

# Artificial Intelligence for Economics

Prof. Dripto Bakshi

Humanities and Social Sciences

Indian Institute of Technology Kharagpur

Week – 01

Lecture - 04

Lecture 04 : Uncertainty in Financial Markets : Idea of Hedging (Contd.)

Welcome to the next lecture. We'll continue with the idea of hedging and uncertainty in financial markets. In the last lecture, this is where we ended. We looked at the payoff from a long call option. That is, if I buy a call option which has a strike price of  $E$ , Then at the expiration date, this is my payoff, where  $P_{C_E}$  is the price of the call option.

Great. What if I go short on a call option? That is, what if I sell a call option to somebody else? Let's say to you. Then what is my payoff? And let's say the strike price of the call option is  $E$ . So there are two possibilities.

Either the price of the call option, sorry, the price of the underlying asset at expiration date, which is  $S_T$ , this becomes more than the call option, more than the strike price. That is  $E+10$ . Then what will happen? Well, I have sold you the call option. So what will you do? Now you have the right to buy this asset at rupees  $E$  from me on the expiration date. okay and I am obligated to sell you one unit of this asset at rupees  $E$  on the expiration date but the price of the asset at the expiration date is  $E+10$  let's say then what will happen I will have to buy the asset from the market at  $E+10$  and then give it to you and you will give me the strike price  $E$  so I will have a loss what is my loss What is my loss here? It is 10.

So as the price of the asset goes up above the strike price  $E$ , I, the seller of the call option, will start incurring losses. Higher the price of the asset, higher my losses. Okay? As you can see from this graph. It is exactly opposite. when I buy a call option.

When I buy a call option, I really want the price of the asset to go up. When I sell a call option, my payoff decreases as the price of the asset goes up, price of the underlying asset goes up. Of course, when I sell a call option, I also get some money because I'm selling it for some amount. So the entire payoff moves up by this much. So if the price is below  $E$  then what will happen? So if  $S_T$  is below  $E$ , so if  $S_T$  is less than  $E$  then what will happen?

Well then you have the right to buy this underlying asset at price  $E$  but the price of the underlying asset in the market is less than  $E$ .

So this right of buying at price  $E$  is a useless right and you won't exercise this right. I on the other hand I am happy why because I will make this profit this much profit which is equal to the price of the call option you will not exercise the option so this is my profit once the price starts going above  $V$  I start my profit starts getting eaten up and eventually I run into losses okay so this is the payoff if I if I am seller of a call option Now we'll start talking about something else. Consider, again consider the TCS stock option, and let's say it is trading at price 3416. And let's say tomorrow the election results will be declared. And I feel that the TCS price will go up to 3500.

So now I own a unit of TCS, one stock of TCS, And after the election results, I'm really hoping that the price of TCS will go up to 3500. So, will I sell my TCS stock now at 3416? Answer is no. Why should I? I'm owning it, I have it in my wallet. I'm tempted to wait after the election results are declared I'm tempted to wait till the election results are declared and sell it after that so that I can sell it at 3500. But then I'm also fearful.

What is my fear? I'm fearing that maybe there will be a hung assembly or something like that and the price will go down to 3300. So, on one hand I am tempted to wait, on the other hand I am fearful that the price will go down to 3300 which is lower than the current value. So, should I sell it now, should I wait, I am caught in this dilemma. So, what do I want now, what if somebody gives me an insurance or right which will allow to sell this one unit of TCS at 3416, which is the current price, tomorrow. The original sentence is indeed grammatically correct; no changes are necessary.

I cannot lose; I can sell it for 3,416 today. I am fearful that I may not be able to sell it for 3,416 tomorrow if the price goes down. However, if someone assures me, "Hey, don't worry, you can sell it for 3,416 tomorrow as well, no matter what," I will feel more confident. Then my fear is gone.

If the price goes up to 3,500, then fantastic; I will sell it for that amount. If it goes down to 3,300, I can still sell it for 3,416 because I have this insurance. Now, this insurance or right allows me to sell one unit of TCS at 3416 on the 1st of September or tomorrow. This is called a put option.

No changes are needed. The call option was the right to buy an asset. It was the right to buy an asset at a particular price, called the strike price, on the expiration date. So, this is the formal definition: a put option is denoted as  $P_E(S, T)$ .  $E$  is the strike price, which is the amount or price at which I am guaranteed to sell on the expiration date denoted by

capital            T.            S            is            the            underlying            asset.

