage cost upfront and, and on the maturity day, simultaneously the trader also enters into a forward contract or short forward or a short futures contracts.

(Refer Slide Time: 7:19)



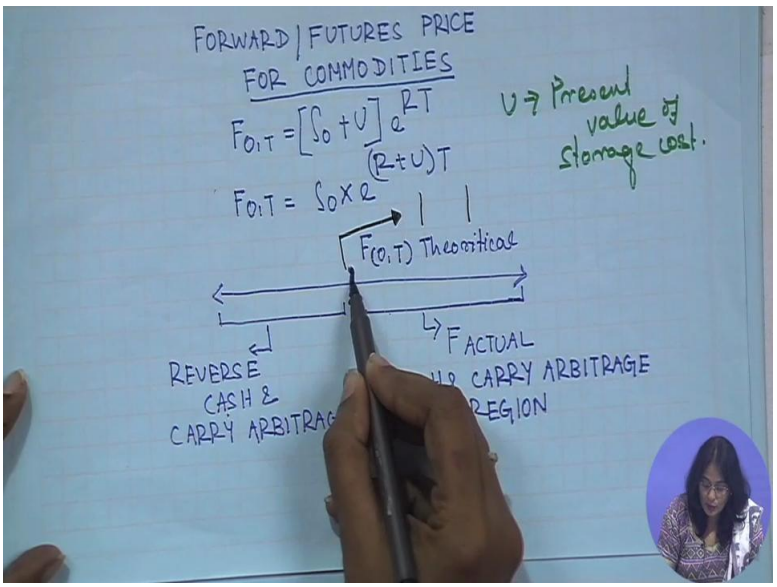
Similarly on the expiry date, it undertakes other set of transactions which leads to an arbitrage profit of 86 rupees. Now let us go back to our, now let us focus on the M 2 contract. In case of M2 contract, what is the theoretical price, theoretical price is 28,939 and actual price is 28,775. So when these 2 prices we are comparing, it can, you can see that the actual price is less than theoretical price, so that means you will be able to undertake reverse cash-and-carry. So as part of the reverse cash-and-carry arbitrage, what should be our strategy?

(Refer Slide Time: 7:59)



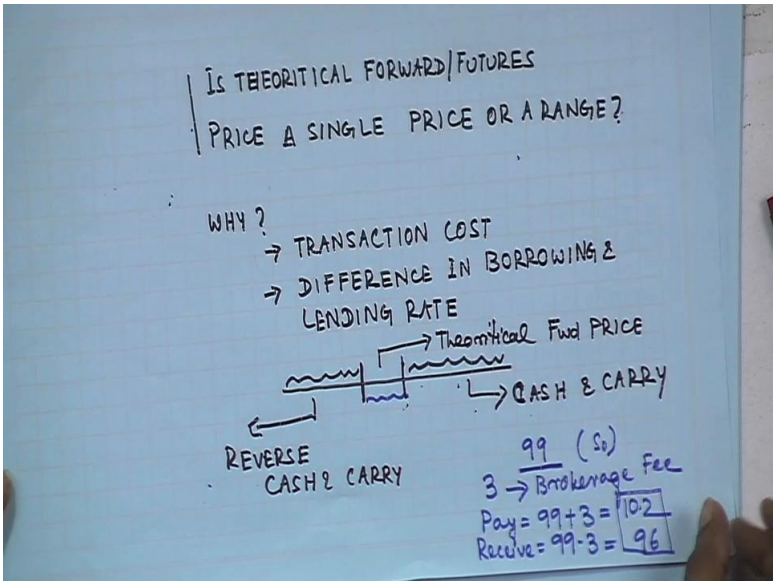
Okay. Our strategy is going to be, our strategy is going to be that on the spot date, we will be selling gold from our own inventory, also we will sell the gold and whatever gold we are holding, whatever money we will be receiving by selling the gold, we will be investing it for, you know 67 days and simultaneously we will enter into a long futures position at 28,775. And on the contract expiry date we will be making a profit of 164 rupees. So these are the examples of how traders in real life can take cash-and-carry arbitrage and reverse cash-and-carry arbitrage.

(Refer Slide Time: 9:01)



Now my question to all of you is that the**,** theoretical price is going to be a single point or its range of price prices? The answer is going to be its going to be range of prices. Now let us focus on to. So this particular document this particular detail shows that, this is our theoretical price, we have calculated theoretical price and if F Actual is to the right of this, that means more than this article price, we will have cash-and-carry arbitrage. And if it is less than, theoretical price is greater than or actual price is less than theoretical price, we will have reverse cash-and-carry arbitrage.

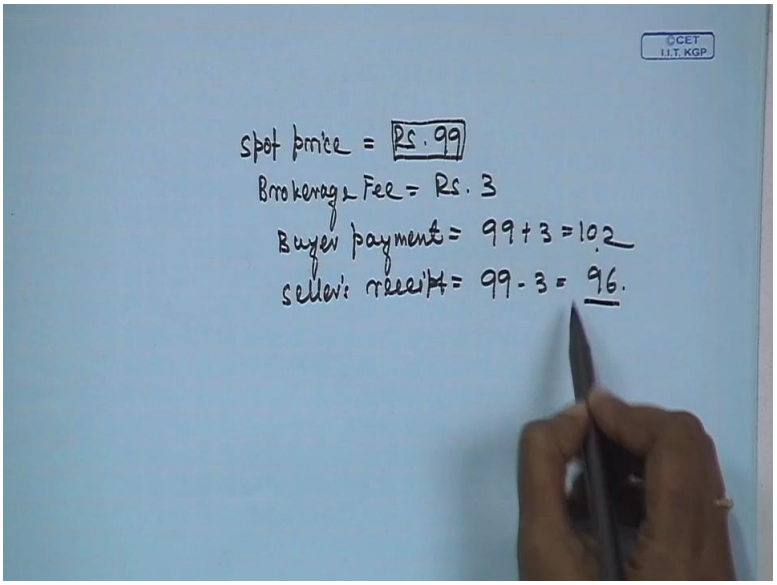
(Refer Slide Time: 9:52)



