Quantitative Investment Management
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Indian Institute of Technology, Roorkee
Lecture 42
Option Trading Strategies – 3

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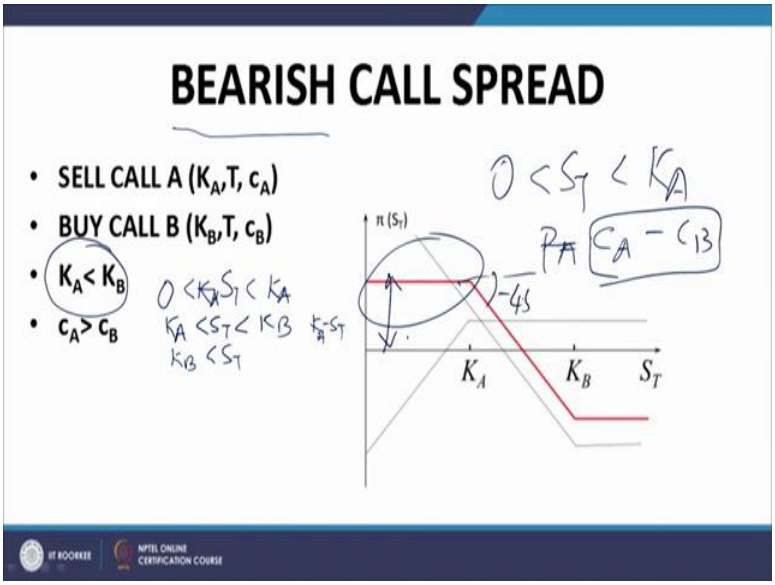

So, let us continue. Before the break I was talking about the bullish call spread or a bullish call spread that was created using two call options. We had a long position in call A which was at a lower exercise price and a short position in call B which was at a higher exercise price. Now, when we try to construct a bearish call spread, we reverse the combination. That is, we have a long position in a call with the higher exercise price and a short position and a call with the lower exercise price

So, assuming that K A is less than K B as you can see here. And then, we sell call A, we take short position in call A and we take a long position in call B. Now, in this case, obviously because the price of call A, that is, at the lower exercise price is the premium of call A, which is at a lower exercise price would be higher compared to the premium of call B, which is at the higher exercise price.

And we are short in call A, long in call B, so we will have a surplus at T equal to 0 when we implement the strategy, when we set up the strategy. Let me repeat, we have call A short position therefore, we will receive the premium, we have call B on which you have a long position and therefore, we will pay the premium. But the exercise price of A is lower, the exercise price of B is higher.

And therefore, the premium that you receive on call A is higher, the premium that you pay on call B is lower. As a result of which, you get a net surplus at T equal to 0 when you implement the strategy. Let us see how the payoff of the bearish call behaves. It is quite easily worked out on the same premise as we worked out for the bullish call spread.

We again split up the spectrum of stock prices between from between 0 less than K A less than as, I am sorry, 0 less than S T is less than K A. In this case what will happen? Both the options A and B will not be exercised because the stock price is below the exercise price of K A and K A is below K B.

And then we have K A less than S T less than K B. In this case what happens? In this case, because this stock price is above K A, option A will be exercise and you are short in that option. Please note this. So, your payoff will be K minus S T, K A minus S T. And what happens in the next case, when K B is less than S T, then what happens?

In that case both options will be exercised because K B less than S T implies that K A is also less than S T. Therefore, both options A and B are exercised and therefore the payoff becomes independent of the stock price because you are long in one, you are long in B, you are short in A, both, and both the payoffs are linearly related to S T. And therefore they would cancel each other.

And the net diagram that we have is as shown in the right hand panel. So, the interesting part that you need to note here is that you make a profit in this region. What is this region? This region is when this holds 0 less than S T less than K A. So, obviously this is the stock price has to be low as low as possible.

And that is the reason that this is classified as a bearish call spread because you tend to make a profit only when the stock price finishes below K A, which is less than K B and so on. The fact that you make a profit when the stock price is on the lower side is the reason behind naming the spread as a bearish call spread.

And what is this profit equal to? This profit is equal to the difference in the premium that you pay for this setting up of the strategy. And what is that equal to? You receive P A and you sorry, you receive C A and you pay C B. So this is the net profit and this is represented by this portion. And again, and when the stock price lies between K A and K B because you are short, in option A, the payoff is having a downward slope of minus 1 that is this angle is, this angle is minus 45 degrees.

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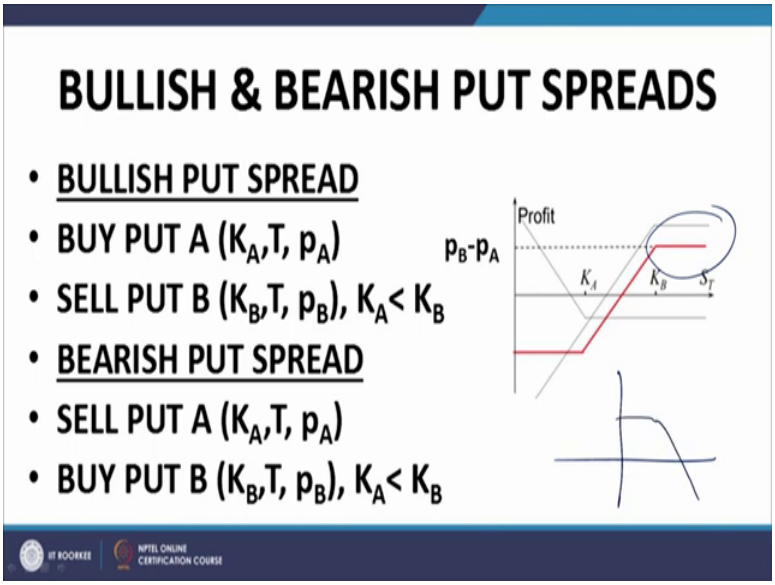

Similar to the situation that we encountered in the context of call options, we can also construct bullish and bearish strategies or bullish and bearish vertical spreads using put options. In the case of bullish put spread, what do we have? We buy put A at K A T comma p A and sell put B at K B T comma p B K is less than K B here. And K A is less than K B means what, means p A is less than p B and because you are buying p A at p A you are selling at p B and p A is smaller, p B is larger.