Fantastic! How will my payoff look? Of course, I am ignoring the price of the put option for the time being. So, I have the right to sell one unit of TCS or one unit of an asset for  $E$  rupees on the expiration date. Fine! Now, let us say that the price of the asset  $(S, T)$  is less than  $E$ ; specifically, let us say it is  $E - 5$ . Then, well, I have the right to sell it for  $E$  rupees, okay? So, let's say that I bought a put option from you. So, I have the right to sell one unit of the underlying asset to you for  $E$  rupees on the expiration date. So, what is my payoff?

Well, I will buy the asset from the market at  $E - 5$ . Then I will come to you and say, Hey, look, I have this put option. I have the right to sell it to you for  $E$  rupees. I will sell it to            you            for             $E$             rupees.

You are obligated to purchase from me. I will make a payment of  $\$5$ . If the price is  $e - 10$ , then I will buy from the market at  $e - 10$  and sell it to you for  $e$  rupees, resulting in a            profit            of            10.

So, the lower the price in the market, the higher my payoff will be if I am the owner of a put option. If I have bought a put option, that is fantastic. So, lower the price to increase profits, okay? Great! What if the payoff—sorry, the price of the underlying asset at the expiration date—goes above  $E$ ? Then what is going to happen? Well, let's say it becomes  $E + 10$ .

Now I have the right to sell one unit of this pen to you for  $E$  rupees, but in the market, it can be sold for  $E + 10$  rupees. So, this right to sell to you at  $E$  rupees is a worthless right. I might as well go to the market and sell this pen for  $E + 10$ . My payoff from the put option will be zero if the price is above  $E$ . This is what the payoff looks like. Of course, I am assuming that the put option was free. I am not taking into account the price of the put option, but if you do consider the price of the put option, then a long put means I am buying            the            put.

Therefore, the entire payoff is reduced by an amount PPE, which is the price of the put option. Is that acceptable? What is the payoff for the seller of a put option? What happens next?

If I sell you the put option, you will have the right to sell the underlying asset to me at  $E$ . If the price of the asset is above  $E$ , what will happen? If the price of the asset on the expiration date is above  $E$ , what will occur? The payoff is zero. So, there is no transaction happening, is there? If the price of the underlying asset at the expiration date is less than

E, for example,  $E - 5$ , what will happen? Then I will have to, as I have sold you the put option.

So, you have the right to sell it to me for E rupees. So, I will have to buy it from you for E rupees and sell it in the market for  $E - 5$ , which means I will incur a loss of 5 rupees. So, you can see that the price should be lowered.

The lower the price goes, the greater my loss becomes. If I sell a put, that will be my payoff. Of course, if I sell a put, I also receive some money upfront, which is the price of the put option. So the entire payoff is scaled up by an amount, PPE, which represents the price of the put option. Great! We have examined the payoff for someone who is long on a call, long on a put, short on a call, or short on a put option. Now we'll talk about another instrument in the financial market known as shorting assets. So, what did you see in the video? In the video, Harshad states the following: "Well, I don't own any stocks." There are no errors to correct. So, shorting a stock basically means selling a stock or an asset without actually owning it. In the following ways: If I do, what I will do is as follows: I will just call the broker and ask him to sell one unit of TCS stock.

What will the broker do? The broker will take a unit of TCS stock and sell it in the market, receiving some money, which he will give to me. Okay, I receive some money—let's say a hundred rupees. Now the broker will remind me that I owe him one unit of TCS stock. I will say, "Yes, yes, I remember." So, I have taken this hundred rupees, put it in my wallet, and I'm waiting.

Now, if the price of TCS goes down to 10 rupees, or let us say to 90 rupees, by 10 rupees, for instance. So, if the price of TCS stock goes down to 90 rupees, what should I do? I have 100 rupees in my wallet, which I received from the broker. I will use 90 rupees to buy one unit of TCS stock. Here's the corrected version of your sentence: "I will give it back to the broker because I remember that I owe one unit of TCS stock. I will have to return it to the broker, as he sold it on my behalf.

Therefore, I will use 90 rupees of the 100 rupees I have in my wallet to buy one unit of TCS stock and return it to the broker. Now I am clear: I don't owe anything to anyone. However, in this entire transaction, what am I left with? I am left with a profit of 10 rupees. Sure! Right, I had 100 rupees.

The broker sold one unit of TCS stock and gave me 100 rupees. The TCS stock then dropped to 90 rupees. I bought the TCS stock at 90 rupees and returned it to the broker. The broker's account was settled, and in the meantime, I made a profit of 10 rupees, which is 100 - 90.

Okay, so this is called shorting a stock. So, the lower the price of the stock, the higher my profit will be. I received 100 rupees from the broker for shorting one share of TCS. But I had to repurchase a stock of TCS later to return it to the broker. If the price of TCS decreases later, my profits will increase. So, it has a downward-sloping payoff curve. And remember, we are talking about call options and put options, which have expiration dates.