But in real life, this is not a single price point, it varies within a range. So this is not a, so what exactly is this? So why it will be a range? It will be a range because of the transaction cost and also because of the difference in borrowing and lending rate. So theoretical price is not going to be a single price because of difference in borrowing, lending, transaction costs (())(9:58), all this will be factored into calculate a, calculate a range. And if actual price is greater than the upper bound, then we will have cash-and-carry arbitrage.

And if actual price is less than the lower bound, so in this range if the actual price remains, that will be a reverse cash-and-carry. And if the actual price is greater than the upper bound, then it will be a cash-and-carry arbitrage. Now, I will just take a simple example to show why this arbitrage is not going to be a single price point but it is going to be a **-,** range of prices.

(Refer Slide Time: 10:56)



Let us say a particular share is quoting in a exchange, let us say price, spot price of a particular share is rupees 99. How much is going to be the buyer, buyer and seller you know payment received from the buyer and sellers point of view. Let us say if a buyer buys it at 99, it will be also paying, you know couple of rupees as brokerage fee. So how much is going to be the cost for the buyer? Let us say the brokerage fee is rupees 3. So buyer is going to pay, buyer payment is going to be 99+3, so 102.

And seller's receipt is going to be, seller will receive 99 but simultaneously seller will pay 3 rupees, so 99 - 3 is going to be 96 rupees. So if you, when we, you know simple example, so you have a price at 99, buyer is going to be paying 102 and seller is going to be receiving 96. So this is also one reason why you will have a range of theoretical forward price, not the actual, not a single forward price.

(Refer Slide Time: 12:19)

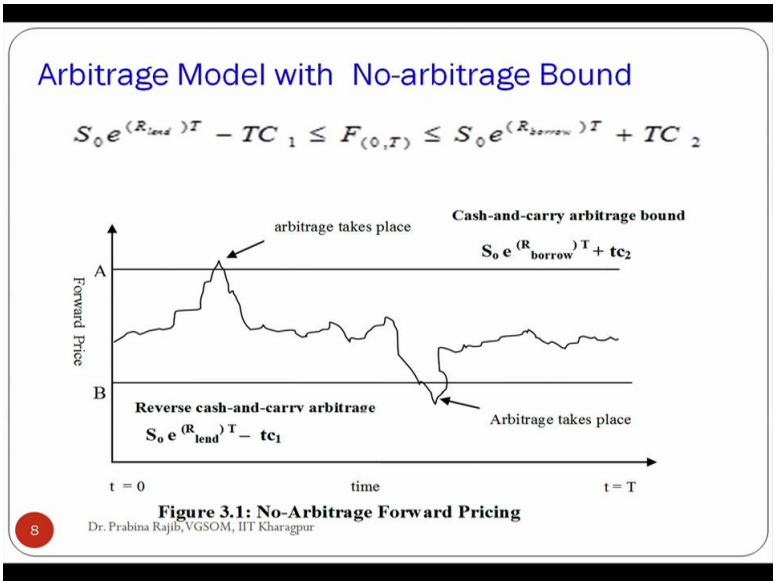
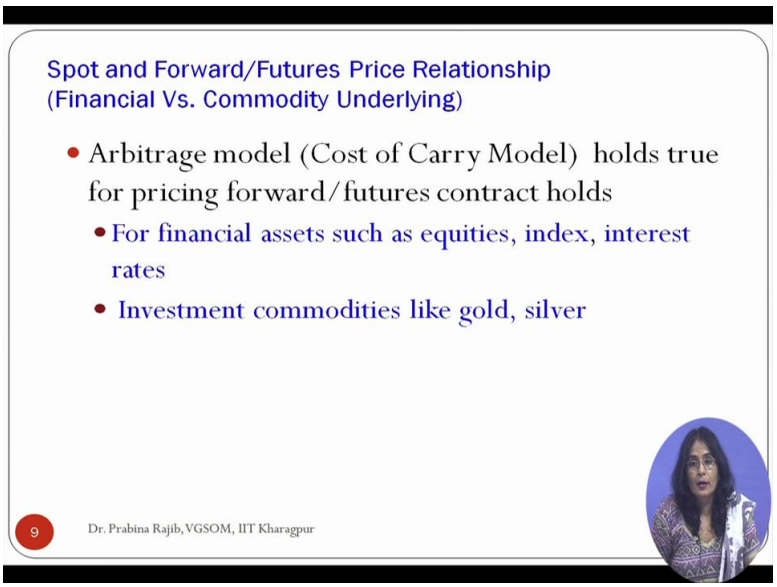


Figure 3.1: No-Arbitrage Forward Pricing

So this particular example shows this, if you see A and B is your upper and lower bound. And if actual price is greater than if actual price is greater than this upper bound, you will have cash-and-carry arbitrage. And if your actual price is less than the lower bound, you will have cash-and-carry arbitrage. And please focus on this formula, if you see this transaction cost is deducted from the spot price at one point, one side and transaction cost is added to the spot price at another side and you have different lending rate, different borrowing rate, so this is the reason why you will have a theoretical forward price as a range of prices.