Because remember, in the case of put options the premia is directly related to the exercise prices. Higher the exercise, price higher is the premium because is the right to sell. So, in this case because a is, K A is smaller than K B therefore p A would be smaller than p B and because you are long in A, short in B, so you will receive more for B, then you will pay for A and there will be a net cash inflow at T equal to 0 as you can see in this particular diagram.

It is this region which is p B minus p A. You are, you are short in B so it is p B, you are receiving p B and you are paying p A. Similarly, we can analyze the bearish put spread and the figure would obviously be inverse of this, it would be something like this.

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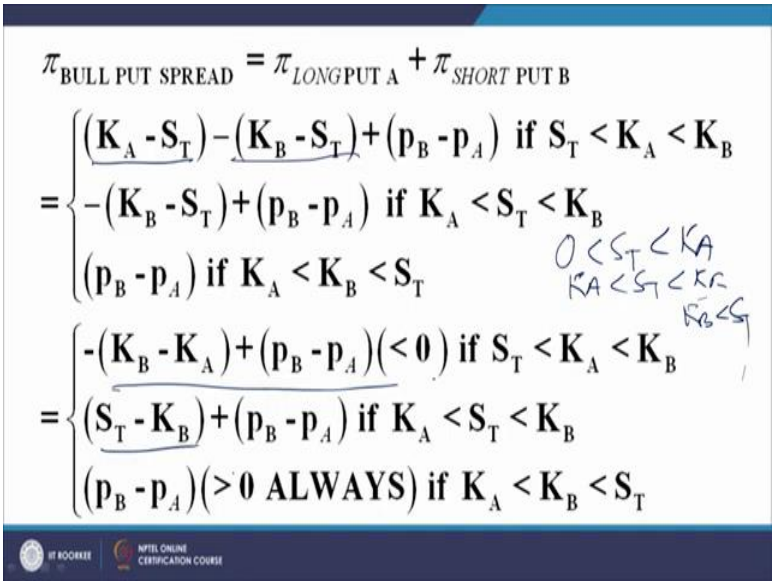

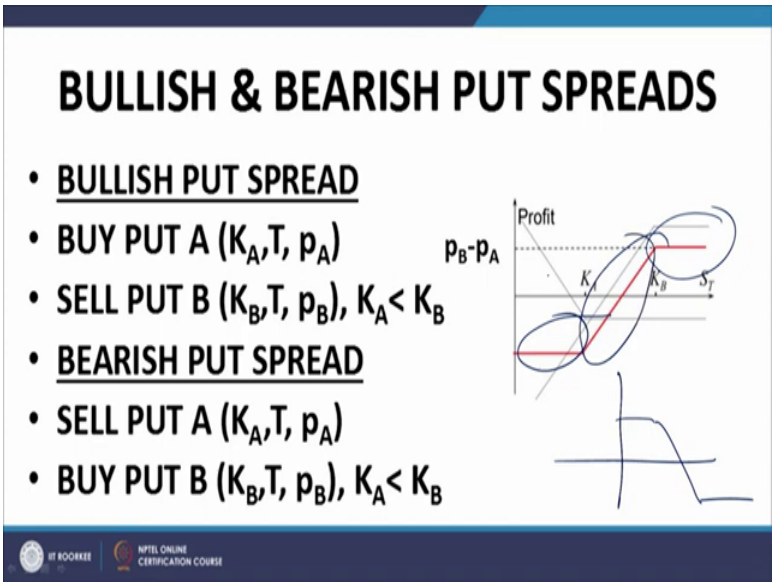

These are the put spread essentials, cardinals of the bull put spread, the profit function of the bull put spread a long in put A and short in put B. You can see here that this expression is less than 0. So this is this portion here, this is this portion, then if 0, if S T lies between K A and K B, then we have this portion. And if S T goes beyond both K A and K B, then we have this portion because none of the two put options are exercised.

You see basically, what is happening is if 0 is less than S T is less than K A, then both A and B are exercised, both options A and B exercised, as you can see here. This is the exercise of option A, this is the exercise of option B then we end up with this net result which is less than 0.

And if S T lies between K A and K B, then only B is exercised, as you can see here this, only B is exercised. And if K B is less than S T, then none of the options are exercised and you pocket the premium equal to what? Equal to p B minus p A, which is obviously greater than 0 because K B is greater than K A.

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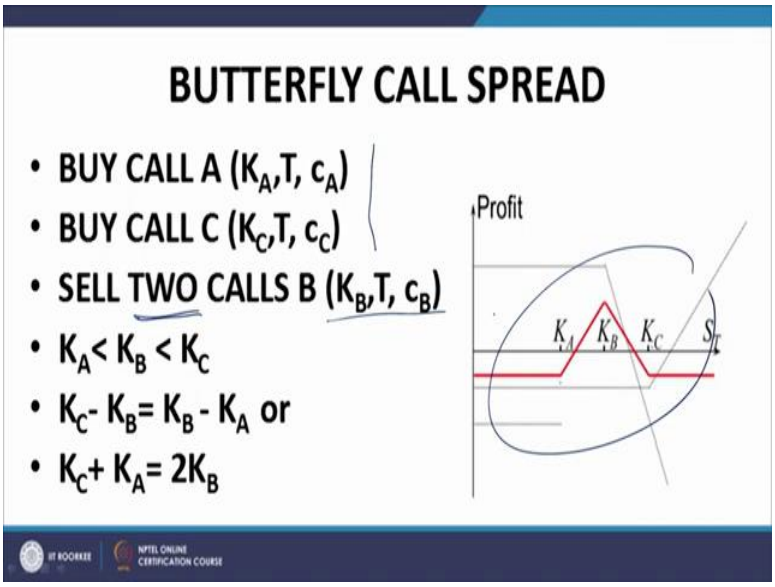

Now, we talk about a butterfly call spread. Butterfly call spread is somewhat similar. In some sense, it is similar to a straddle, similar to the straddle strategy. What does it consist of? It consists of a body and it consists of the wings. The wings comprise of options A and C, long position in call option A, long position in call option C, these are the wings. And then we have the body which is the short position two calls with exercise wise K B.

So, let me repeat. We have a long position in call option A exercise price K A maturity T same underlying, all these options are same underlying, same maturity and the only difference is as far as their exercise prices are concerned. And obviously that translates to difference in premium as well.

So, we buy call option A, long position in call option A, long position in call option C, and short position in two call or two calls B. The exercise price of K A is the lowest, the exercise price of K C is the maximum and the exercise price of option B, that is K B, is midway between K A and K C.

