Quantitative Investment Management
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Lecture 15
Z Spread & Option Adjusted Spread (OAS)

Welcome back. So, let us continue. Towards the end of the last lecture I was talking about Z spread, so let us pick it up from there.

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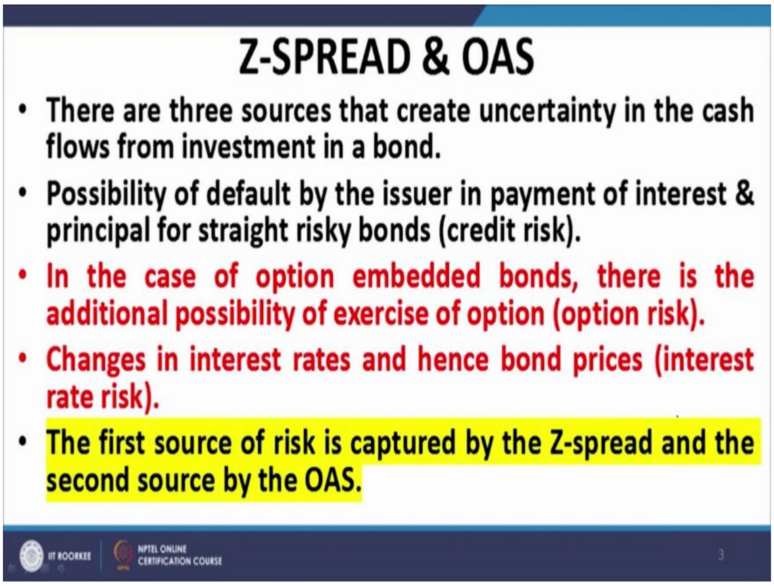

There are three sources that create uncertainty in the cash flows from the investment in a fixed income security. Number 1 is the possibility of default, that is the issuer of the bond defaults on the payment of the principal or the interest there on, this is called credit risk. Then the bonds have option features embedded in them, then there arises the possibility of the party who is long in the option of exercising that option that creates uncertainty, insofar as the projected cash flows from the bond are concerned.

Then finally, there is the issue of interest rate risk. So, these are three sources that give rise to uncertainty insofar as the cash flows from and bond investment is concerned. The first source of risk is captured by the Z spread and the second source of risk is captured by the option adjusted spread. I shall be talking about the interest rate risk in a later point in time in today's lecture.

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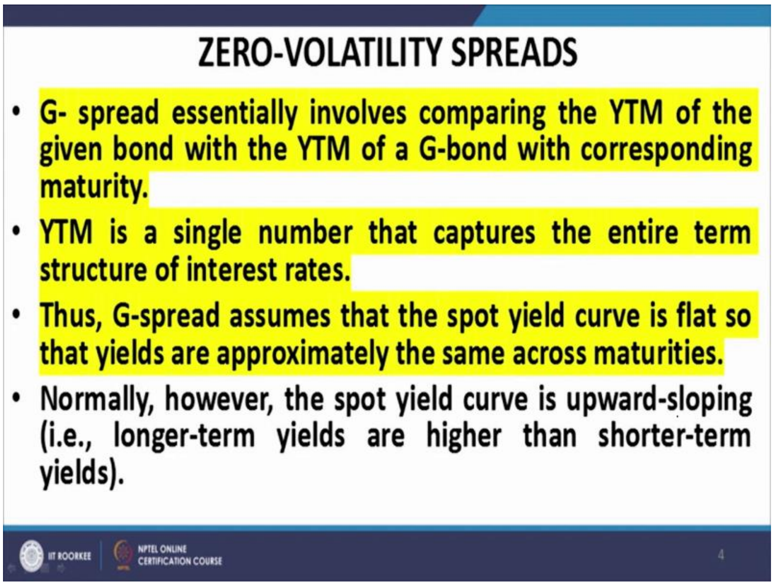

So, let us talk about the Z spread, the 0 volatility spreads. The G spread essentially involves comparing the YTM. (())(01:50) cardinal issues here is the YTM. We are talking about the YTM. And please recall the definition of YTM, it is some sort of average it is one single number, which captures the entire spectrum was spot rate, which are relevant to the discounting of a bond.

So, G spread essentially involves comparing the YTM of a given bond with the YTM of a G bond with corresponding maturities. You have two bonds of identical maturities, one is your risky bond and the other is the government bond. You compare the YTM or take the difference in YTMs between that of the corporate bond or your risky bond, and that of the government bond, the differential represents the G spread. YTM, now as I mentioned just now, YTM is a single number that captures the entire term structure of interest rates.

Therefore, the G spread assumes at the spot yield curve is flat because you are capturing it with one number. You are discounting all cash flows during the life of the instrument at one number that is the YTM number. And therefore, you make the implied assumption that the spot rate curve or the spot yield curve is a flat curve. And the yields are approximately the same across maturities.

Normally, however, the spot yield curve is upward sloping. In abnormal circumstances, it could be downward sloping, it depends on the demand and supply for money as we move into the future. But nevertheless, the spot yield curve has a certain amount of curvature in it, it is not just a flat curve. And therefore, the value of G spread that we compute is not a precise estimation of what it is supposed to represent.

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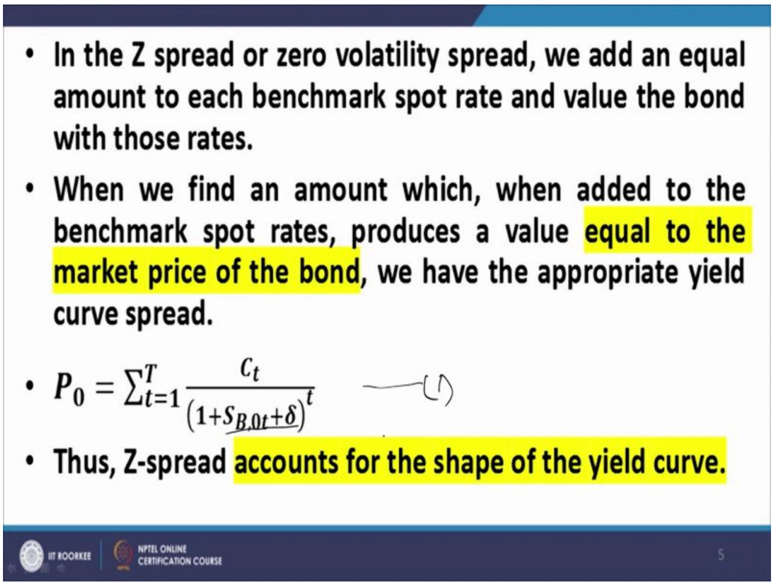

In the Z spread, which is an improvement of what happens as we try to capture the curvature of the yield curves. And how do we do it? That is very interesting. What we do is we identify this spot benchmark rates, we use the spot, the real, that is the spot rates that are captured from the spot yield curve, but we use the rates which are relevant to the benchmark security.