(Refer Slide Time: 13:05)

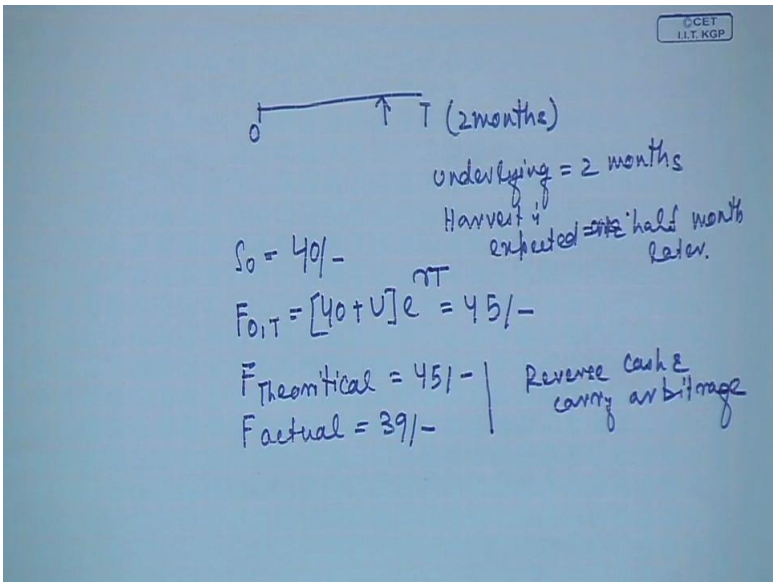


Now let us go to our discussion on how do we you know value commodity futures contract and forward contracts when the commodity underlying has certain supply constraints or does not have a supply constraint. So let us 1st focus on the commodity contracts where the underlying asset does not have supply constraints, that means it is freely available, anybody's interested to buy any amount of commodity at that point of time, it is available. So in that case, commodities having without any supply constraint can be valued using your cash-and-carry model.

Sorry it will be valued using your cost of carry model and any deviation from the cost of carry model price will result in cash-and-carry arbitrage and reverse cash-and-carry arbitrage. So the theoretical price will be within a specific range. Now let us go to a commodity which has a supply constraint, that means it is not available for to be traded, to be bought and sold in the market. Typically agricultural commodities have supply constraints just before the harvest period.

I am sure you must have noticed, at some point of time you may have let say potato price increasing, increasing for substantial amount because the new crop is yet to be arrived and not enough of old crop is available. So in that case you may have experienced the potato price going up significantly higher given point of time. Now at that kind of a situation, we may have the forward price deviating from the cost of carry model. So why that will happen, let us understand.

(Refer Slide Time: 15:35)

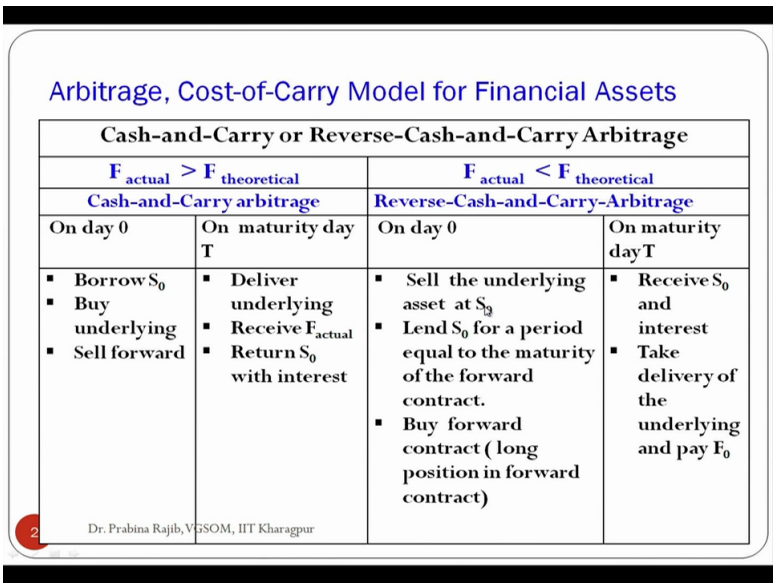


Now let me take an example. Let us say, so we have today here we want to take a forward contract for 2 months and underlying is, underlying is 2 months. Underlying is 2 months. So and this harvest is maybe expected, harvest is expected one and half months, 1 and half months later. So what is the spot price because of the supply constraint? Let us say potato is quoting at 40 rupees in the spot market. So you go to a spot market in local market or in a Mundy, bought in Mundy, potato is quoting at 40 rupees a kg.

So what is going to be based on you know the cost of carry model, so what is going to be the theoretical price F0T? And T is your 2 months, so it is 40+ storage charges multiplied into E to the power RT is going to be your let us say 45 rupees. So this is going to be our theoretical price. Let us say in the market, the 2 months forward price of future price is quoting at let us say 39 rupees. So this F theoretical is, theoretical price is 45 rupees and F Actual is 39 rupees.