So, let me repeat one long call with exercise price K A, one long call with exercise plus K C, two short calls with exercise price K B such that the exercise price K B is midway between K

A and K C. So, buy long A with the exercise price K A maturity T and cost case, cost C A, buy call C, parameters K C, T and C C.

Sell two calls, please note this, sell two calls B with K B, T and C B. K A is less than K B is less than K C and the difference between them, between K B and K A is the same as the difference between K C and K B. In other words B, K B is midway between K A and K C. This is the diagram of the payoff, of the profit from the butterfly spread which is represented by this combination of options.

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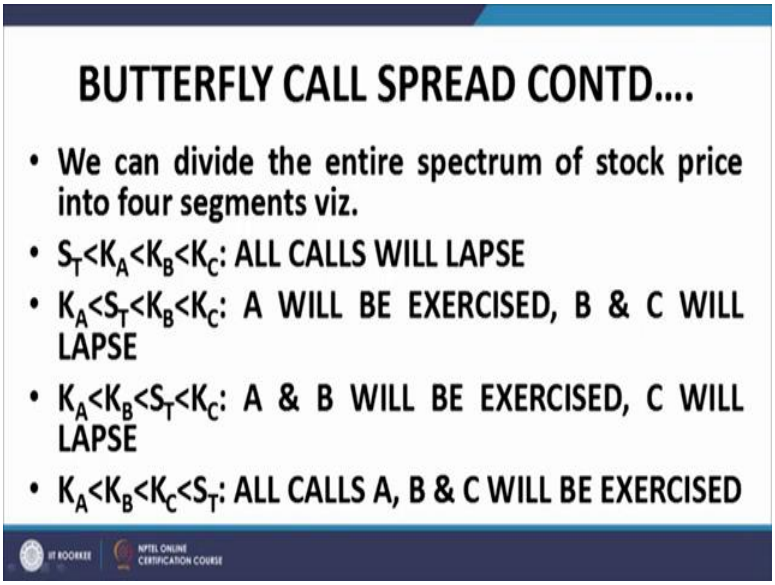

Now, we analyze this diagram. We can now split up the spectrum of spot prices into again different segments, 0 less than S T less than K A, K A less than S T less than K B, K B less than S T less than K C, and K C less than S T. So, let us see what happens in each situation. When S T is less than K A, what will happen? None of the options will exercise, all the options will lapse, all the calls will lapse.

Because remember all of these are call options and call options will be exercised only if the stock price is greater than the exercise price. Since the stock price is lesser than all the exercise prices that we have, none of the calls will be exercised. Then number two, when K A is less than S T is less than K B. Then option A will be exercised, B and C will not be exercised because S T is lesser than K B as well as K C because K C is greater than K B.

So, in this case only option A is exercise. When S T is between K B and K C then what happens option A is exercised because if S T is greater than K B, it is obviously greater than

K A. So option A is exercised, option B is exercised, option C is not exercised. And if S T turns out to be greater than K C, then all the options will be exercised because they are calls.

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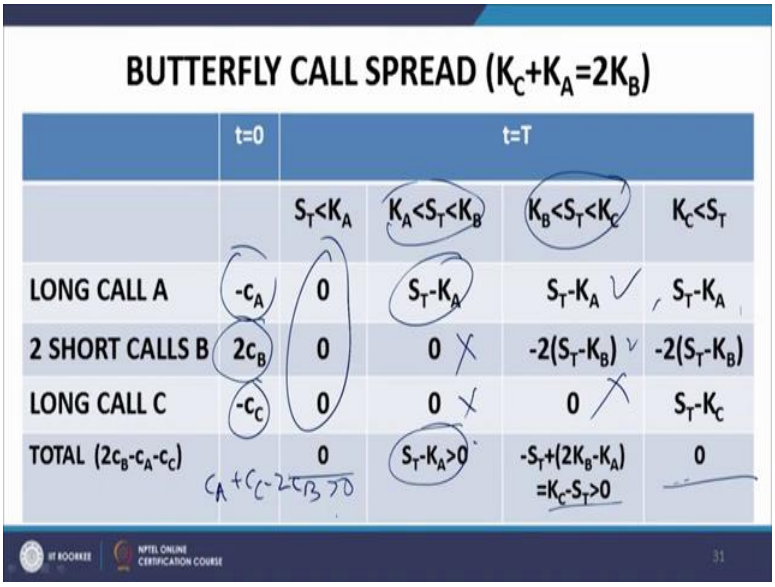

Now, this is the tabular form of the payoff, and that is what I said. If S T is less than K A, none of the options is exercised and you can see here none of the options are exercised. If S T lies between K A and K B only A is exercised, B and C are not exercised. And if K B is less than S T is less than K C, then what happens? A is exercised, B is exercised, C is not exercise and if K C is less than S T, then all the options are exercised.

Now, the interesting feature is that if you look at the net payoff, the net payoff in the first case is 0, the net payoff in the last case is 0 as well and in the other cases, you find that the net payoff is positive because you see here, that is, S T minus K A and from this condition S T minus K A is greater than 0.

Similarly, from this condition, it is K C minus S T and because of this K C minus S T is also greater than 0. So, the net result is that the payoff from the butterfly is either 0 or greater than 0, it is never less than 0. That is one part. And the cost of setting up of the butterfly, you are long in call A, so you pay a price for that, that is, C A. You are long in call C, you pay a price for that that is C C. And you are short in two calls B, so you receive the price of calls B that is 2 C B.

So, the net price that you pay for this is equal to the net price that you pay or the net cost that you incur is equal to C A plus C C minus 2 C B. Now, because there is another interesting

point here, let me also touch upon that. You see the payoff of the strategy at maturity is either 0 or positive, it is never negative.

And therefore, what does it mean? It means that the cost of setting up of the strategy must always be positive or in the extreme case, it can be 0 but for all practical purposes at least it has to be greater than 0. The cost of setting up of this strategy has to be greater than 0, because the payoffs in each case are either 0 or greater than 0.