In the case of shorting, we have something called a settlement date. So, if the price of TCS is lower than 100 rupees on or before the settlement date, I will make a profit. If it is higher, I will incur a loss. I will have to buy a stock of TCS and return it to the broker anyway.

If it reaches 110, I will have to buy it at that price and return it to the broker. Great!

Now, let's try to be a little more sophisticated. Let's use the concepts of call options, put options, and short selling that we have examined. Now, let's try mixing them to create more complex instruments. Shorting with a call option is not a common practice. Okay So, let's say that the current price of an asset is  $S$  rupees. Short a stock and receive  $S$  rupees; it's a downward curve, as you can see here.

However, it can decrease significantly. What I am doing is buying a call option, so as the price of the stock goes up on the settlement date, my payoff will decrease, and ultimately, my losses will become substantial. To mitigate this, what should I do? I'm buying a call option that allows me to purchase one unit of this underlying asset for  $E$  rupees. Let's say that the settlement date and the expiration date coincide.

Since I have shorted the stock, the payoff keeps decreasing as the price rises.

I have the right to buy this asset for rupees  $E$  since I own the call option. Remember, I will have to pay the broker back one unit of the underlying asset, and now I have the call option, which allows me to buy the underlying asset for  $E$  rupees. So, no matter how much the price of the underlying asset increases, my loss cannot exceed  $E$  rupees; in fact, I will definitely be able to buy it for  $E$  rupees. Fine, that's the problem. Let's examine a specific real-life situation and try to understand the intuition behind investing or trading. Well, this is something that happened some time ago: a court case between Amazon and the Future Group. Basically, Reliance was acquiring the Future Group, and Amazon filed a case that was initially in the Supreme Court and later moved to the Singapore International Arbitration Centre.

The situation was as follows: Amazon opposed the deal. If the Reliance-Future deal goes through, imagine you are standing and reading in the newspaper that a deal is expected to occur between Reliance and Future, whereby Reliance will acquire Future. However, if

a...

If Amazon wins the case, the deal won't happen, or it may be delayed indefinitely. So, if the deal goes through, the price of Reliance will increase. If the deal is terminated in court, Reliance will take a hit, and the price will decrease. Right, so let's say you are reading this in the newspaper. You are caught in a dilemma: you don't know whether the price of Reliance will go up or down.

I don't really know what's going to happen, but I know that something will occur. Whichever way the verdict goes, the price of Reliance stock will either rise or fall based on this news and the outcome of the court case. So, what should you do? Should I go, or should I buy stocks in Reliance? No, I'm afraid it might go down. Should I short Reliance's stock? No, I don't know.

If the court's verdict is in favor of Reliance, the stock price will rise; otherwise, I will incur a loss. Right, I know it can go either way, and I understand that it will go one way or the other.

May I have a trading strategy, please? Okay. So, let's use the following trading strategy that we can apply to this situation. Let's see. So, what am I betting on? What do I hope will happen? I'm essentially betting on movement.

I'm hoping that the price of Reliance will go either up or down. So I'm really hoping for some progress, aren't I? So, I will do the following: It has the same expiration date and the same strike price.

This strategy is called a straddle. The stock of Reliance consists of one share of Reliance. Now, if that is the price of the underlying asset, which is above  $E$ , then which option will I exercise? If the price of the underlying asset is above  $E$ , the call option gives me the right to buy it at  $E$ , making it a worthwhile option, and I will exercise the call option.

Will I exercise the put option? No. If the price of the asset is above  $E$  and I have the right to sell it at  $E$ , then it's a useless right because I might as well sell it in the market at a price above  $E$ . Therefore, if  $S_T$  is greater than  $E$ , I will only exercise the call option. By a symmetric argument, if  $S_T$  is less than  $E$ , I will exercise only the put option.

What is my payoff if I buy a call option and a put option? Of course, right now, I'm ignoring the prices of the options. Let's see.

I have a put option (PE) and a call option. If the price of the underlying asset, which is  $S_T$ , exceeds the capital  $E$  on the expiration date, what will happen? Well, I will exercise

the call option. Let's say it becomes  $E+5$ ; in that case, I will exercise the call option. I will exercise the call option, which gives me the right to buy the asset for  $E$  rupees.

Then, I will sell it in the market for  $E+5$  rupees, making a profit of 5 rupees. As the price of the asset rises, my payoff increases, so this segment of the line is important. If the price is above  $E$  in this zone, I will exercise the call option. What if the price goes below  $E$ ? Let us say it becomes  $E-5$ .