So this is the, you go to the commodity exchange and 2 months of futures contract is quoting at 39. So just nearly comparing these 2 prices, you may say that there is some arbitrage opportunity and if you recall this leads to a reverse cash-and-carry arbitrage. And F Actual is less than F theoretical, so it has a reverse cash-and-carry arbitrage. So as part of a reverse cash-and-carry arbitrage, what do we do? I am sure you will be able to answer this question, so let me take you to the reverse cash-and-carry arbitrage.

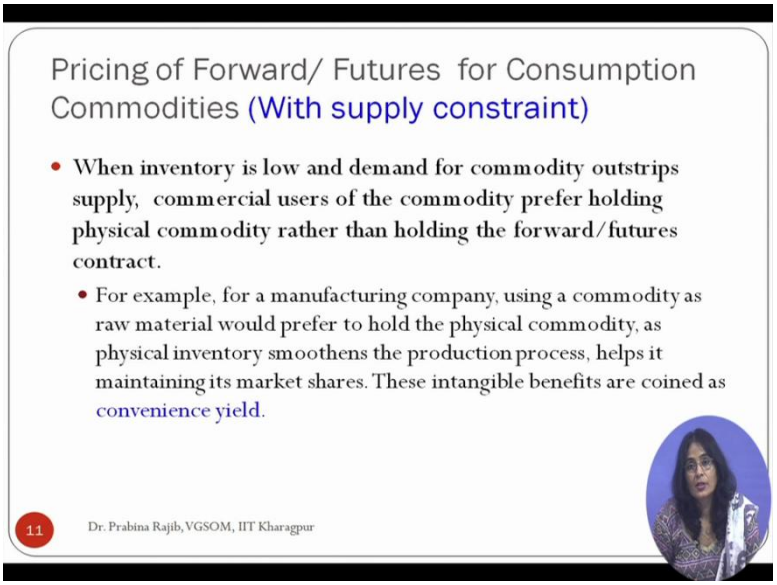
(Refer Slide Time: 18:04)



If you see, we will be selling the underlying asset at the spot price and simultaneously entering into a long forward contract. So let me highlight all these sentences. Selling the

underlying asset at the spot price. So if somebody wants to undertake a cash-and-carry arbitrage, so what should be his strategy at this point of time?

(Refer Slide Time: 18:26)

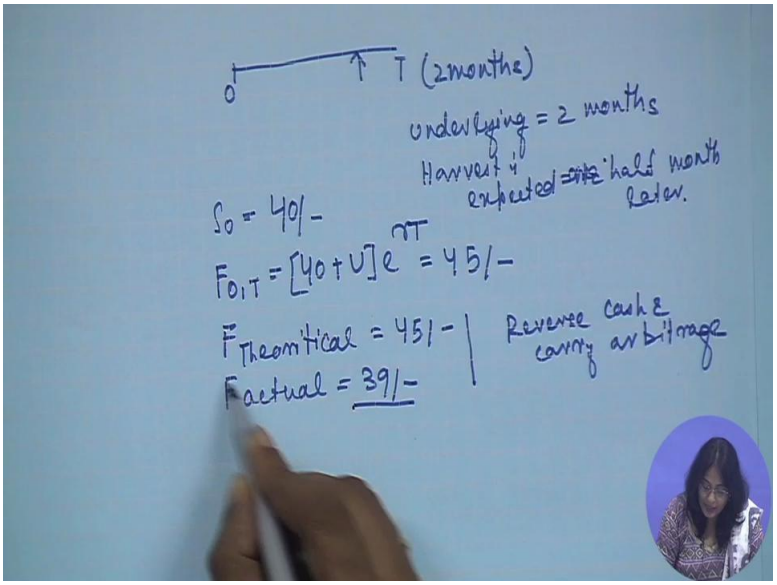


So the, his strategy at this point of time is to go and sell potato. But who is going to, who can sell the potato? The party or the people who are holding potato. So, you know considering that the potato is in short supply, so there will be not be much, there will not be many people who will be willing sell potato because the, you know the entities who would be holding potato, they will be holding to do their, run their day-to-day operation. Let us say potato manufacturing, potato chips manufacturing company may be holding you know some 200 tonnes of potato.

And this company may consider entering into a reverse arbitrage and may sell the potato in the market and try to get some benefit from the reverse cash-and-carry arbitrage. However if it does so, then it may not have the potato to run its plant and you know start, run its plant and have enough potato chips to be sold in the market. So in that case its production will be hampered, its market share may go down. So even if a company is holding potato, that company may not be interested to undertake a reverse cash-and-carry arbitrage.

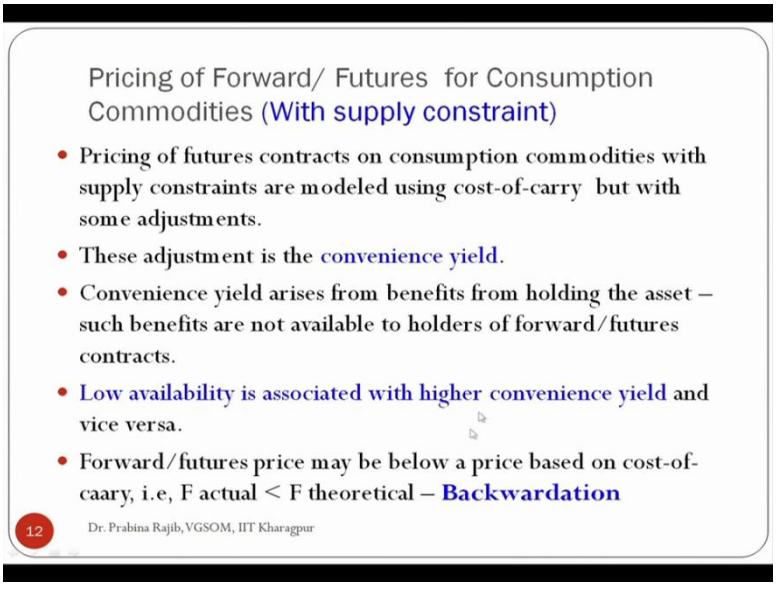
So what basically I am driving is that there can be a situation for commodity underlying where you have a opportunity to undertake arbitrage but there will not be many people to undertake arbitrage because the underlying commodity is in short supply. So in that case we, experience a situation where you have the future price is less than the spot price. Let us focus on this example here.