And then to each of the spot rates, to each of these spot rates which are relevant to the cash flows for discounting of a given bond we add a certain constant number the same number across the entire spectrum was spot rates, and we discount the cash flows at this new rate, which is as a given, as we see here SB0t plus delta.

We use and where delta is that additional number that I was talking about. Now, the question is, how do we determine delta? We determine delta by equating the right-hand side which is the discounted cash flows on at the spot rates, at the benchmark spot rates plus delta plus that add on that I mentioned, and we equate it to the current market price.

This gives us one equation in one unknown, the unknown as delta the equation is given here, let us call it equation number 1. So, from this equation, we are able to estimate the value of delta by using iterative procedures. And that delta gives us the Z spread or the 0 volatility spread. Let me read it out. In the word spread or 0 volatility spread, we add an equal amount to each benchmark spot rate.

SB0t is the benchmark spot rate corresponding to a maturity of T, where T runs from 1 to capital T over the life of the instrument, and to discount the respective cash flows. Each benchmarks for trade and value the bond with those rates. When we find an amount, when we find that value, how do we find the value of delta?

We find that value of delta which when added to the benchmarks for trades produces a value on the right-hand side that is produces a discounted value of all future cash flows equal to the market price of the bond. That is that value of delta is called the Z spread. Thus, Z spread accounts for the shape of the yield curve. In other words, what we are simply doing is we are lifting the G spot yield curve by an amount delta across the entire spectrum of maturities, that is we are lifting it parallel to itself.

We are lifting the spot yield curve for government securities parallel to itself by an amount delta and the new rates that we have in the lifted curve, we use those rates for the discounting of cash flows of the risky bond. And to find out that delta by which we have lifted that spot yield curve for the G securities, we equate the discounted value to the current market price and we get the value of delta. So, that is what is Z spread or Z spread.

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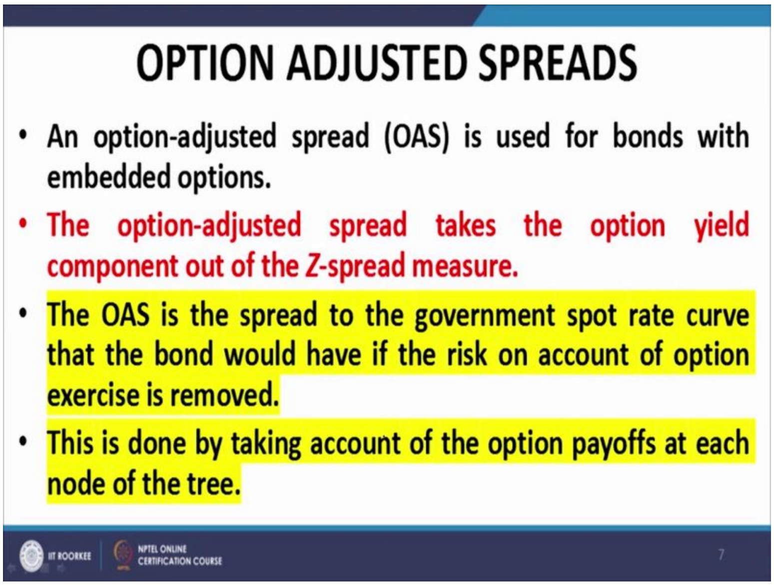

Now, we talk about the Option Adjusted Spread. An Option Adjusted Spread - OAS actually using the abbreviation OAS. For the Option Adjusted Spread is used for bonds with embedded options. The option-adjusted spreads takes the option yield component out of the Z spread measure. How it happens? Shall be discussing in this sequel.

The option-adjusted spread is the spread to the government's spot rate curve that the bond would have if the risk on account of option exercise is removed. Let me repeat this is the definition of the option-adjusted spread. The option-adjusted spread is the spread to the government's spot rate curve that the bond would have if risk on account of option exercise is removed.

This is done by taking account of the option payoffs at each node of the binomial tree. If you are using the binomial tree for the valuation of option embedded bonds, what we do is, I will also illustrate it by an example, what we do is at every node we examine whether the option is in the money or out of the money and if the option happens to be in the money, the options is deemed to be exercised and the cash flow at that node adjusted accordingly.

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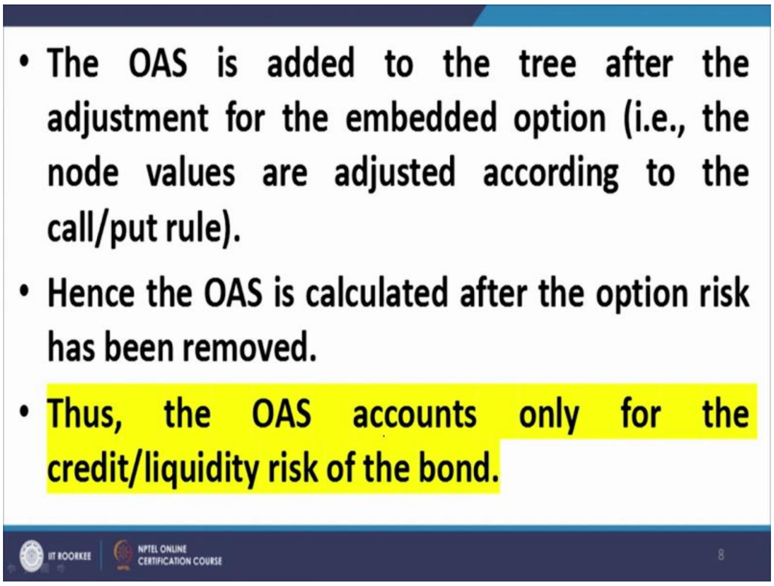

So, the Option Adjusted Spread is added to the tree after the adjustment for the embedded option. That is the node values are adjusted according to the call oblique put role that we discussed earlier, when he talked about valuation of a bonds with embedded options. So, this is precisely what I mentioned just now.

The option-adjusted spread is worked out on the premise that at any node, where the option turns out to be in the money, the presumption is that the option holder will exercise the option to his benefit and as a result of it the cash flows will change and the changed cash flows are then carried forward or carried backwards rather in this case to value the rest of the tree.

Hence the Option Adjusted Spread is calculated after the option risk has been removed. Thus, because the payoffs are taken into account. So, there is no risk remaining as far as the exercise of the option is concerned. In other words, the option adjusted spread is the spread which takes into account or which is arrived at after the optionality risk is eliminated.

Thus, the Option Adjusted Spread accounts only for the credit or liquidity risk of the bond. The option risk is eliminated by virtue of using the payoffs corresponding to exercise of options wherever that option turns out to be in the money.