The put option gives me the right to sell the asset for  $E$  rupees. The sentence is already grammatically correct. I will buy one unit of the asset from the market for  $E-5$  rupees, and then I will use the put option to sell the asset for  $E$  rupees. And thereby receive a payoff of five dollars. So, the lower the price, the higher my profit in this segment will be.

So, here I am using the put option. So, we see that the higher my deviation from  $E$ , the greater my profit will be if I use the straddle strategy; the greater my deviation from  $E$ , the greater my profit will be. And remember, I was betting on the move. I hoped that the price would change and that I would make a profit.

Of course, if we take the price of the options into account, I bought a put option and a call option. Do you remember? I have spent some money.

So, the entire payoff is shifted down by an amount equal to  $P_E + C_E$ . So, if  $E$  is the strike price at which I am buying, let's say this is the zone from  $E-\epsilon$  to  $E+\epsilon$ . So I hope that the change in price will move the price of the reliant stock either above this band, to the right of it, or to the left of it. So, I hope for progress. A straddle is a trading strategy in which you don't know whether a particular asset will go up or down, but you know for sure that it will move significantly in either direction.

So here you are betting on movement, but you don't know the direction of that movement. Great, that's a straddle! There is a slight change here, though it is strange.

I am betting on movement, but I also have a hunch about the direction. Let's see what that means. So, what am I doing here? Once again, I am buying a call option and a put option." This maintains the original meaning while enhancing clarity. But in this case, the strike price of the put option is less than capital  $E$ , which is the strike price of the call option.

So, you can imagine what the payoff will be. If the price of the underlying asset  $S$  at time  $T$  is greater than  $E$ , I will exercise the call option. If it is less than small  $e$ , I will exercise the put option. The sentence is grammatically correct as it is.

This is how the payoff will look. I've taken this into account; it's exactly like a straddle, but we have a plateau in between. The straddle was sharp and V-shaped, but here we have a steady zone. Okay, but when is a strangle used instead of a straddle? Let's understand this: the strike price of the put option I am buying in a strangle is lower than that of the straddle.

What is a put option? A put option is the right to sell an asset at a specified strike price. The higher the strike price, the more valuable that right is; thus, the higher the price of the put option will be.

This means that the price of the put option in a strangle is lower than the price of the put option that I buy in a straddle, so the strangle portfolio is cheaper than the straddle portfolio.

Okay, but I'm still betting on movement. If you look at the payoff, you can see that I truly want... The stock price can either go above this band, to the right of it, or to the left of it. But I am betting more on upward movement; let's see how it goes. Assume that the stock is trading at 15 rupees in April. Now suppose I have a call option: I bought a call option with a strike price of 15 and an expiration date in June. So, this is a straddle.

Now, if I buy a straddle with a strike price of 100, what does that mean? It means I am buying 100 call options and 100 put options, okay? Now, each call option with a strike price of 15 is worth 2 rupees, and each put option with a strike price of 15 is worth 1 rupee. So, what is the price of my straddle portfolio? It's 300 rupees. That's the amount I need to spend to buy 100 calls and 100 puts of this type, which is equivalent to 100 straddles. The straddle value will increase as the stock moves higher or lower.

So, you can imagine that. So, if 15 is my strike price, I will need to make a profit of 3 to break even. Because one put option and one call option have cost me three rupees, I need to reevaluate my investment strategy. I really hope that the price goes above 18 or below 12. Either above 18 or below 12 years old. That's what I hope for. This is my straddle scenario.

The straddle has no directional bias. Whether it moves by an amount greater than three units to the right or left, I don't care; I will make a profit. Now, in this triangle, what I am doing is the following: I'm buying a call option again with a strike price of 15, but now I'm buying a put option with a strike price of 12.5 instead of 15. Instead of buying a put option with a strike price of 15, as I did in the straddle for \$1, I am looking to buy a put option with a strike price of 12.



50. Now, the price of that particular put option, with a strike price of 12.5, is 0.25. That's okay. That remains at two. Then, what is the price of each put-call pair that I have? Two for the call option and zero point twenty-five for the put option.

If I buy 100 of those, what will I receive? The number is 225. That's the amount I need to spend to buy a strangle portfolio.

Okay, which is significantly less than 300, the amount I need to spend to buy your straddle portfolio. Also, since 2.25 is the amount I am spending on one particular unit of the strangle, which consists of one put and one call, I am hoping for a movement of 2.25 to break even; that much is sufficient. Is that acceptable? So it's a little cheaper than a straddle that way. Great! I think I will stop here, and in the next lecture, we'll look into a few more interesting financial instruments and trading strategies.

We will also try to determine the payoff of any particular portfolio, including any complicated portfolios that we may construct. But we'll have to wait for that until the next lecture. See you at the next lecture!