(Refer Slide Time: 20:32)



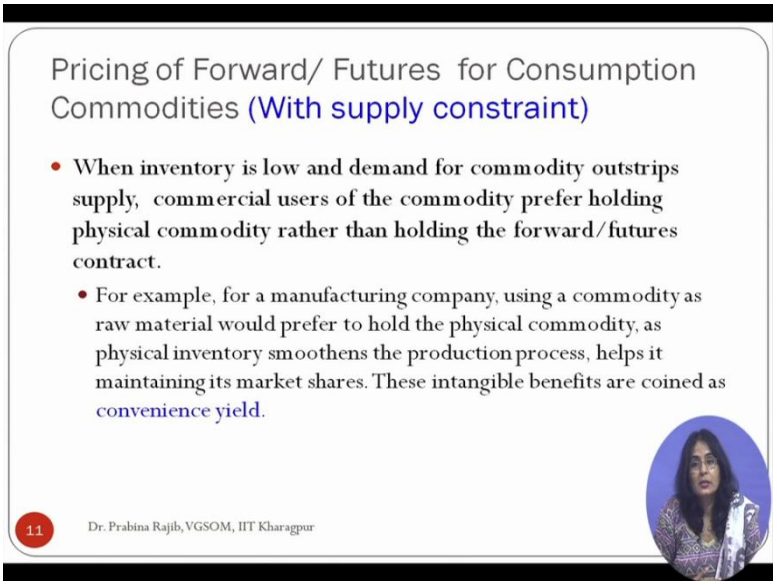
So what is the actual future price? The actual future price is 39 rupees. And what is the spot price? Spot price is 40 rupees. So the actual future price is less than, you know the spot price of the commodity and this kind of situation is known as backwardation in a commodity, in a jargon.

(Refer Slide Time: 21:02)



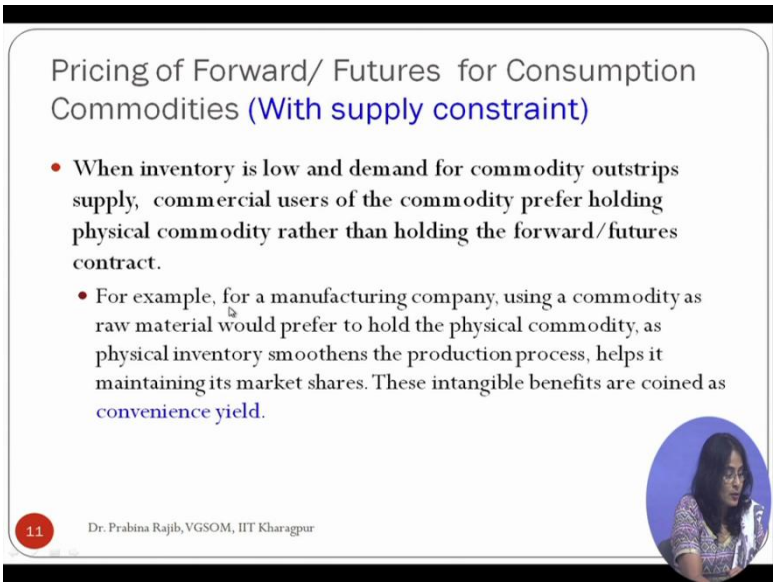
So what exactly is a, if you see this one, forward or future price may be below the price based on the cost of carry, that is F Actual may be less than the F theoretical. And that is known as your backwardation.

(Refer Slide Time: 21:21)



And why this, why this happens? This happens because you have supply, restrictions or supply constraint for the underlying commodity. Now this discussion on backwardation gives rise to a concept called a convenience yield. So what exactly is a convenience yield?

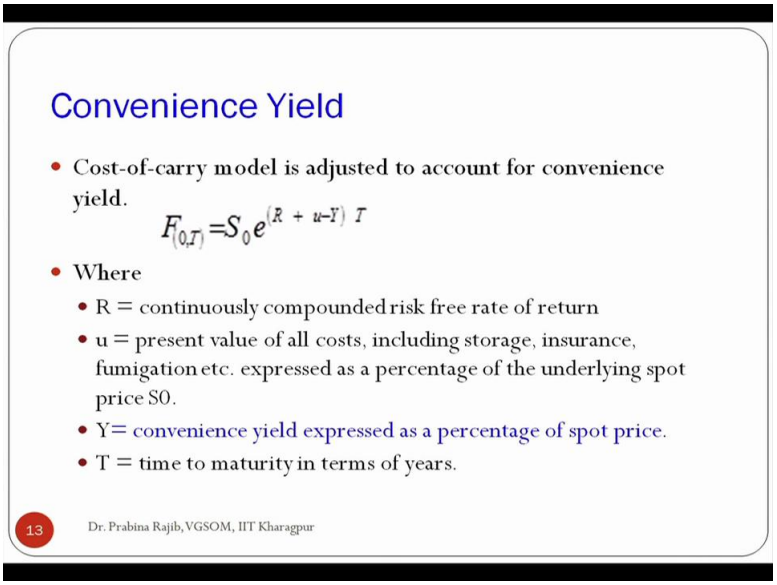
(Refer Slide Time: 21:49)