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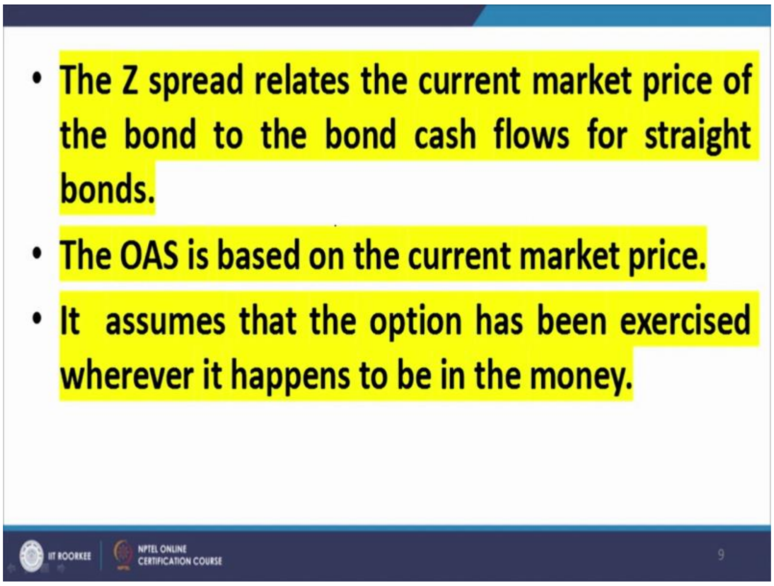

So, just to recall the Z spread relates the current market price of the bond to the bond cash flows for straight bonds. The Option Adjusted Spread is based on the current market price just like their spread, but it assumes that the option has been exercised wherever it happens to be in the money.

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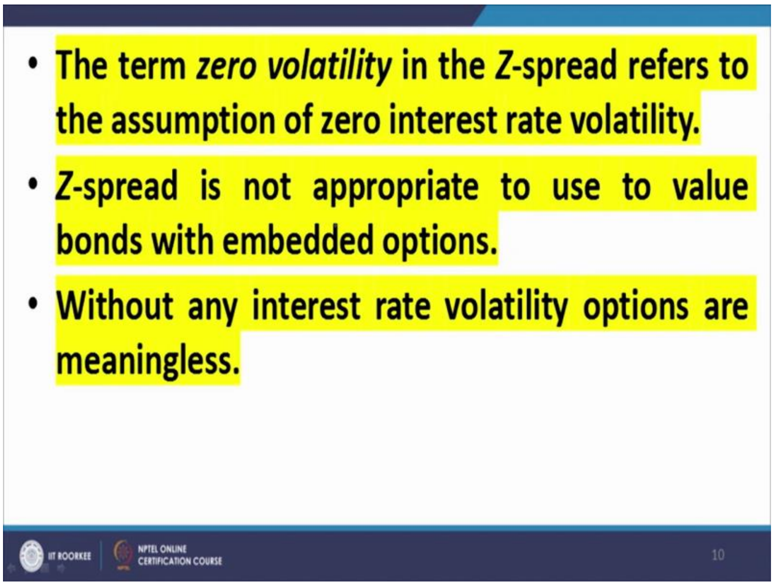

Now, the important thing here is to see, I have been mentioning again and again that the Z spread is not an appropriate measure as far as the riskiness of option embedded bonds is concerned, the OAS is the correct measure of the spread, insofar as bonds with embedded options are concerned.

Why is that? Let us see. The term 0 volatility in the Z spread refers to the assumption of 0 interest rate volatility. Z spread is a short form of the 0 volatility spread. And in the 0 volatility spread we assume that the interest rates have 0 volatility over the life of the instrument. Now, if that is so, what happens?

If there is 0 volatility insofar as the interest rates are concerned, naturally, the options become meaningless, the embedded options become meaningless because everything would be known upfront, all the rates would be known upfront. And under the assumption of 0 volatility these rates are not going to change over the life of the bond, at least that is our perception at t equal to 0.

And therefore, we would know whether the option is exercisable or not and the option, in fact, loses its significance, loses its value. Options are only relevant when we talk about instruments which have a certain amount of randomness embedded in them, there is a certain amount of uncertainty insofar as the values that the instrument is going to take at a future date, it is only then that options make sense.

Otherwise, options do not make any sense at all. So, Z spread is not appropriate for use to value bonds with embedded options, without any interest rate volatility options are meaningless and that is what I emphasized just now.

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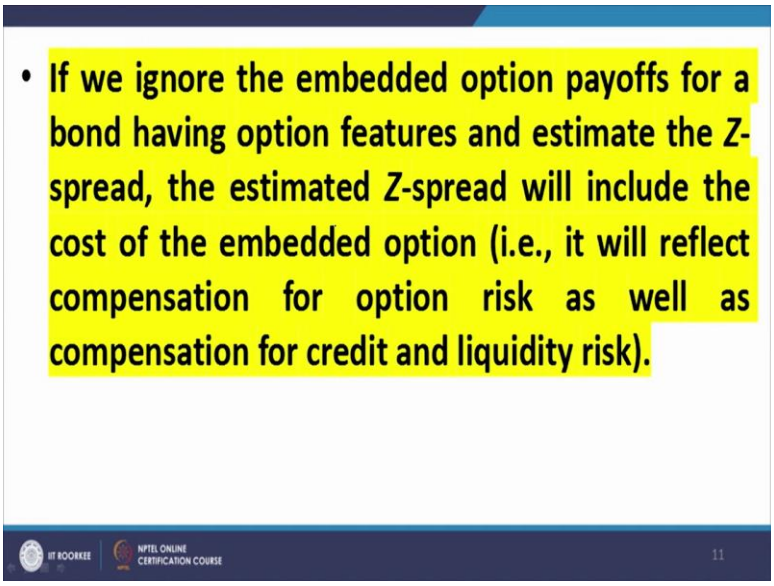

If we ignored the embedded option payoffs for a bond having option features an estimate the Z spread, the estimated Z spread will include the cost of the embedded option, because we see what is happening here is on the right hand side, you are ignoring the payoffs on the option.

However, on the left hand side the price that, for example, let us take the case of a callable bond, the price that the investor is going to pay would be reduced by the value of the call, why, because the investor is short in the call. The issuer of the bond can call back the bond at his discretion, is having a right, is having a discretion, is having a power and as a result of it he has to pay a price for that.

The net outcome is that the investor in the instrument, investor in the callable bond will pay a lesser price. So, what happens on the right-hand side, the payoffs are not adjusted for the option, but on the left-hand side, the price that we are using incorporates the value of the option. So, that creates sense, some sort of asymmetry that reduces the relevance of the Z spread insofar as bonds with embedded options are concerned.

And therefore, let to read it out again. If we ignore the embedded option payoffs for a bond having option features and estimate the Z spread, that is you are having the, you are using the payoffs from the straight bond and your using the price of, the real price that is the price with the embedded option features.

The estimated Z spread will include the cost of the embedded option that is it will reflect compensation for option risk in as well as compensation for credit and liquidity risk. This is very important. Let me repeat this to clarify the thing on the right hand, what is the meaning of the statement is that on the right hand side, when you discount the cash flow, the cash flows that you are going to consider the cash flows of the spread bond.

