Quantitative Investment Management
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Lecture 31
Fixed Income Portfolio Strategies - 3

Welcome back. So, towards the end of the last lecture, I was discussing the various strategies that can be implemented to profit from one's perception of the evolution of the yield for a, yield curve, the spot yield curve. In other words, you have a certain perception of the spot yield curve, how the spot yield curve is going to behave in the future. And on that basis, you create a portfolio of bonds such that you can profit from your perception if your perception turns out to be correct. So, let us quickly recap those strategies and then we will move on to the next topic, that is financial derivatives.

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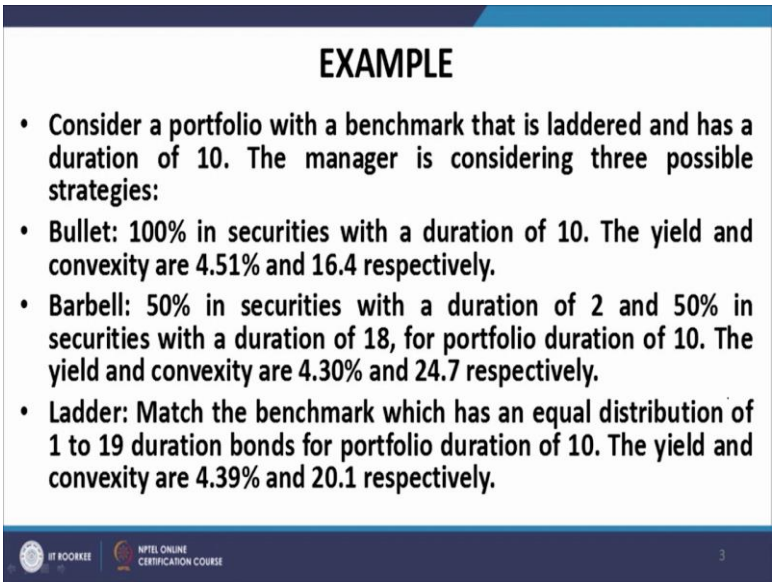

So, selection of curve strategy. The first example we have is that consider a portfolio with a benchmark that is laddered and has a duration of 10. The manager is considering three possible strategies, a bullet strategy with 100 percent insecurities with a duration of 10. The yield and convexity are 4.51 percent and 16.4, respectively, the barbell 50 percent in securities with a duration of 2 and 50 percent in securities with a duration of 18 for portfolio duration of 10. That is the average duration of the portfolio.

The yield and convexity are 4.30 percent and 24.7 respectively. So, clearly you find that the yield of the bullet is slightly higher, whereas the convexity of the barbell is slightly higher. In the case of the ladder, it lies in between both these parameters lie in between the bullet and

the barbell, we match the benchmark, which has an equal distribution of 1 to 19 duration bonds for portfolio duration of 10. The yield and convexity is 4.39 percent and 20.1, respectively.

So, clearly the yield as well as the convexity lies between the bullet and the barbell strategies. Now, we have a certain perception about this strategy. And we look at what should be the optimal strategy.

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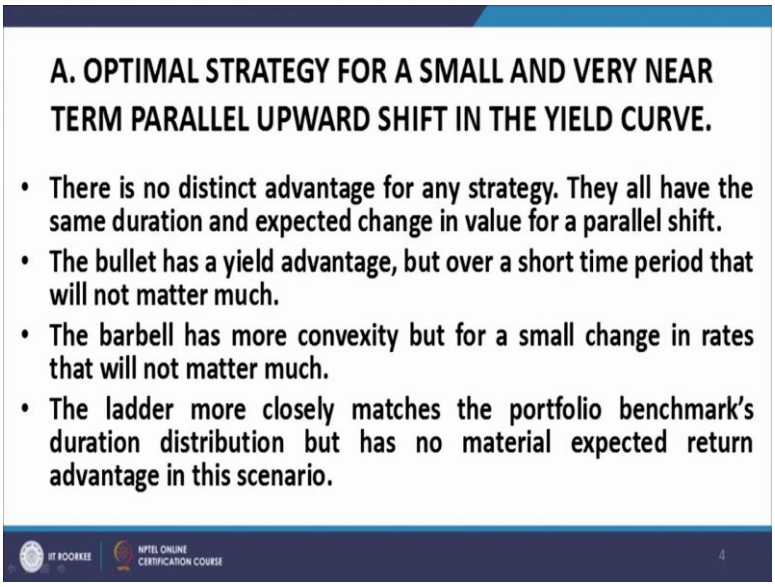

The perception is that there is a small and very near term parallel upward shift in the yield curve. In other words, the investor or the marketplace believes that there is going to be a small and very, small shift in the yield curve upwards, and it is going to occur pretty soon. If you evaluate these strategies, that is the bullet and the barbell and the ladder portfolio, what you find is that in this case, each of them has a certain advantage and the advantages tend to neutralize each other.

For example, the bullet has a yield advantage, but over a short period of time that will not matter much, the barbell has more convexity but again a small change in interest rates a small shift in the yield curve, small upward shift in the yield curve is not going to give a material convexity correction, the ladder is more closely matching the portfolio benchmark, duration distribution but has no material expected return advantage in this scenario.