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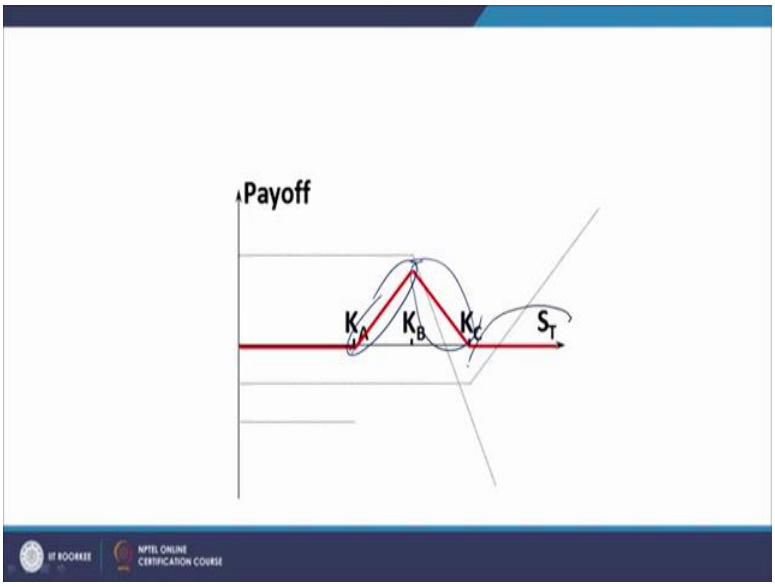

This is the payoff diagram, this is the payoff diagram, please note. Up to K A, the payoff is 0, none of the options are exercised. K A to K B, option A is exercised, this region. K A B to K C option A and 2 B are exercised and therefore the slope is downward and minus 1, rather. And in the last case when all the options are exercised, then S T is greater than K C, this is the region.

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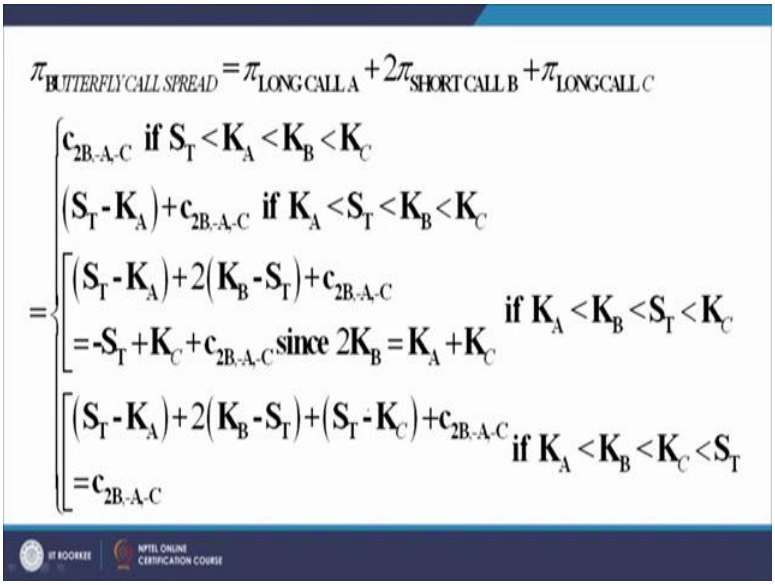

This is the analysis, this is the analytical the representation of the profit function.

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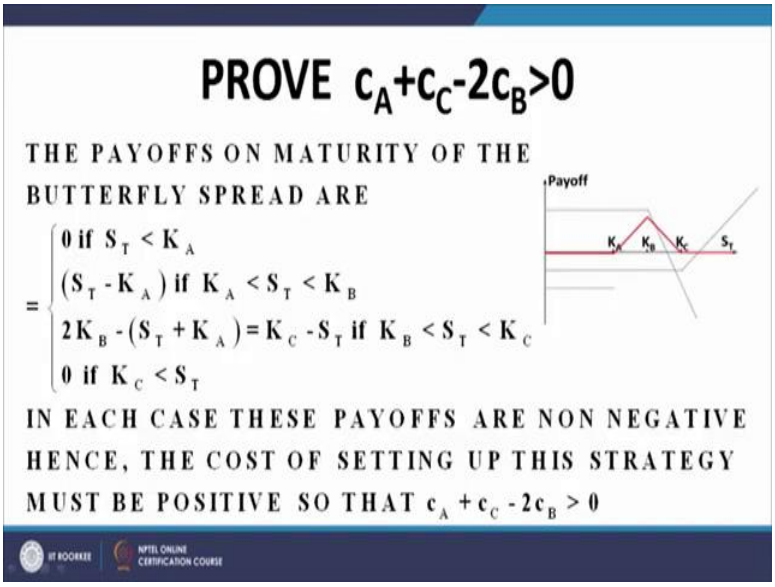

Then, I proved this just now, because the payoff at, under any, all the circumstances you can see here, the payoff under all the circumstances either 0 or greater than 0. Therefore, the cost must also be greater than 0 and that is what is represented by C A plus C C, which is the cost. Please note this.We are talking about cash outflows here as positive because we are talking about cost.

When you talk about cost, cash outflows are taken as positive and when you talk about the cash flows, then cash outflows are taken as negative. So, in either case the situation does not

change, the cost of setting up of the strategy has to be positive or the cash flow has to be negative.

So, all the signs across the board will become negative and this greater than would be replaced by less than and that would mean that the same situation again emerges, whether you take the cost aspect of it or you take the cash flow aspect of it. A positive cost means a negative cash flow or a cash out flow and a negative cost means a positive cash flow.

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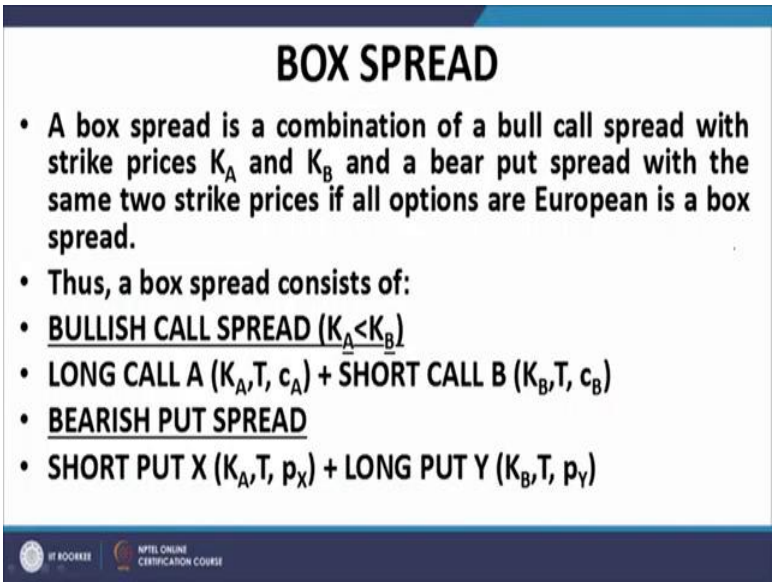

Now, we talk about a box spread. A box spread is a combination of a bull call spread with strike prices K A and B, K B and a bear put spread with the same strike prices. All the options are European, the same maturity and the same underlying. So, let me repeat, a box spread is a combination of a bull call spread with strike prices K A and K B, same maturity, same underlying, same type, all are European.