Without the optionality there would be no consideration of the option being in the money or out of the money, will not consider the payoffs on the option at all. But on the left hand side, when you equate it equal to the current market price, that current market prices for the option embedded bond.

And therefore, the current market price contains a premium or a price for the optionality feature as well. As a result of which the price, in other words the spread that you are going to get on doing this equation or on solving this equation will incorporate the component of option risk as well as the component of credited default risk or liquidity risk as well.

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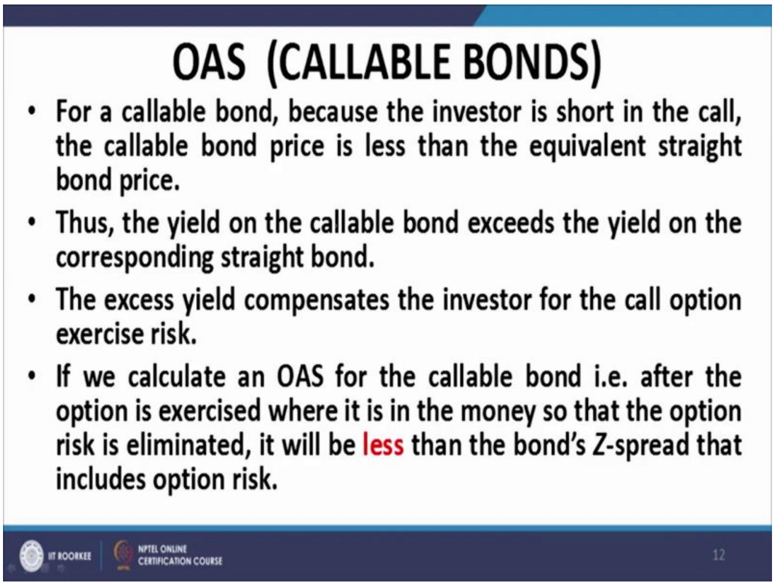

So, let us now look at this specific case of callable bonds. What are callable bonds? Callable bonds are bonds where the issuer of the bond retains the right to call back the bonds prematurely in terms of the provisions contained in the offer document, and that of course, is going to occur when the interest rates regime decreases, it falls significantly.

And as a result of it the issuer is considering replacing the existing high cost step with a relatively lower cost step, at the current market interest rates which are lower. So, for a callable bond, because the investor is short in the call, the callable bond price is less than the equivalent straight bond price.

Let me repeat, here the issuer has retained the right to call back the bonds, that privilege or that prerogative that the issuer has retained in terms of the offer document means that the investor will be short in the call, the investor will call for a premium on that and as a result of it the net cost that the investor will pay for buying that bond would be lower than the cost of buying a corresponding straight bond.

Thus, the yield on the callable bond exceeds the yield on the corresponding straight bond. Naturally, if the price of the instrument is lower, the yield increases provided the cash flows are unchanged. So, that is what is happening here, because the call price or because the price of the callable bond is lower than the price of the straight bond, the yield on the callable bond has to be higher than the yield on this straight bond. And why is that?

It is obviously due to the price that the issuer is paying for retaining the call option, because the issuer is long in the call, because the issuer is retaining a right, a prerogative of privilege, it follows that he has to pay a price for that and this is done by providing the investor with a relatively higher yield compared to the yield on this straight bond.

The excess yield compensates the investor for the call option exercised risk. If we calculate an Option Adjusted Spread for the callable bond that is after the option is exercised, where it is in the money, so that the option risk is eliminated, it will be less than the bonds is Z spread that includes the option risk.

Naturally the Z spread contents a component of option risk as well. It is bound to be larger in the case of the callable bond because the investor is short in this instrument, investors short in the call option, please note this point and therefore, the yield that it demands on the callable bond is more than the yield on the straight bond.

In other words, the option-adjusted spread would be lower and the Z spread would be relatively higher. The Z spread would be higher and the option-adjusted spread would be lower. Because the option-adjusted spread will contain more options risk element, whereas the Z spread element contains the option risk element in addition to credit and liquidity risk.

Option-adjusted spread contains only the case of liquidity risk, we account for the, we eliminate the risk due to option exercise.

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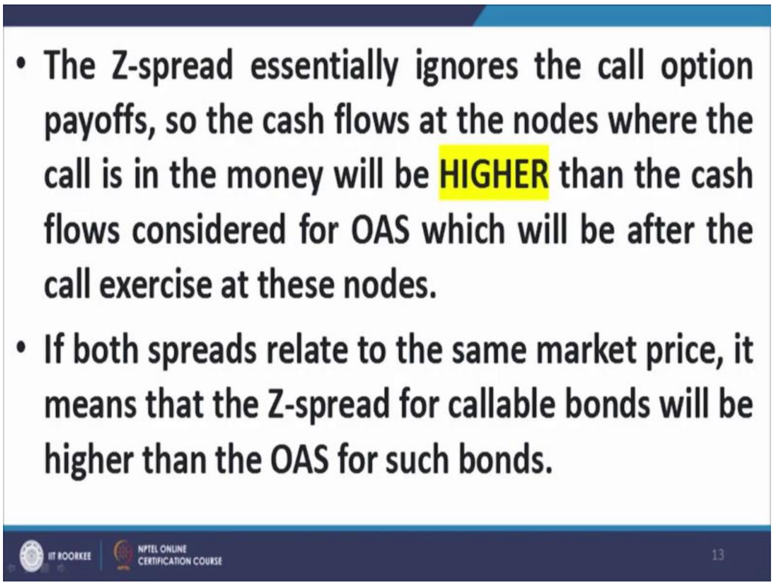

The Z spread essentially ignores the call option payoffs. So, the cash flows at the notes were the, now we are talking about the binomial tree aspect. If we use the binomial tree for this exercise, then what happens? The Z spread essentially ignores the call option payoffs, so the cash flows at the nodes where the call is in the money will be higher than the cash flows considered for Option Adjusted Spread, which will be after the call exercise at these nodes.

And this will also be cleared by the example that I will take up, but the important thing is to see if at a particular node, the call option turns out to be in the money that is the computed price of the bond at a particular node is higher and the exercise price is lower, then what happens? We assume that the issuer has exercised the option and issuer call back the option by paying the exercise price.

Now, please note here the exercise price is lower and the computed price is higher. So, what is happening from the perspective of the issuer and the investor, the valuation parameter at this particular node has reduced it has reduced from the computed value which was higher to the exercise price which is lower in this context in the case of the call option being in the money.

Of course, if the call option is not in the money at a particular node, nothing will happen, we will retain the computed value. If the computed value is lower and the exercise price is higher, we will simply ignore the option, will assume that the option is not exercise. But where the option, where the converse happens that is a computed price is more and the exercise price is lower, we assumed that the issuer will exercise the call option.