So, in this case, it is difficult really to identify or to do this distinguish off which strategy one should implement as the optimal strategy, a small upward shift in the near term.

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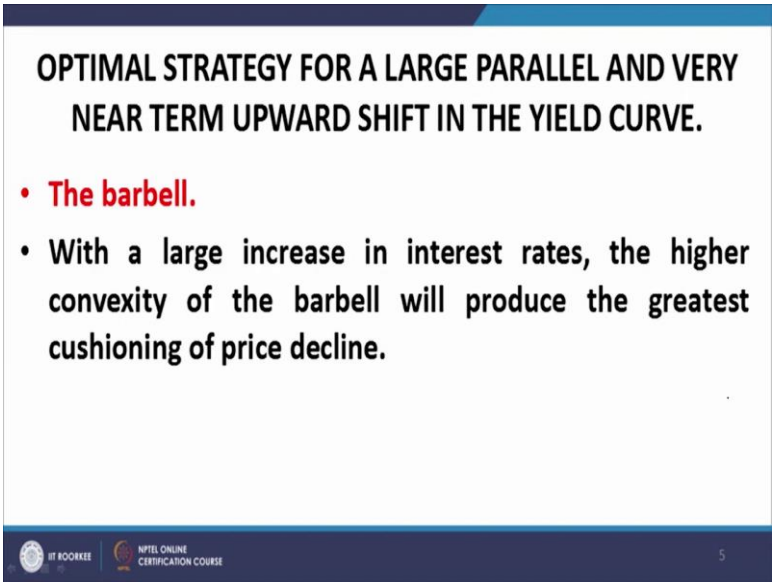

Now, let us look at a large parallel shift and very near term shift in the very near term there is likely to occur a large parallel shift. So, in that case, what happens whenever we talk about a large shift in interest rates and a parallel shift in interest rates, the convexity correction comes into play it becomes very relevant and therefore, the barbell with the highest convexity turns out to be the optimal strategy in this case. The convexity correction assumes the significance and it is on that basis that we would select the optimal portfolio. So in this case, because the barbell has the highest convexity, the barbell strategy would be the optimal strategy.

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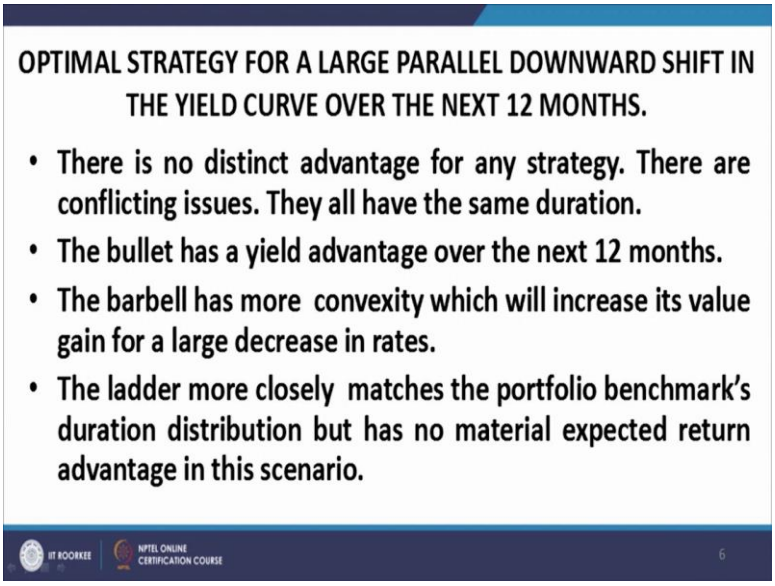

Let us look at the third case. In this case, we have a lot parallel downward shift in the yield curve over the next 12 months. Now, this is the catch here, the shift is going to occur over the next 12 months. Although prima facie because it is a large parallel downward shift again the convexity correction becomes the overwhelming criterion for optimality. But because that shift is going to occur over 12 months, the yield issue of the bullet also needs to be considered.

Because the shift is going to occur over 12 months the higher yield generated by the bullet strategy will need to be considered when we decide upon the optimal portfolio. So, it is basically a trade off in this case between the higher yield generated by the bullet portfolio and the higher convexity correction of the barbell portfolio.

So, in this case, there is no distinct advantage for any strategy. There are conflicting issues, as I mentioned, just now, the on the one hand, the bullet has a higher yield, which could give you higher returns over the sustained period of one year. And on the other hand, because the shift is large and parallel, although downwards, the convexity correction will operate, so the barbell has more convexity, which will increase its value gain for a larger decrease in interest rates.

So, because there is a decrease in interest rate, the prices will increase and the convexity correction will add on to those prices. And as a result of it, the prices will increase more than what is anticipated of what has worked out on the basis of the duration model or the pure duration parameter. The ladder more closely matches the portfolio benchmark duration distribution, but has no material expected return advantage in this scenario.