Let us you know focus on this. The, you know the explanation of convenience yield. Suppose a manufacturer is using a commodity as a raw material would prefer to hold the physical commodity as physical inventory smoothens the production process and helps it to maintain its market share. These intangible benefits are coined as convenience yield. So the party who

is holding the underlying, the asset itself is giving certain benefit and that benefit is resulting in, you know the forward price of futures price being lesser than the spot price.

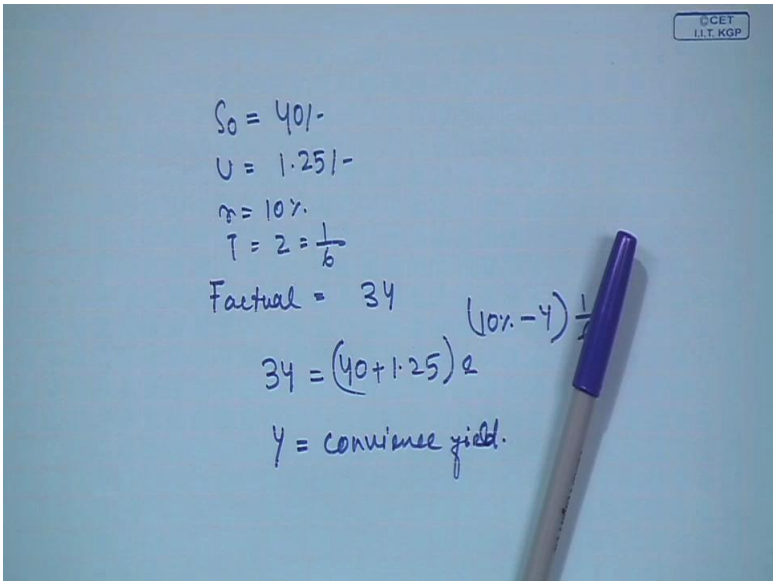
(Refer Slide Time: 22:37)



Now let us go to you know model, what is the convenience yield, so when we do some adjustment to the cost of carry model, we calculate the convenience yield. If you see the formula which is mentioned here F0T in real life is equal to, is less than your S 0. So when we equate this when we you know using a formula when we equate this, we bring in a concept called Y if you see that S0 into E to the power R + U - Y into T. So this Y is nothing but your convenience yield.

Convenience yield is expressed as a percentage of spot price. So again here one thing I would like to tell you is that convenience yield is never available in the market to be, you know to be used in the calculation. The convenience yield is calculated from the price when F0T is less than your S0 into E to the power, S0 into E to the power R + T. Then we use the, we calculate the Y. Let us take an example.

(Refer Slide Time: 23:53)

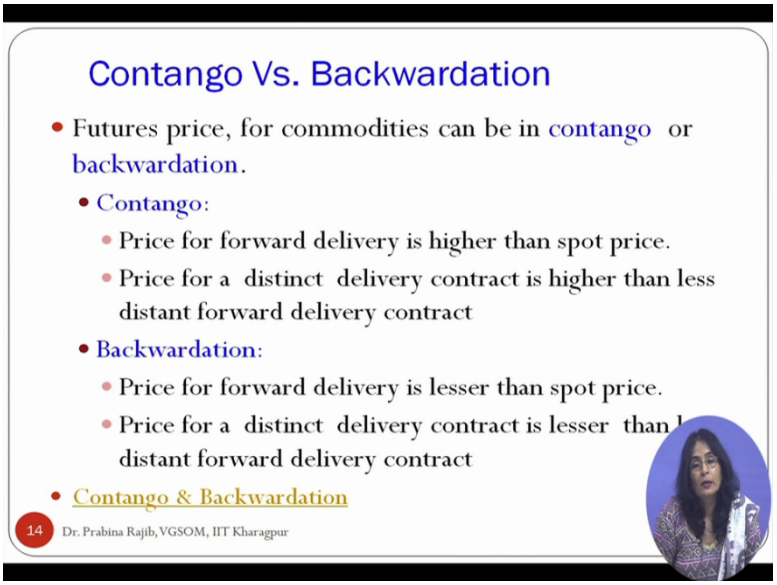


Let us say spot is, as we go back, spot is let us say as we mentioned 40 rupees, U is let us say, present value of U is 1.25 rupees and R is 10 percent and T is 2 months, which is 1 by 6. And you have suppose F Actual is quoting at let us say 34 rupees. So when we calculate 34 is equal to 40+1.25 into E to the power 10 percent - Y into 1 by 6. And when we, when we equate this, we calculate Y, that is going to be our convenience yield. That means this, this is the return which the owner of the asset is getting by holding the asset.

And like your or if you recall in basic financed we discuss something called as real rate of return. And we do not get a real rate of return anywhere, you know directly given to us. So we calculate the real return from the nominal return, nominal interest rate and the you know the inflation rate. And we, adjusting the nominal rate of return with inflation rate, we calculate the real rate of return. Similarly this convenience yield, it is a return but it is not available directly anywhere.