And once he exercises the call option, the exercise price replaces the computed price at the exercise price lower. Therefore, the cash flows from the perspective of the investor or the issuer for that matter turned out to be lower, when the option payoffs are considered in the case of a call option. So, let me read it out again - The Z spread essentially ignores the call option payoffs.

So the cash flows at the nodes where the call is in the money will be higher, because the Z spread is not considering the payoff that these nodes, where the option is in the money. Option Adjusted Spread considers the payoffs and because it considers the payoffs, the payoffs would either be the same as in the case of Z spread.

If the option is out of the money at that node, and if the call option is in the money at a given node, then the payoffs corresponding to the option-adjusted spread would be lower. Why? Because the exercise price will replace the computed price and the computed prices higher the exercise prices lower.

So, it will be higher than the cash flows considered for option adjusted spread which will be after the exercise of these options, exercise of call at these notes. So, if both spreads relate to the same market price, then what happens? If both spreads relate to the same market price what happens? In the case of the Z spread because we are not considering the optionality, we are not considering the payoffs due to the option, the payoffs are higher as I explained just now.

And because the payoffs are higher, the price is the same that means the discount rate has to be higher, that means the discount rate, that means the yield has to be higher. In the case of option-adjusted spread we consider the option payoffs which happen to be either equal to or lower than the computed price, which is considered for the Z spread. And as a result of which, when we equate it to a price, we need a lower discount rate. And that gives us the lower option adjusted spread.

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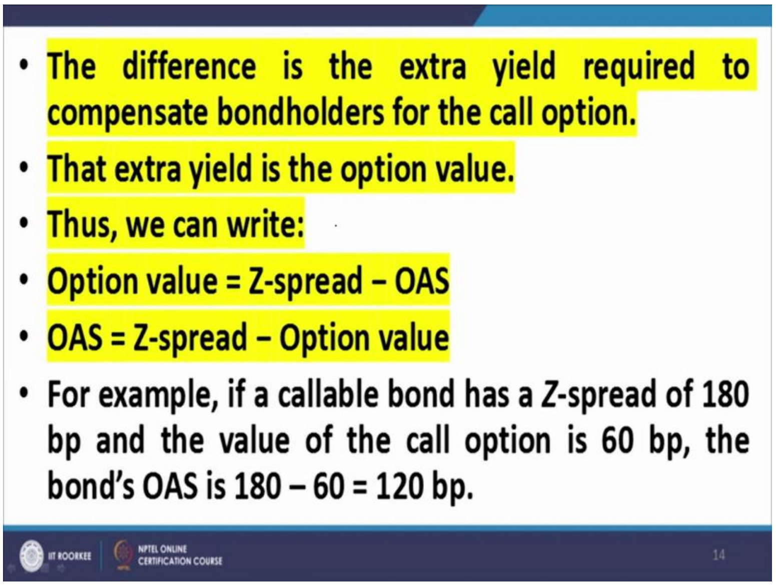

The difference is the extra yield, the difference between the Z spread and the option-adjusted spread is the extra yield, as I mentioned just now required to compensate bond holders for the optionality risk or for the prerogative attached to the (())(22:47) to the call option. So, that extra yield is the option value this we can write option value is equal to Z spread minus Option Adjusted Spread option and option adjusted spread is equal to 0 Z spread minus option value.

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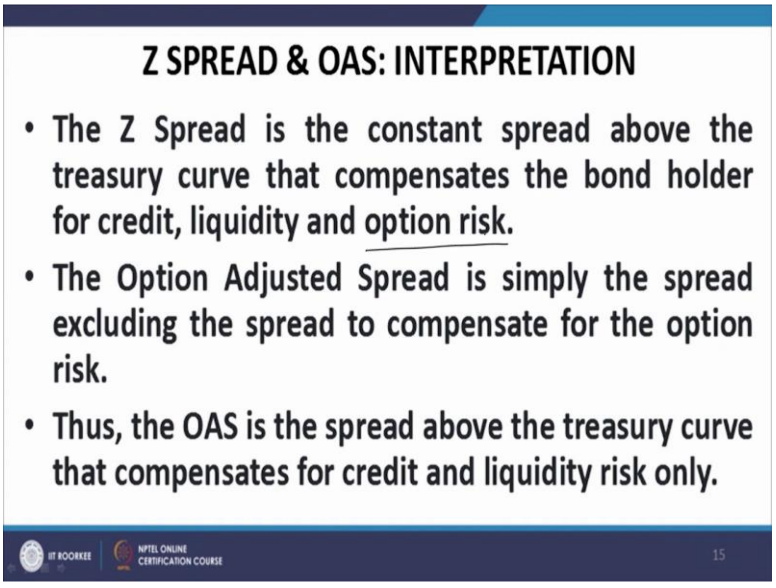

Now spread, Z spread and Option Adjusted Spread interpretation. The Z spread is the constant spread above the treasury curve that compensates the bond holder for credit liquidity and options risk. The important as I have emphasis is this, option risk. So, this is a composite, this is a spread which is composed of the price that we are paying for the default risk that is the credit risk, the liquidity risk and the option risk.

On the other hand, the option adjusted spread is simply the spread that excludes the spread for on account of optionality risk, and as a result of it, it compensates the investor for taking the credit risk and the liquidity risk, but not the option risk. Why? Because the option exercise has already been factored into the valuation of the Option Adjusted Spread.

We have assumed that wherever the option turns out to be the money, the option will be exercised and the payoffs are adjusted accordingly. Thus, the option adjusted spread is the spread about the treasury curve that compensates for credit and liquidity risk only.

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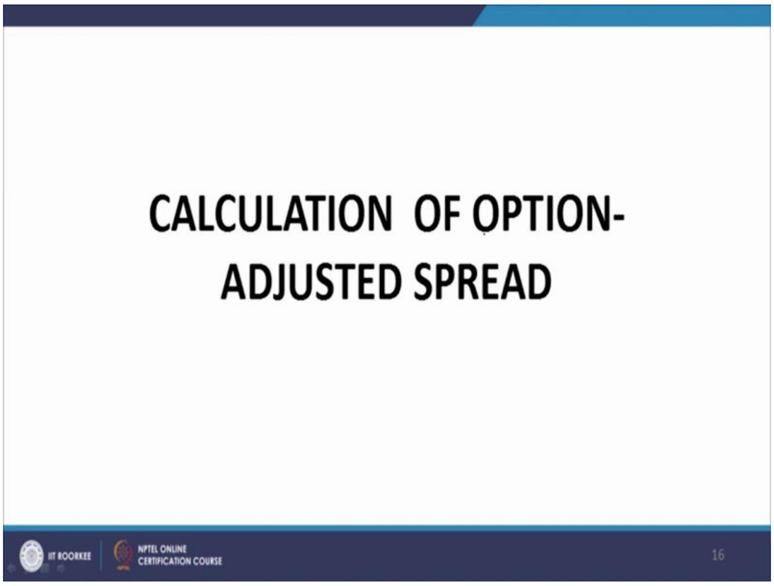

Now, let us look at the calculation of option adjusted spread.