So this is a very interesting scenario, where on the one hand, we have a large parallel downward shift, and on the other hand, the shift is going to occur over the next 12 years, or the holding period of the investor in the next 12 months, I am sorry. So if it is the this issue of the holding, extended holding period, over 12 months would mean that the higher yield of the bullet assume significant.

On the other hand, because the shift is large and parallel, the convexity correction also assumes significance so for with the barbell is the best strategy, barbell with the highest convexity. And therefore, we are now in a catch 22 situation, whether the yield on the bullet over the period of 12 months will give us more return, or whether the convexity corrections,

which assume significance, because of the downward partnership would give us more real, more returns on advantage.

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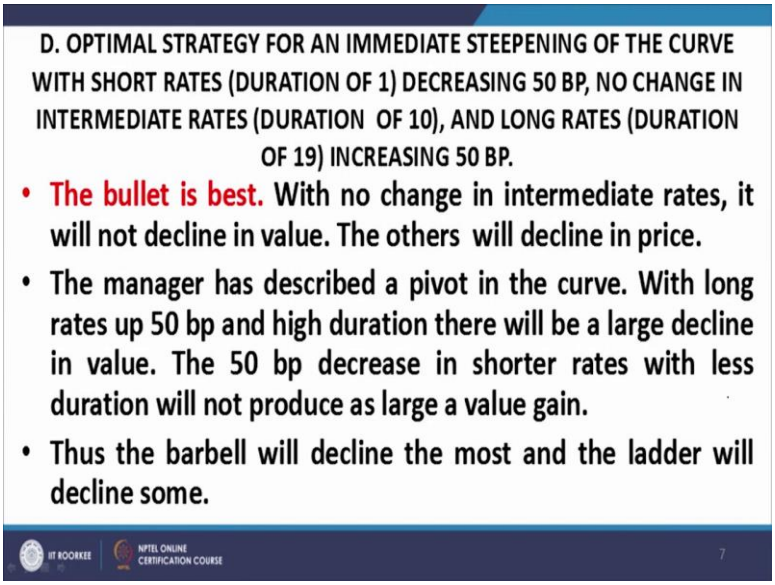

So now we come to the next strategy. The next strategy is that there is an immediate steepening of the curve with short rates, duration of one decreasing 50 basis points and no change in intermediate rates and the long rates increasing by 50 basis points. Now, because the intermediate rates are unchanged, the value of the bullet strategy will remain unchanged. And because it is a near term change, the yield advantage would also not be very significant.

However, there is a decrease in the near term, near end interest rates and an increase in the long end interest rates. What does that mean? Decrease in the near end interest rates would mean increase in prices of the short duration or short maturity component of the barbell portfolio. And increase in interest rates of the over the long end would mean that the decrease in price that there will be a decrease in price over the long end that is the long maturity and long duration bonds.

Now the important thing is, because the price change or the percentage price change is proportional to duration, the percentage price change of the short end bonds of the barbell portfolio would be less, the percentage price change of the long end component of the barbell would be much more because its duration is higher. So that means because the increase in because the short end prices are increasing, the long end prices are decreasing. The barbell would not be the optimal strategy. And the bullet would be the optimal strategy. Because its prices are not going to change there is no change in the intermediate rates.

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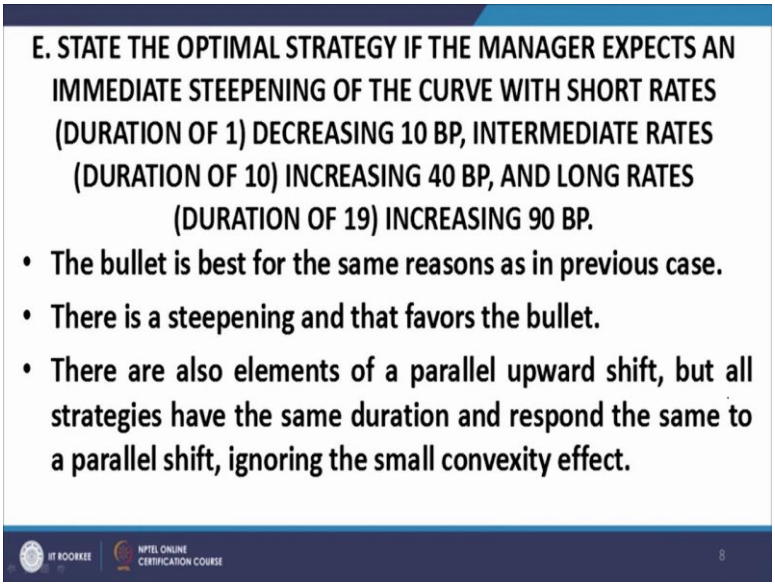

Then we will look at the strategy if the manager expects an immediate steepening of the curve with short rates, duration of 1, decreasing 10 basis points, intermediate rates, duration of 10 increasing 40 basis points and long rates duration of 19, increasing 90 basis points. So again, this is pretty much similar to what we had in the previous case. And the bullet continues to be the best strategy because the decrease in prices of the long end component of the barbell is going to be more significant because the yields over the short end are decreasing and therefore, the prices or the short end are increasing and the increase in prices for the barbell or this component of that barbell short end component of the barbell would be less and therefore, in this case, the bullet continues to be the optimal strategy.