And a bear put spread with the same two strike prices, all the options are European, same underlying, same maturity. Thus, the box spread consists of a bullish call spread. If you recall, a bullish call spread consists of two options A and B with K A less than K B and we are long in this spread with the lower exercise price, that is, K A. We are long in the option with the, we are short in the option with the higher exercise price, that is K B or that is option B.

So, let me repeat. We are long in call A with the exercise price K A, we are short in call B with exercise price K B. And as far as the bear put spread is concerned, we are short in the

put X with exercise price K A and we are long in the put Y with the exercise price K B. So, please note this inverse relationship.

As far as the bullish call spread is concerned, you are long in the call with the lower exercise price and you are short in the call with the higher exercise price. As far as the bear put spread is concerned, you are short in the put with the lower exercise price and long in the put with the higher exercise price.

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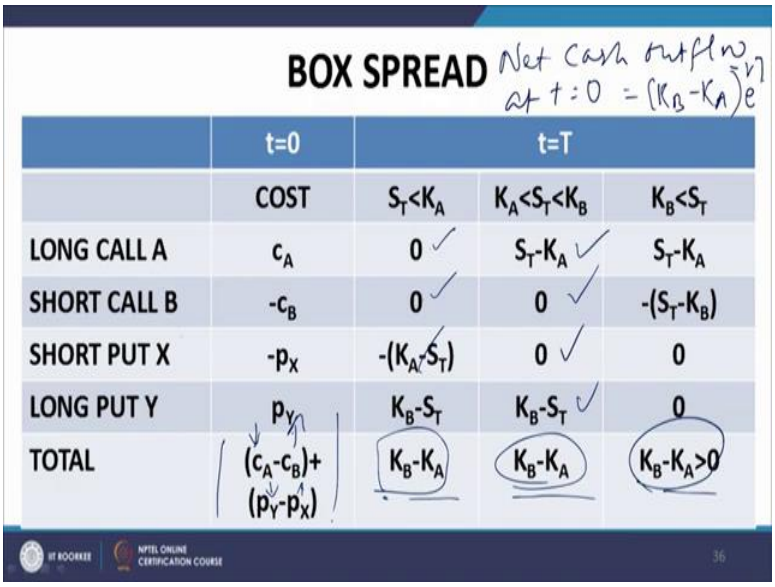

The payoff is very interesting. If you look at this payoff, obviously we can again split up the spectrum of spot prices into different parts. 0 is less than S T is less than K A. Then K A is less than S T is less than K B and then K B is less than S T. Now, look at long call A. If 0 is less than S T is less than K A, call A will not be exercised, call B will also not be exercised because K A, K B is greater than K A. So if S T is less than K A then it is obviously less than K B. So, A and B both the calls are not exercised, but both the puts are exercised.

And because both the puts are exercised, this is, and you are short in one, you are long in the other, therefore S T and S T will cancel and the net payoff turns out to be K B minus K A. Now, look at the second situation when K A is less than S T is less than K B. Then option A is exercised, option B is not exercised. Why it is not exercised?

Because S T is less than K B. Option X is not exercised. Why? Because S T is greater than K A and this is a put option. So, option X is not exercised and option Y is exercise because S T is less than K B and this is a put option. So, this is K minus S T and the total payoff again turns out to be K B minus K A.

And in the last case what happens? Both options, call option A and call option B are exercised, put option X and Y are both not exercised. And therefore again we have a payoff of K B minus K A, this is very interesting. What is the interesting part? The interesting part is that irrespective of the state of nature in which the stock price evolves, irrespective of whether S T is less than K A, S T lies between K A and K B or S T is greater than K B, irrespective of wherever it lies the profit, the payoff from the box spread is always K B minus K A.

You can see it clearly in the last line of this particular table, last row of this particular table. Therefore, what does it mean? It means that the cost of setting up of this box spread, the cost of setting up of this strategy must be equal to the present value of K B minus K A. It must necessarily be equal to the present value of K B minus K A. Why? Because it is giving you a risk free payoff of K B minus K A at the maturity of the option.

So, let me write it here, net cash outflow at T equal to 0 must be equal to K B minus K A e to the power minus r T. Please note the signs when you are considering cash inflow and outflow and when you are equating this to this, the consistency in signs must be maintained. And in fact you can use this to derive the put call parity relationship as well.

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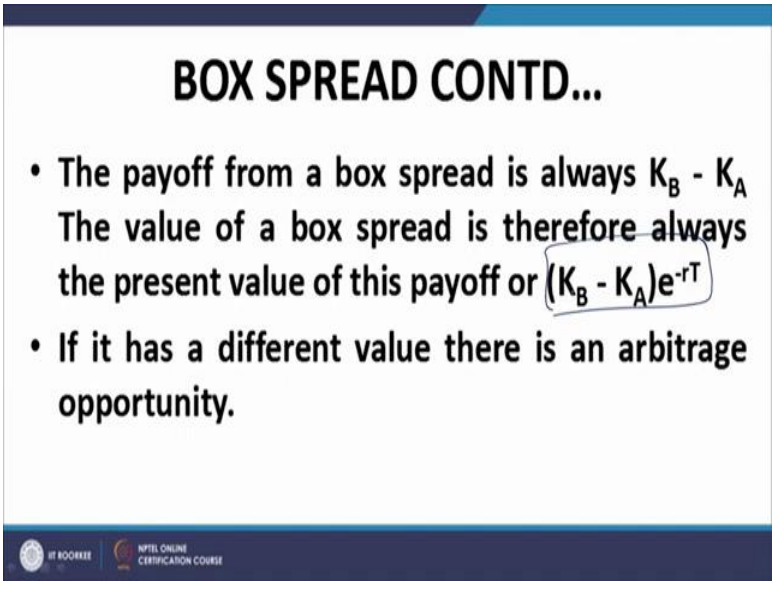

The payoff from a box spread is always K B minus K A, the value of a box spread is therefore always the present value of this payoff or K B minus K A e to the power minus r T. That is what I mentioned just now. If it has a different value, then it is an arbitrage opportunity.