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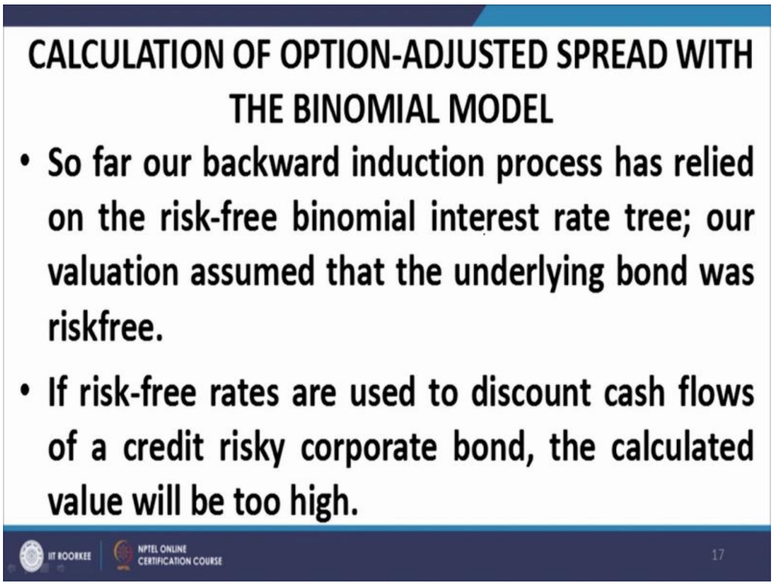

So, we shall obviously use the binomial tree model for this purpose, binomial interest rate tree. So, far our backward induction process has relied on the risk-free binomial interest rate tree, our valuation assumed that the underlying bond was risk free. Now, if risk free rates are used to discount cash flows of a credit risky corporate bond, the price that we will arrive at the computed value that we will arrive at using the binomial interest rate tree and discounting accordingly will be higher will be too high.

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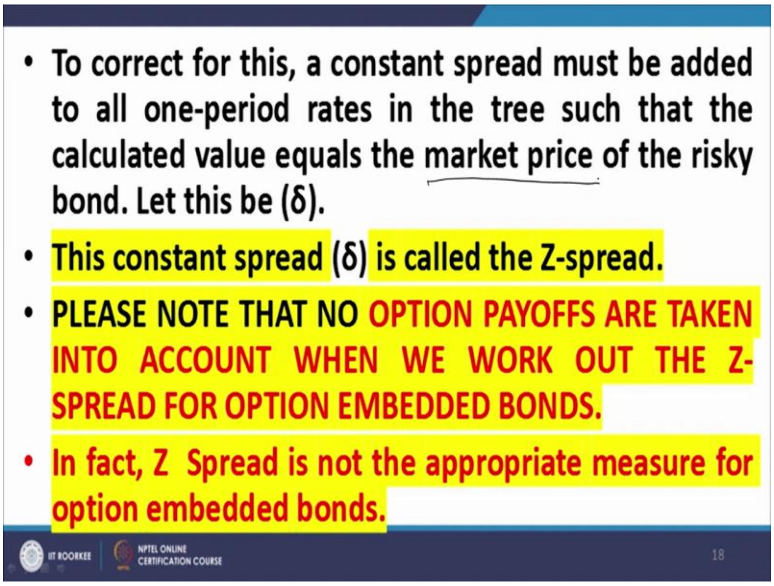

So, to correct for this a constant spread must be added to all the one period rates in the tree such that the calculated value equals the market price of the risky bond. And this number, this value that we add to all the interest rates on the tree such that when we work out using backward induction, the computed value of all the future cash flows emanating from the instrument, they equate the current market price of the instrument.

By doing this what we get? We arrive at the value of delta, the value of that add on, and that value of that add on gives you the value of the spread. So, this is called the Z spread. As I have explained also. Please note that no option payoffs are taken into account when we work out the Z spread for option embedded bonds as well.

In the case of bonds, which do not have any embedded option features obviously this statement is irrelevant, but even in the case of option, embedded bonds, when we are computing the Z spread, we are ignoring the option we work out on the on the premise that the payoff or the cash flows emanating from the bond are those that arise out of the bond being a straight bond. In fact, Z spread is not the appropriate measure for option embedded bonds. I have emphasized that also.

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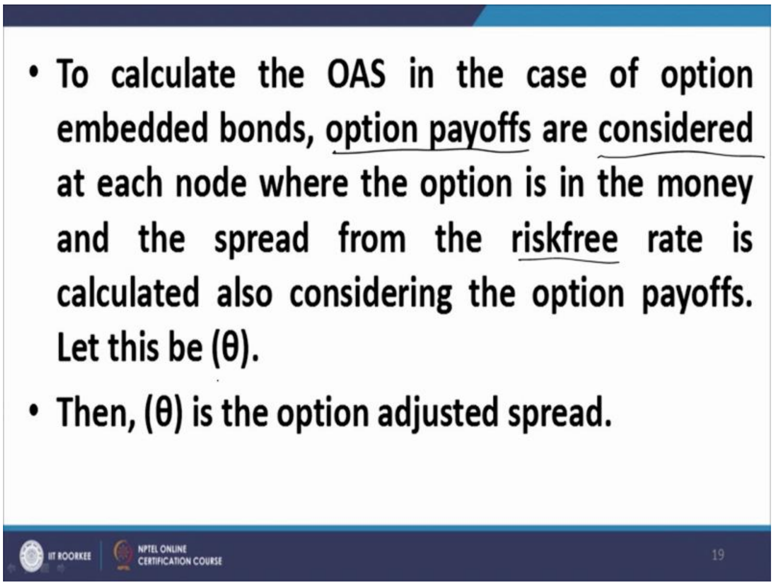

To calculate the Option Adjusted Spread. So, that was insofar as the approach as to the methodology for the calculation of the Z spread using the interest rate binomial interest rate tree how do we modify that when we try to work out the option adjusted spread in the context of option embedded bonds.

What happens in this case is at every node, we check for the option being in the money both. Firstly, when we are using the risk free rate for the discounting and secondly, when we are using the risk free rate plus the add on, plus the option adjusted spread ad on for valuing the cash flow, for discounting the cash. Let me repeat at every node when we do the valuation or whether the computed value of the, at that node allows for the exercise of the option whether the option happens to be in the money at that node.

And then we work out the computed value of the bone at t equal to 0 working backwards as usual. But the important thing is this is done for both the computations number 1, when we use the risk free rate when we use the government rate or benchmark rate as the case may be. And then when we use the benchmark rate plus that add on which happens to be the option adjusted spread.