By equating the theoretical future price with the, with the spot price, we, theoretical futures price with the actual spot price, actual forward price, we calculate, we calculate the convenience yield.

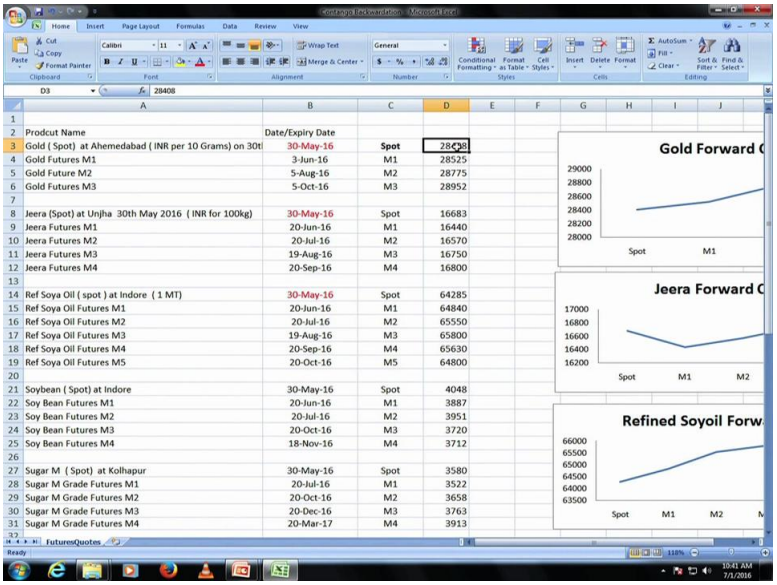
(Refer Slide Time: 26:03)



Now, so let us discuss little bit on what is the contango and backwardation. Contango is a market where the forward price or future price is more than the spot price or a price of it distant delivery contract is higher than the less distant delivery contract. That is spot is, spot, that is M1 is greater than spot and M2 is greater than M1. That is the market we call it, this market is known as a contango market. And which is a backwardation market? What is a backwardation market? Backwardation market is M2 is less than M1 and M1 is less than M1 is less than your spot.

It may so happen, M2 can be also less than spot, so if degree of backwardation is substantially higher, so you may have a longer distant, longer maturity contract quoting at a price less than the spot price. Now does the contango and backwardation happen in real life? Yes, it happens in real life.

(Refer Slide Time: 27:25)