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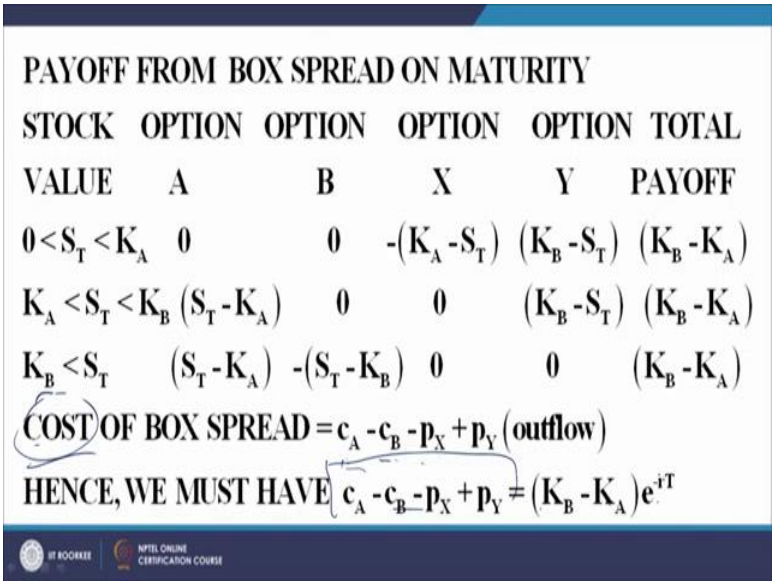

You can see here the cost of the spread is C A, C A, please note we are talking about the cost here, and C A is a cash outflow, C B is a cash inflow. C A is a cash outflow, and it is a cost so it is taken as positive. C B is a cash inflow. Here, you are writing the call so you are receiving money, so it is a negative cost. So we say, put a negative sign.

Then similarly, p X is short put so again you are receiving money so it is a negative cost. And p Y, you are buying the put option, therefore, you are paying a price and that is a positive cost. Let me repeat, when you talk the cost aspect, it is inverse to the cash flow aspect. A positive cost means a negative cash flow and a negative cost means the positive cash flow.

So, because we are talking about the cost aspect, we are taking the signs opposite to the signs of the cash flows. C A minus C B minus p X plus p Y is equal to K B minus K e to the power minus r T. The cost of setting up of this strategy must be equal to the present value of K B minus K A. Because you are getting K B minus K A, irrespective of the state of evolution of nature, and so far as the stock price is concerned, that means what? That means it is a risk free receipt or a risk-free cash inflow at maturity, because it is occurring in all possible circumstances.

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Box spread arbitrage. If the market price of the box spread is too low, it is profitable to buy the box. This involves buying a call with strike price A, buying a put with strike price B, selling a call with strike price B and selling a put with strike price K A. Let me repeat, if the market price of the box spread is too low then it is profitable to buy the box.

Buying the box means what? Buying a call with strike price K A, buying a put with strike price K B, selling a call with strike price K B and selling a put with strike price K A. If the market price of the box is too high, it is profitable to sell the box. It is important to realize that a box spread arbitrage works with European options only.

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Now, we talk about horizontal spreads. A horizontal spread can be created, let us talk about horizontal call spreads, to start with. It can be created by selling a call option with a certain strike price and buying a longer maturity call option with the same strike price.

The longer the maturity of an option, the more expensive it usually is. A calendar spread therefore usually entails an initial cash outflow. It entails the initial cost, positive cost negative cash flow. So it involves a negative cash flow because what is the calendar spread, it is a long position in a longer maturity call option and a short position in a shorter maturity call option.

Because the call price, the call premia are related to the maturity of the options, the longer maturity options in which you have a long position will cost you more, the shorter maturity call option in which you have a short position will give you less, and therefore the setting up of the strategy entails a positive cost or a negative cash flow at T equal to 0.

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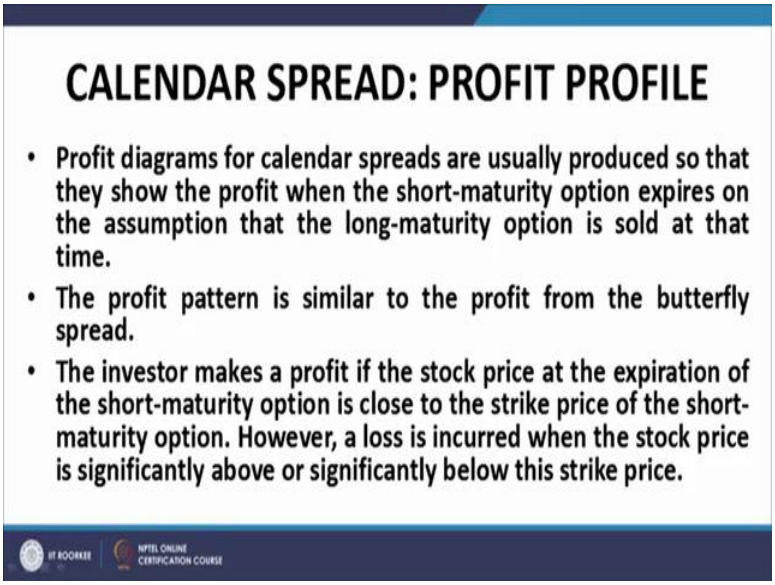

Now, we look at the profit profile. Profit diagrams for calendar spreads are usually produced so that they show the profit when the short maturity option expires on the assumption that the long maturity option is sold at that date. The profit pattern is similar to the profit from the butterfly spread.

The investor makes a profit if the stock price at the expiration of the short maturity option is close to the strike price of the short maturity option. However, the loss is incurred when the stock price is significantly above or significantly below the strike price. Why is that let us look at it.