So, let me read it out again, to calculate the option adjusted spread in the case of option embedded bonds, option payoffs are considered. So, we are considering explicitly the option payoffs. At each node, we investigate, we examine whether the option is in the money. If the option is in the money, then we replace the computed value with the option exercise price. At each node, where the option is in the money and the spread from the risk free rate is calculated also considering option payoffs.

So please note for consistency, this is important. For consistency, consistency I am sorry, we need to consider the option payoffs both when we are using the risk-free rate and when we are using the risk-free rate plus the option adjusted spread add on. So, if that add on is theta and theta happens to be our option adjusted spread.

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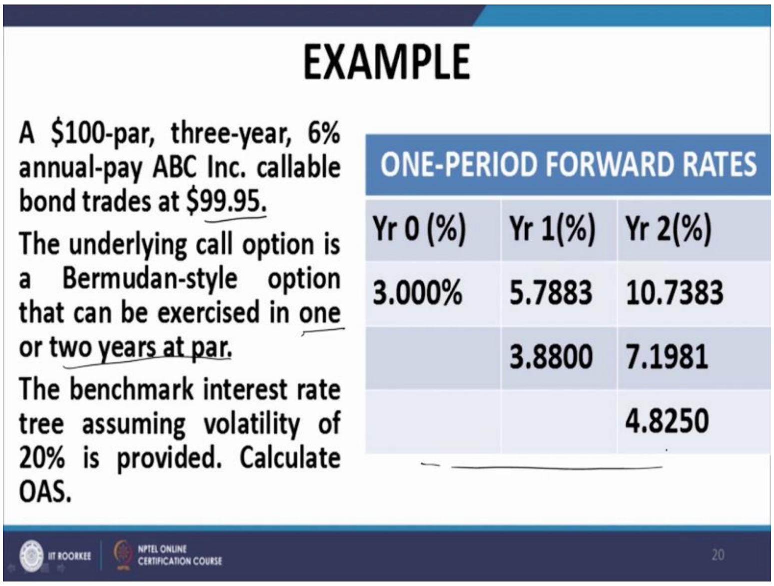

This is the example here of how to calculate the option adjusted spread. It illustrates what has gone just know dollar 100 par 3 year 6 percent annual pay, ABC incorporated callable bond trades at 99.95 trades at 99.95. The underlying call option is a Bermudan style option that can be exercised in 1 or 2 years at par.

The benchmark interest rate tree is assuming a volatility of 20 percent is shown in the right-hand panel. We need to calculate the option adjusted spread. So, the first step is that we use this benchmark rates that is the rates that are given in this option. This interest rate tree we use these rates as it is and we work out the value of the bond at t equal to 0.

On the premise that if at any node the option is exercisable it will be exercised and the cash flow is adjusted accordingly. Please note that this is a callable bond, this is the call option and the call option is accessible at par at t equal to 2 years and t equal to 1 year.

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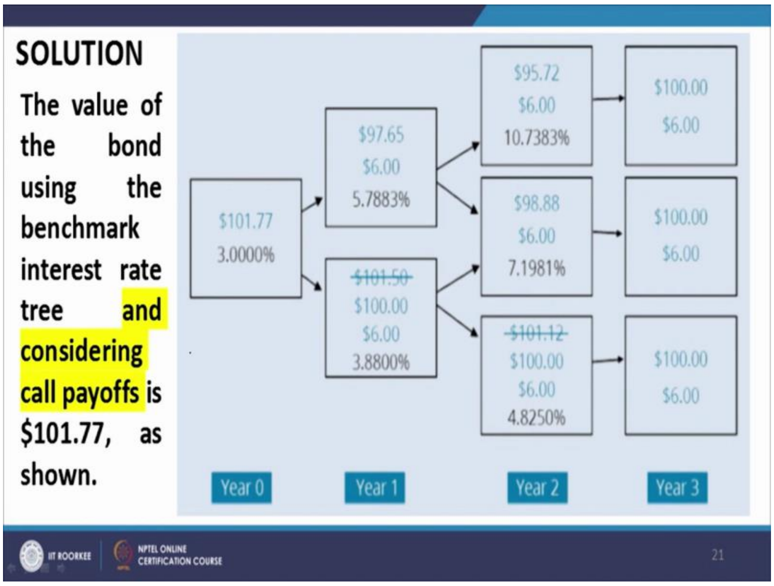

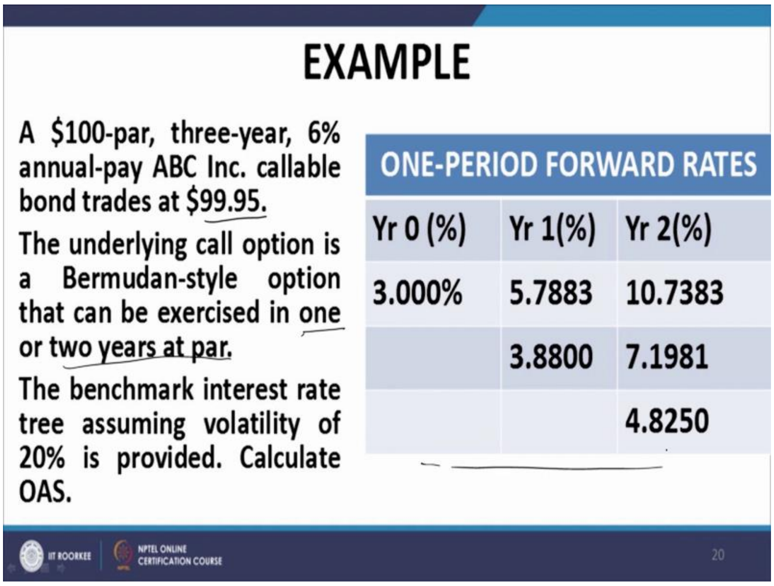

So, this is the working as you can see here, whenever the computed value of the instrument at any node happens to be higher than the exercise price which is par, the par value replaces the computed value. So, this is for the risk-free rate, this is for the rates as present here in the right-hand panel. And when we do this entire competition, as I explained a number of times, the value that we arrive at is 101.77.

The important feature is you have done this exercise earlier, the only important feature is that whenever at any node, the option becomes exercisable, we assume that the option is exercised, and we adjust the cash flows at that node accordingly.