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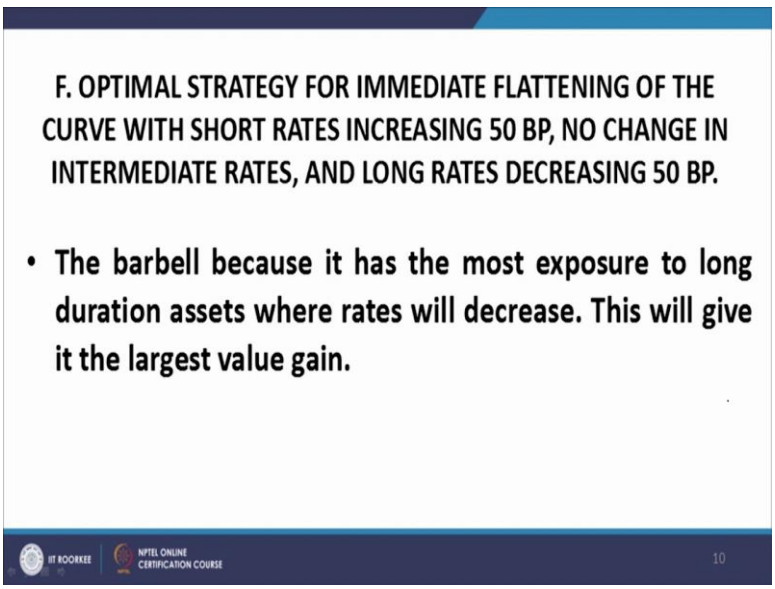

Then we look at the flattening of the curve with short rates increasing 50 basis points, no change in the intermediate rates and long rates are decreasing. Clearly if the low rates are decreasing, the barbell becomes better, the barbell turns out to be the optimal strategy in this case.

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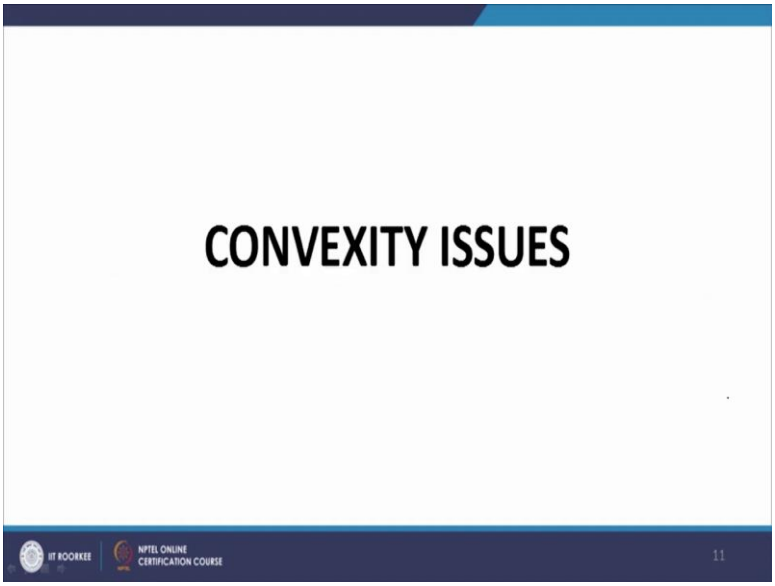

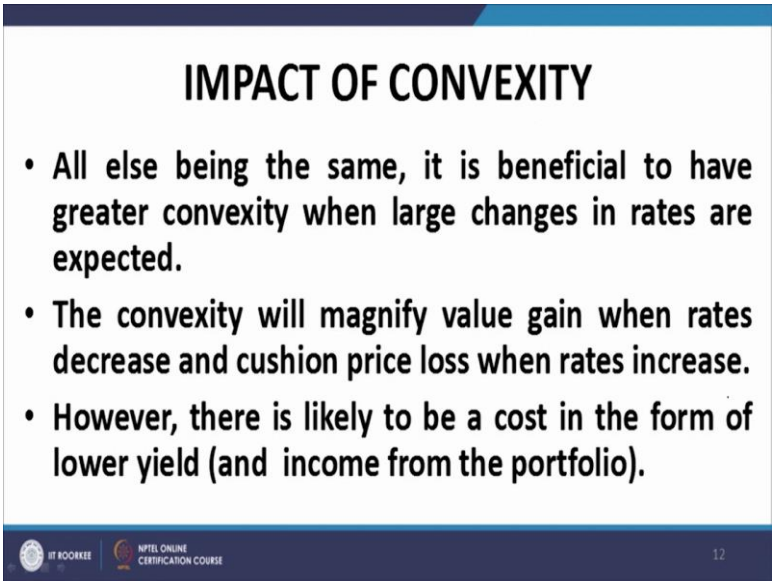

Convexity issues. Now, all else being the same, it is beneficial to have greater convexity when large changes in interest rates are expected because as I as I have been emphasizing, in fact, in the last couple of lectures, in fact that the convexity correction is always positive. So, irrespective of whether there is an increase in interest rates or the decline in interest rates, it always operates to increase the percentage price change compared to what we have using the duration alone.