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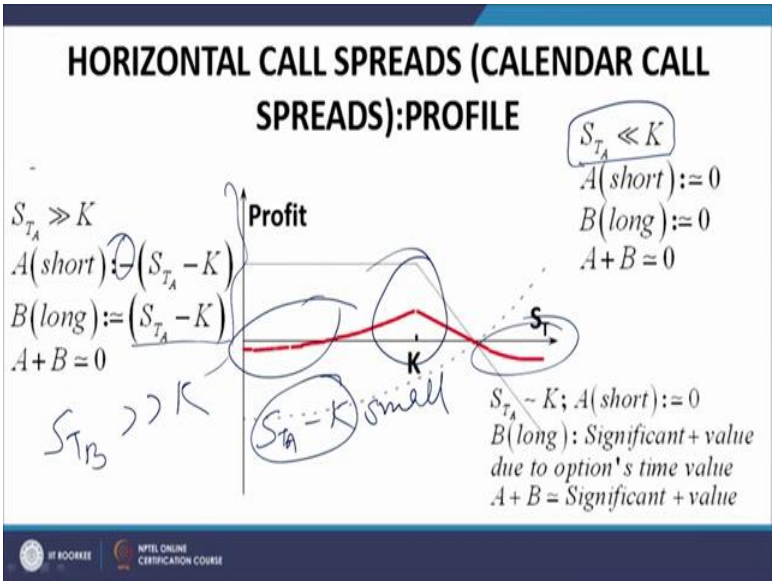

Let us look at the case first where stock price, the stock price is far away from the exercise price of the two options. It is far away from the exercise price K S T A is less than equal to less than less than, much less than K. Now, in this case what happens option A, let us call it, let us let it let us assume that option A is the short maturity option, that is, a short position in option A, which is the short maturity option, long position in option B, which is the long maturity option.

Now, let us look at the situation where the stock price is much lower than the exercise price of the option. What happens? Because the strike price is much above the stock price, both the options are out of the money, significantly out of the money. Therefore, because the investor perception is that the both the options are likely to expire worthless, so both of them are pretty much out of the money.

And therefore the value of the strategy would be pretty much equal to the value of the price that you have paid for implementing the strategy for setting up of the strategy and that will be equal to the price that you have paid for B minus the price that you have paid for A. This would be a negative amount because the price of B which is a longer maturity is higher, the price of a which has a shorter maturity is lower.

And you are long in A, long and B, short in A, and therefore, the net, there is a net cash outflow, that is the price. And if the stock price is very far away, below the exercise price then the possibility of option exercise is very limited. In both cases short and long maturity

and as a result of the strike price is pretty much. As a result of it, the value of the strategy rather, would be pretty much equal to the cost that is for setting up of the option.

Now, let us look at the other situation. Let us look at the situation where this stock price is significantly higher than the strike price, significantly higher than the strike price. Then what happens. Both the options would be very much in the money, strongly in the money, deeply in the money and as a result of which, this particular scenario would hold. The short payoff or the price of the short option would be pretty much equal to or the payoff in the case of exercise of this option will be S T minus K T A, where T A is the maturity of the short option and T B is the maturity of the long option.

So, the price of the short maturity option or the payoff that may be realized by exercise of the short maturity option will be S T A minus K. But because you have a short position, there will be a minus sign here. And the value of the long option which is also deeply in the money would also be pretty much equal to the payoff that you can get from the exercise of that option, which would again be S T A minus K. And as a result of which the payoff would be 0.

And therefore, the value of the option would be equal to the net cost that you have incurred when implementing strategy. These are this region and this region. However, if the stock price finishes up at T A very close to K A, if the stock price is in close proximity of K A, at the maturity of the, short maturity option, then what happens?

Then the payoff from the short maturity option, because, what will be the payoff from the short maturity options? It will be S T A minus K. Now, this amount is going to be very small because we are assuming that the stock price is very close to the exercise price. So this figure would be very small. But, the value of the longer maturity option in this case would be significant.

Why? Because it still has some time to go. And as it is, because there is some time to go to the maturity of the long maturity option before it becomes mature. It could still be as, there could be a situation that we could get a high payoff or the stock price could end up in such a way that let us say it could end up as S T B is greater than greater than K.

This situation could possibly happen and that possibility of the situation happening could translate to a price or to transfer to additional value in option B. And as a result of it the composite strategy which involves a long position in B and short in A would have a positive

value, which is represented by this region. So, that is how we work out the payoffs and the profits of a horizontal call spread.

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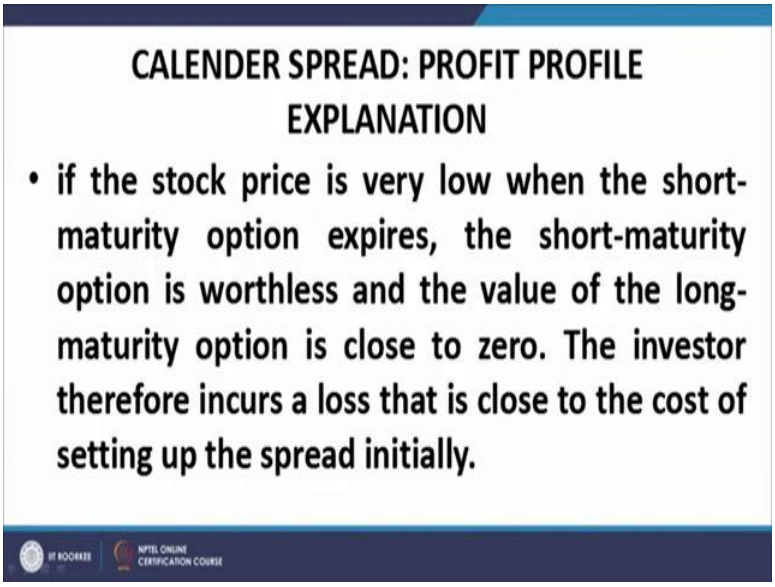

Therefore, let me quickly read out the explanation which I have given so far quickly. If the stock price is very low when the short maturity option expires, the short maturity option is worthless and the value of the long maturity option is close to zero because they are deeply out of the money. The investor therefore incurs a loss that is close to the cost of setting up of this strategy.