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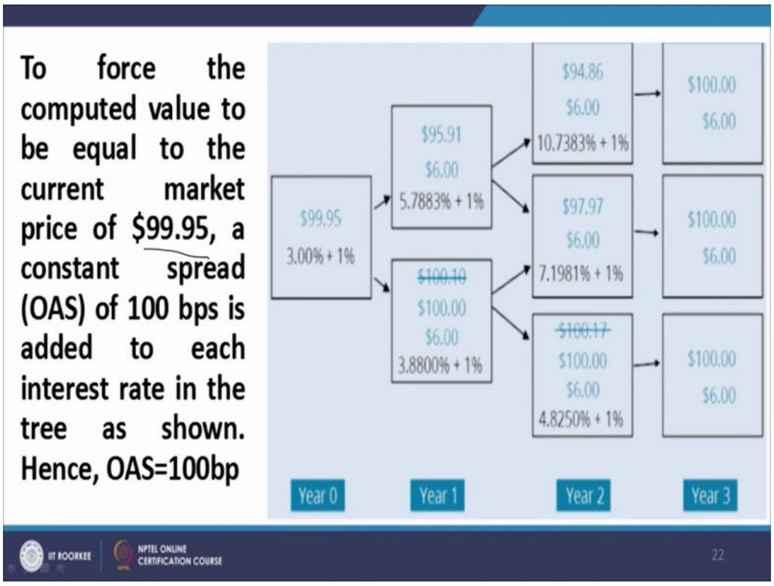

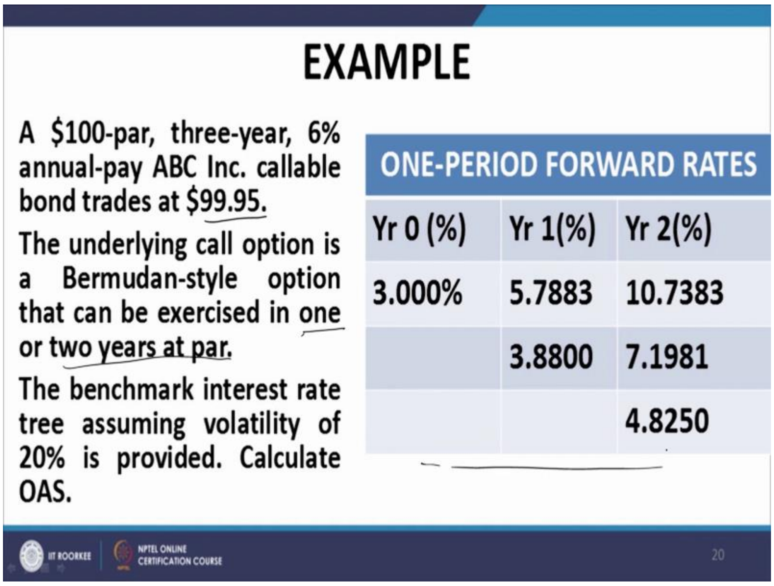

Then what we do is, we add a certain value to each of these interest rates. Which interest rates? These interest rates. To each of these interest rates we add a certain value say theta, plus theta, plus theta, same theta, please note this, plus theta. And we repeat the same exercise. When we repeat the same exercise…

Now, what we will get is the right-hand side value will be a function of theta, we equate this right-hand side to the current market price. What is the current market price? The current market price is given to us as 99.95. And that will enable us, usually through an iterative process to arrive at the value of the parameter theta, which is nothing but the option adjusted spread.

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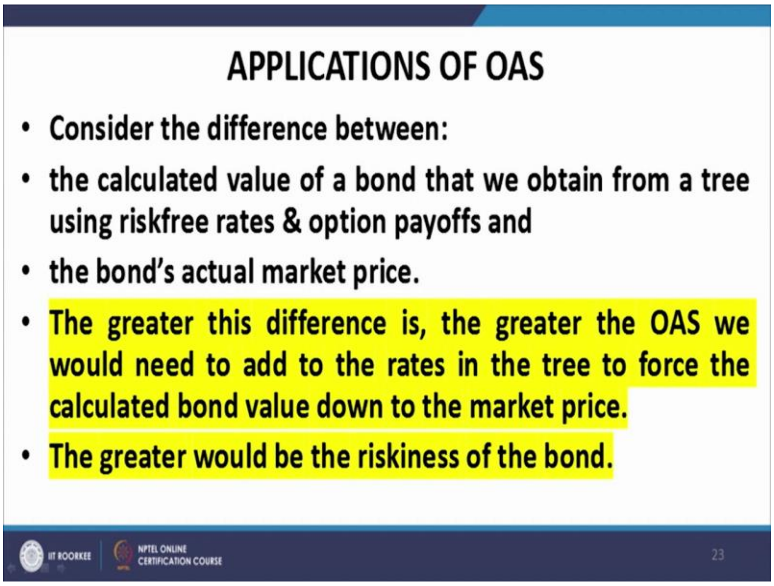

So, applications of Option Adjusted Spread, see basically it is a measure of risk. Consider the difference between the calculated value of a bond that we obtained from a tree using risk free rates and option payoffs and the bonds actual market price. The greater the difference is, the greater is the add on that we need to incorporate to the risk, to add to the risk free rates to arrive at the current market price.

The greater is the difference between the computed value as per the risk free rate and the current market price, the greater would be the add on that you have to add, you see you need a higher discount rate. So, the greater would be the add on to your discount rate that you have used earlier for the risk-free discounts rates to arrive at the discounted value which equals the current market price. And therefore, higher would be the option adjusted spread.

So, the greater this difference is, the greater is the option adjusted spread, you would need to add to the rates in the tree to force the calculated bond value down to the market price. The greater would be the riskiness of the bond.

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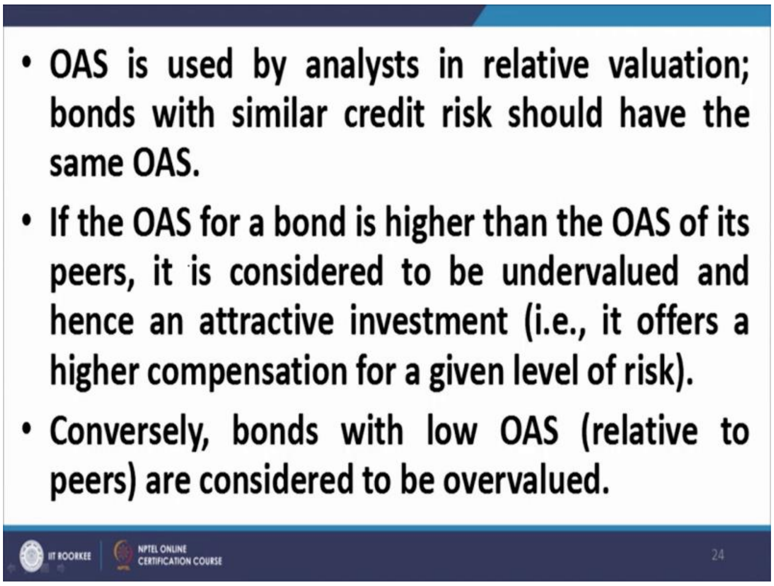

Option Adjusted Spread is used by analysts and relative valuation bonds with similar credit risk should have similar OAS. If the Option Adjusted Spread for a bond is higher than the option adjusted spread for its peers, then naturally, that means what, that means it is undervalued because for the same level of risk, it is trading at a higher yield.

So, it is undervalued and it may provide you an attractive or lucrative investment opportunity. Conversely, bonds with low option adjusted spreads are considered to be overvalued. We will continue from here in next lecturer. Thank you.