The convexity correction always adds on to the price increase. So, the convex, higher the convexity of the bond or higher the convexity of the portfolio, higher is the convexity correction and higher the price increase compared to what we estimate using the duration alone. The convexity will magnify value gain when interest rates decrease and cushion price loss when interest rates increase.

So, the convexity will magnify value gain when rates decrease and cushion price loss when rates increase. However, there is likely to be a cost in the form of lower yield, higher the convexity of a bond, lower would be the yield at which it would be trading in the market, because of the simple principle that there is no free lunch in the market. Everybody prefers higher convexity because of the positive nature of the convexity correction. And therefore, if you are having a bond with higher convexity, then it would carry a marginally lesser yield.

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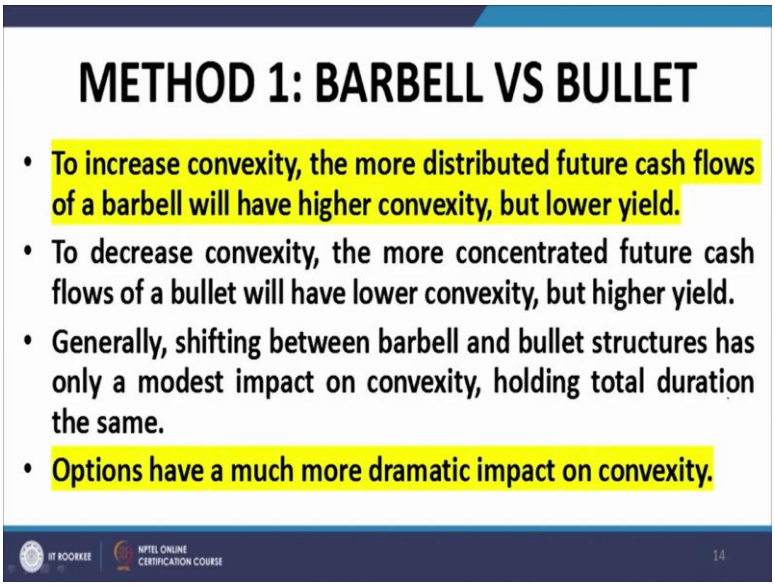

Increasing convexity. The first is barbell was vs bullet. We have been discussing this in a lot of detail we have already talked about it. We have taken, we have discussed examples also in this larger is the dispersion of cash flow as in the case of barbell, higher is this convexity. In fact, larger is the dispersion higher is the convexity of a bond. And there is a direct relationship between the dispersion of cash flows and the convexity of the bond from which those cash flows are arising.

So, barbell is the higher convexity instrument relative to the bullet and therefore barbell has higher (con) if you want to increase the convexity of, of a portfolio, you incorporate a barbell strategy with the same duration as the bullet in lieu of the bullet. So, to increase convexity,

the more distributed future cash flows of a barbell we will have higher convexity but lower yield to decrease convexity the more concentrated future cash flows of a bullet will lower convexity but a higher yield, generally shifting between barbell and bullet structures has only a modest impact on convexity, holding total duration, the same, options have a much more pronounced, much more dramatic impact on convexity.

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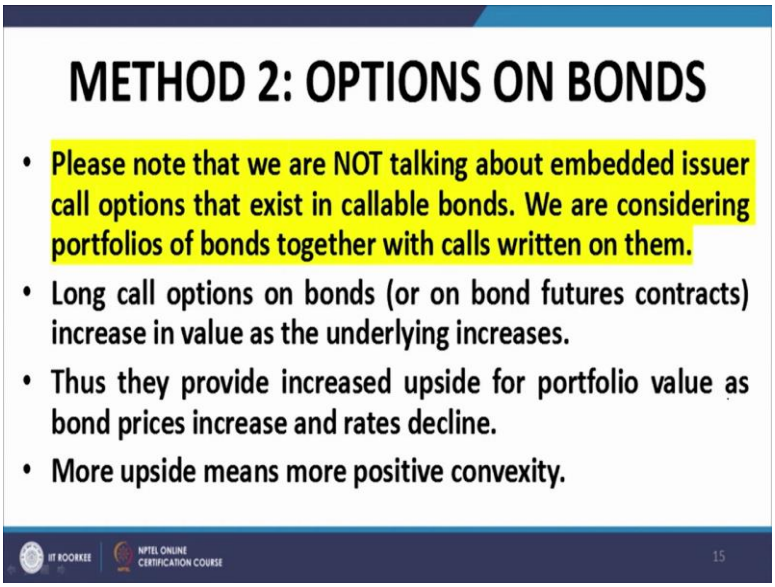

So, now we talk about up how options can be used to increase convexity. Now, please note this is different from embedded options in bonds, we are not talking about embedded options in bonds that we shall be talking about in the next slide. In this slide, what we are talking about is a portfolio that consists of bonds and that also has options written on the bonds. Now as we know in the case of call options on any underlying as the price of the underlying increases, the value of the call option increases because the payoff arising out of the call option increases.