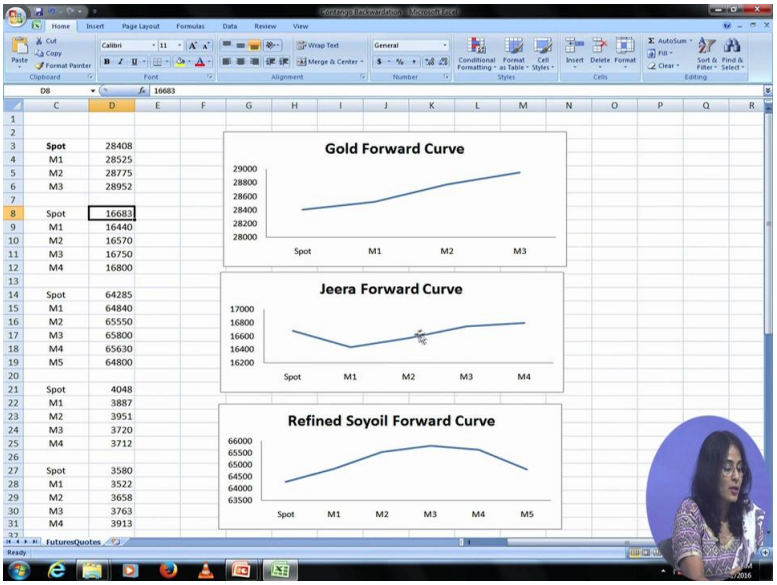


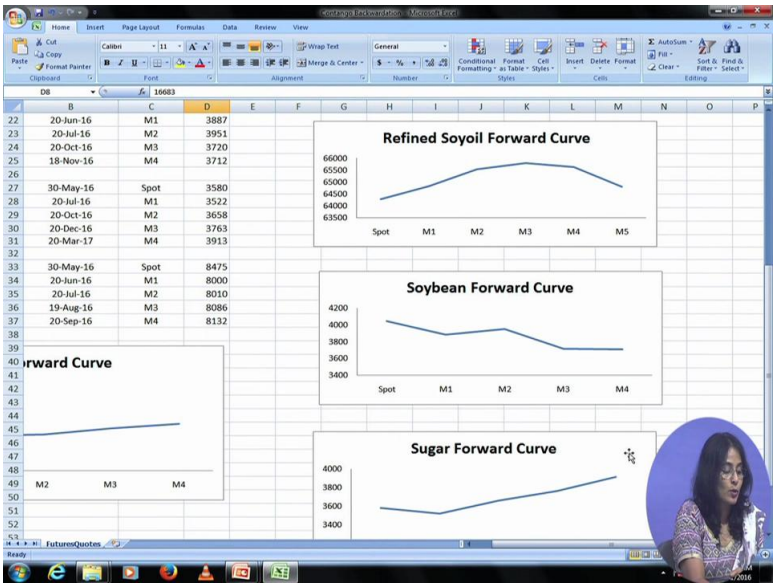
	A	B	C	D
1				
2	Prodcut Name	Date/Expiry Date		
3	Gold (Spot) at Ahemedabad (INR per 10 Grams) on 30t	30-May-16	Spot	28408
4	Gold Futures M1	3-Jun-16	M1	28525
5	Gold Future M2	5-Aug-16	M2	28775
6	Gold Futures M3	5-Oct-16	M3	28952
7				
8	Jeera (Spot) at Unjha 30th May 2016 (INR for 100kg)	30-May-16	Spot	16683
9	Jeera Futures M1	20-Jun-16	M1	16440
10	Jeera Futures M2	20-Jul-16	M2	16570
11	Jeera Futures M3	19-Aug-16	M3	16750
12	Jeera Futures M4	20-Sep-16	M4	16800
13				
14	Ref Soya Oil (spot) at Indore (1 MT)	30-May-16	Spot	64285
15	Ref Soya Oil Futures M1	20-Jun-16	M1	64840
16	Ref Soya Oil Futures M2	20-Jul-16	M2	65550
17	Ref Soya Oil Futures M3	19-Aug-16	M3	65800
18	Ref Soya Oil Futures M4	20-Sep-16	M4	65630
19	Ref Soya Oil Futures M5	20-Oct-16	M5	64800
20				
21	Soybean (Spot) at Indore	30-May-16	Spot	4048
22	Soy Bean Futures M1	20-Jun-16	M1	3887
23	Soy Bean Futures M2	20-Jul-16	M2	3951
24	Soy Bean Futures M3	20-Oct-16	M3	3720
25	Soy Bean Futures M4	18-Nov-16	M4	3712
26				
27	Sugar M (Spot) at Kolhapur	30-May-16	Spot	3580
28	Sugar M Grade Futures M1	20-Jul-16	M1	3522
29	Sugar M Grade Futures M2	20-Oct-16	M2	3658
30	Sugar M Grade Futures M3	20-Dec-16	M3	3763
31	Sugar M Grade Futures M4	20-Mar-17	M4	3913

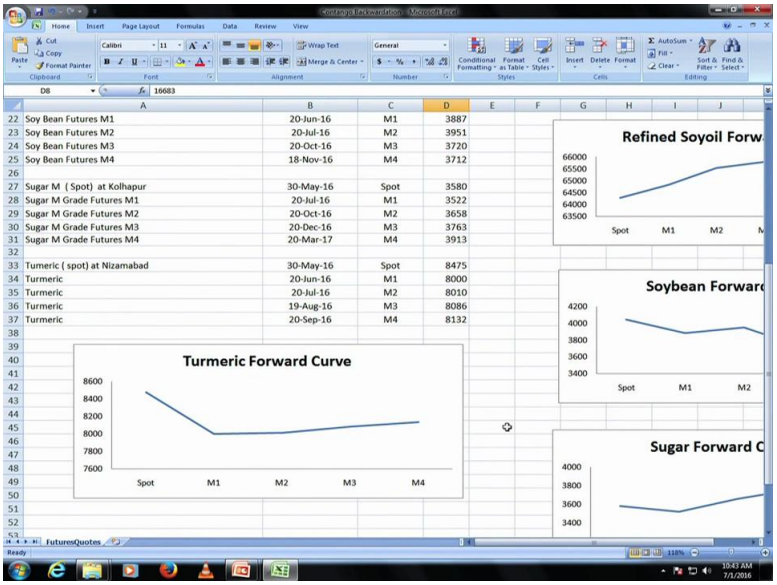
Let us, I will quickly take you through this detail I have downgraded from the NCDEX website. If you see this particular picture, this particular detail, you have a gold spot is 28,408 and what is the M1, M2, M3? M1, M2, M3 is higher than all these 3 contracts are higher than the spot. And if you see M2 is higher than M1 and M1 and M3 is higher than M2, so this your typical market of a contango market. Let us go back to this contract Jeera.

So what is the spot price? Jeera's spot price is, Jeera spot price is 16,683 but what is the M1 price? M1 price is 16,440 and M2 price is 16,570. So this M1 and M2 are less than your spot price. So this part you have a backwardation market but these 2 price, there is this more than the spot price and this is, will be a, this will be a contango market.

(Refer Slide Time: 28:23)







So if you see the Jeera forward curve is combination of both back, contango and back, content and backwardation. Similarly you have refined oil forward curve, you have soya bean forward curve, you have sugar forward curve and turmeric forward curve. So, you know, some market, some, some commodity maybe purely a contango, some commodity maybe purely backwardation and some commodity maybe combination of combination of contango and backwardation.

Ah This this kind of a situation, all kind of situation we may get to see depending upon the you know, commodity contract which we are considering. Now, with this we come to our, you know end of our discussion today. So we started with our discussion on contango, we started with our discussion on what is the reverse cash-and-carry and what is cash-and-carry and how traders can take benefit from this cash-and-carry and reverse cash-and-carry model, you know arbitrage opportunity.

We also discussed what is contango and backwardation and backwardation happens only when you have the forward price or future price is less than the spot price and contango happens when the spot price is less than the forward price and future price. And in the real-life, we can have all kinds of possibilities, we can have contango, pure contango or we can have your backwardation and we or we can have contango and backwardation for different commodities.

Of course another you know, another important part which needs to be highlighted is that a commodity maybe purely contango today maybe sometime later it may move into backwardation or vice versa. So with this I will end up this session today and looking forward

to continuing with this you know pricing and valuation aspect of commodity futures and forwards in the subsequent session. Thanking all of you.