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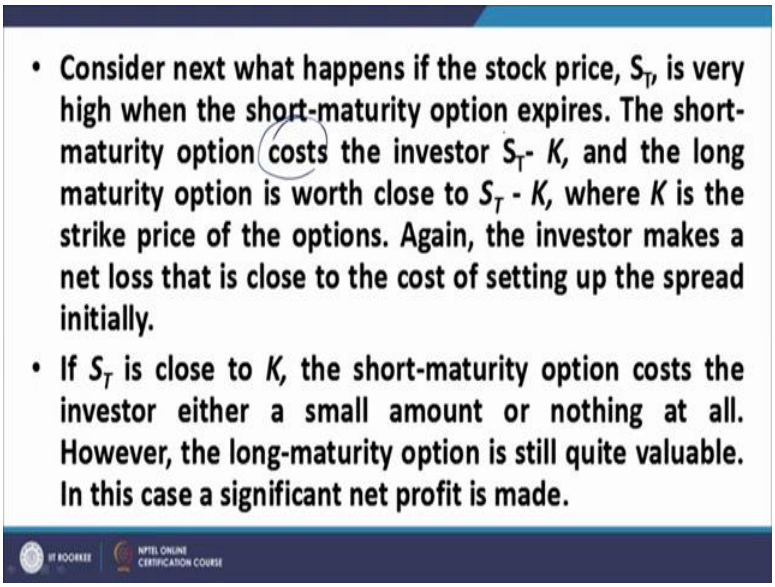

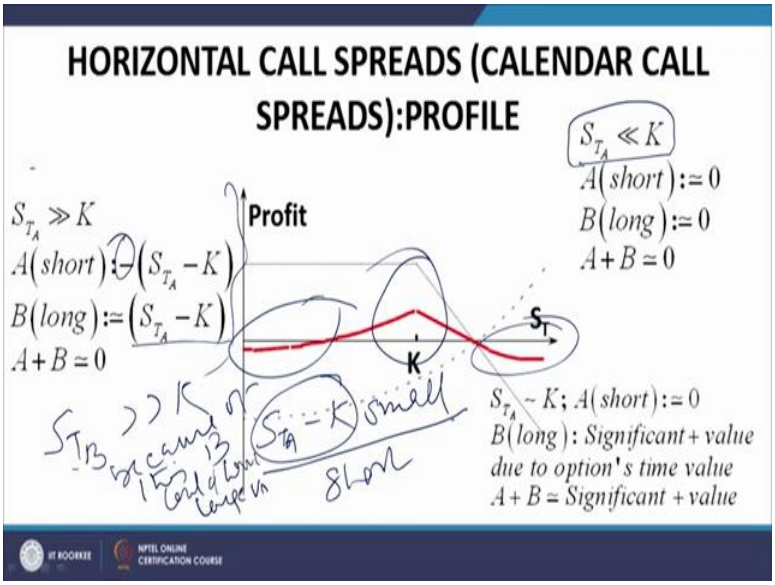

Consider next what happens if the stock price S T is very high when the short maturity option expires. The short maturity option costs the investor S T, costs the inverse S T minus K because it, please note, I have used the word costs here because this is negative, this is a, you are having a short position in this option.

So the payoff is negative, you have to payoff this amount of S T minus K. And the long maturity option is what? Close to S T minus K, where K is the strike price of the options. Again, the investor makes a net loss that is close to the cost of setting up of the strategy initially. If S T is close to K, the short maturity option costs the investor either a small amount or nothing at all in this part.

This is small. So the cash outflow on account of the short position option A is also small. Because of this, because of this, B could have such a large value. So, if S T is close to K, the short maturity option cos the inverse either a small amount or nothing at all. However, the long maturity option is still quite valuable. In this case a significant net profit is made.

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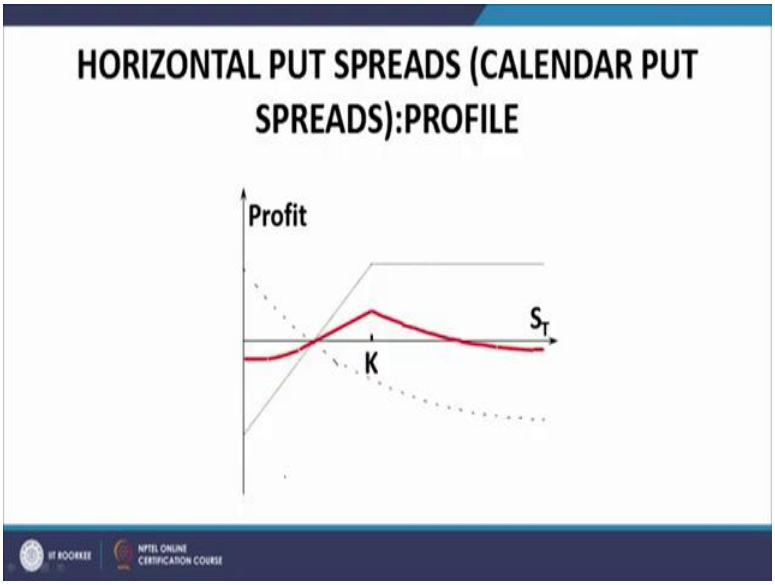

This is the case of horizontal put spread using put options.

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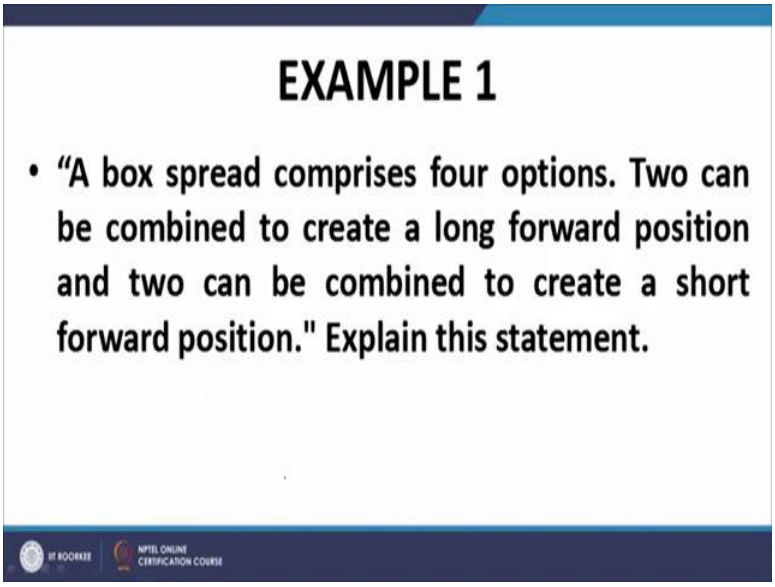

We will continue from here in the next lecture. Thank you.