So if you have call options written on bonds, and those call options are incorporated in the portfolio that we were talking about, you will be adding to the convexity because you are adding to the upside of the portfolio comprising of the options, the call options and the underlying bonds. Let me repeat if you have a portfolio comprising of some bonds and of call options written on that bond you are logged in the call options written on those bonds, then as the value of that, those bonds increase as the interest rates decline, the value of the call options will increase and as a result of it the total value of the portfolio increases relative to given decline in interest rates. And that means that portfolio has higher convexity.

So, let me read it out. Please note that we are not talking about embedded issuer call options that exist in callable bonds, we are considering portfolios of bonds together with calls return on them. Long call options on bonds, or on bond future contracts increase in value as the underlying increases. Thus, they provide increased upside for portfolio value in bond prices as bond prices increase or interest rates decline, more upside means more positive convexity.

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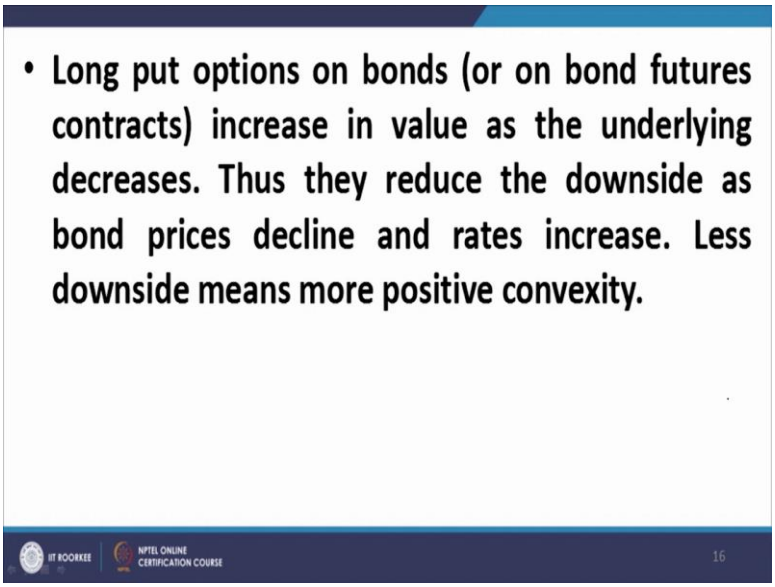

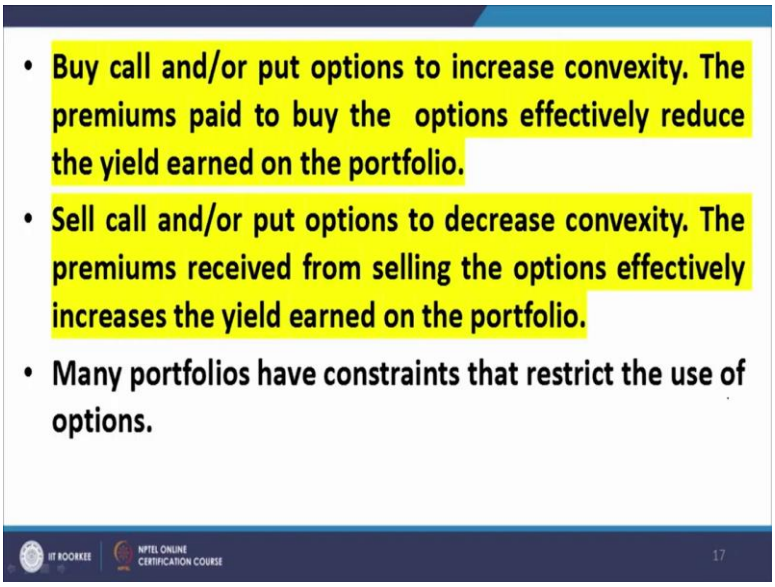

Long put options on bonds, or on bond futures increase in value as the underlying decreases thus they reduce the downside as bond prices decline or as interest rates increase. They also increase the convexity of the portfolio. So, adding long calls or adding call options to the portfolio of bonds written on those bonds or put options return on those bonds will add to the convexity of the portfolio, so buy call and or put options to increase convexity. The

premiums paid to buy the options effectively reduce the yield earned on the portfolio, sell, call or put options to decrease the convexity the premiums received from selling the options effectively increase the yield and on the portfolio. Many portfolios have concerns that restrict the use of options.

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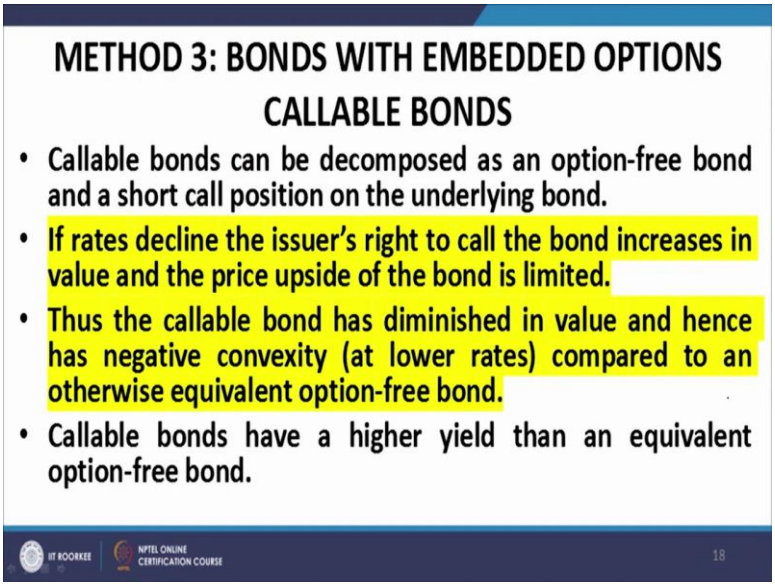

Then, bonds with embedded options you have callable bonds, what are callable bonds, we have talked about in a lot of detail they give the issuer the right to call back the bonds if the price of the bond increases beyond a certain level which is called the excess price. In other words, if interest rates decline, and as a result of it the prices of the bonds increases above the excise price, the issuer has the discretion, the power to call back the debt and close out the debt by repaying the amount of money due to the investors.

So, this right obviously, is a right is a prerogative and as a result of which the yield on these bonds for the investor point of view is higher, because the issuer is retaining a certain right and he has to pay a price for that right. Therefore, the yield on the callable bonds would be higher than this trade bonds which do not have such feature. Remember, this is the issuers right to call back the bonds not the investors.

And because the issuer is retaining this right retaining this privilege, therefore, he has to pay a price for that in terms of the higher yield to the investor. Now, the second thing that is important in the context of callable bonds is that as the interest rates would decline, the prices would increase, but as soon as the prices rise about the excess price issuer will call back the bonds.

Therefore, in this context, or in this sense, the upside of the bonds is curtailed, the upside of the bond is truncated by the excess price. If interest rates declined further, there would be no increase in the price of the bond because the issuer will call back the bonds at the excess price. So, that maximum that the investor could receive corresponding to or consequential to the decline in interest rates will be the excess price thus the upside potential of the callable bonds is restricted by the call options that are embedded in them and therefore, the convexity of such bonds is lesser.

So, let me read it out. Callable bonds can be decomposed as an option free bond and a short call position on the underlying bond. If rates decline the issuer's right to call the bond increases in value and the price upside of the bond is limited. Thus the callable bonds has diminished in value and hence, the negative convexity at lower rates compared to the otherwise equivalent option free bonds.

So, in the proximity of the options excess price, the bonds would exhibit negative convexity. Callable bonds have a higher yield than an equivalent option free bond because of the right that is embedded in that bond to the issuer to call back the bonds.

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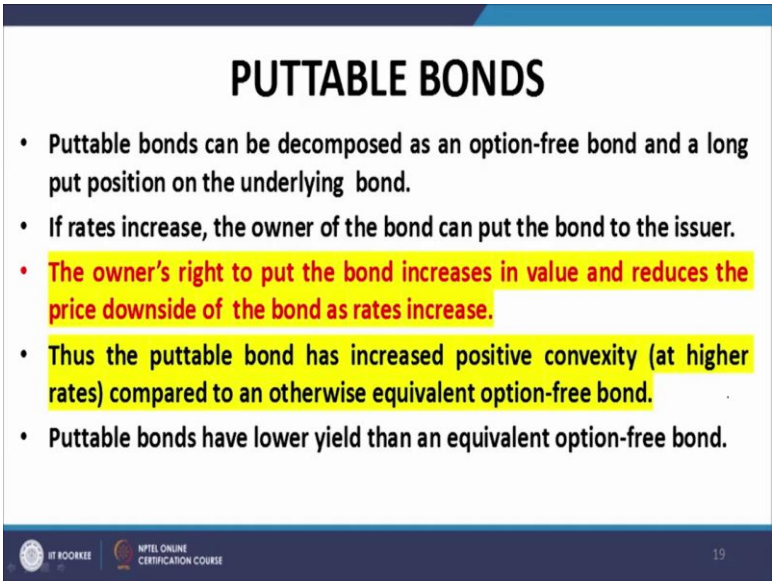

Puttable bonds can be decomposed as an option free bond and a long put option on the underlying bond you see in the case of the puttable bond the investor has the right, investor the privilege, investor the prerogative that if the interest rates, interest rates increase, then the price will go down, the price of the bonds will go down and the investor can then sell the bond back at the excess price not the market price, market price is lower, the excess price is

higher and the investor can sell the bond back to the issuer at the excess price, the higher price.

Therefore, in that case, the investor has that right, investor has the prerogative and therefore, the yield on these bonds is lesser than the shared bond because the investor is getting a right he has to pay a price for that right and the price is paid in terms of a getting a lesser yield on such puttable bonds or bonds that have a put option embedded in them.

So, puttable bonds can be decomposed into an option free bond and a long put option on the underlying bond. If rates increase, the owner of the bond can put the bond to the issuer, prices decline on account of an increase in rates, you can put the bond back to the issue and ask for the repayment of the debt proceeds out of the bond, the owner's right to put the bond increases in value and reduces the price downside of the bond as rates increase.

So, this is an important part that as rates increase, the price should go down. But then the downside is truncated, the downside is cut out curtailed by the excess price. As soon as the price would go down below the excess price the investor will set back, sell back the bonds or deliver back the bonds to the issuer and therefore, the price of the bonds will not go down below the excess price. So the downside is curtailed.

Therefore, puttable bonds, therefore what happens in this case, because the downside is restricted the puttable bonds gives you positive convexity. So, puttable bonds are lower yield than an equivalent option free bond this point I have already discussed and puttable bonds have increased positive convexity at higher rates compared to an otherwise equivalent option free bond.

So, in the proximity of the near where the option is in the money or close to the money or near the money, the downside due to the increase in rates would be curtailed, would be cut out because the investor can always put the bond back to the issuer. And therefore, that excess price at the minimum that the bond price could go down to and as a result of which it shows positive convexity in this region.

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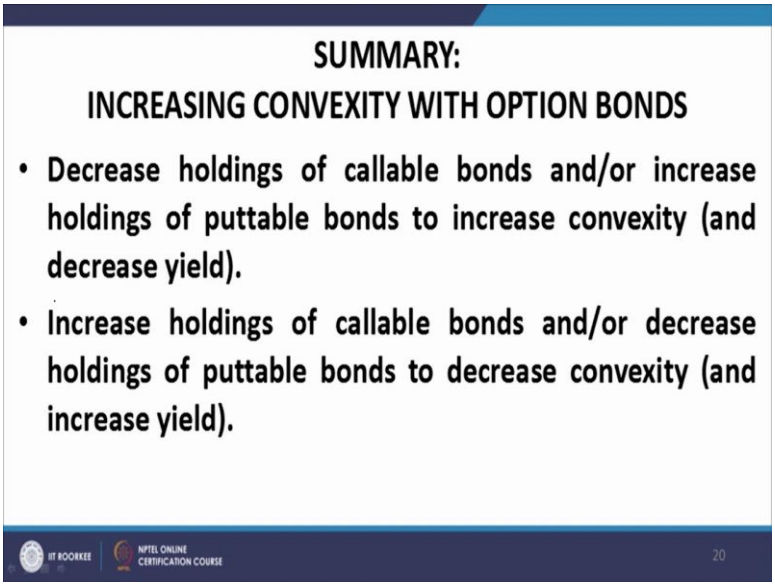

So increasing convexity with option bonds, decrease holdings of callable bonds at and or increase holding of puttable bonds to increase convexity and decrease yield, increase holding of callable bonds and or decrease holdings of puttable bonds to decrease convexity and increase yield.

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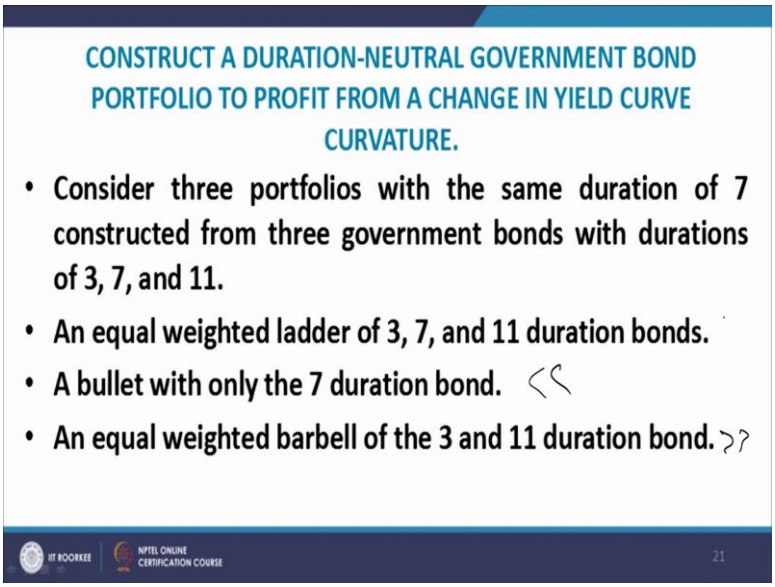

So again, we look at some more instances, some more examples of strategies. Consider three portfolios with the same duration of 7 years constructed from three government bonds with durations of 3, 7 and 11. The first portfolio consists of equal weighted ladder of 3, 7 and 11 duration bonds. The second is a bullet portfolio with only the 7 duration bond and the third is

an equally weighted barbell of 3 and 11 duration bond. Please note, the most important thing the duration of all the three bonds are the same.

In so far as convexity is concerned, the barbell has the highest convexity barbell has the highest convexity the bullet has the lowest convexity and this lies in between, the ladder portfolio lies in between in terms of convexity.

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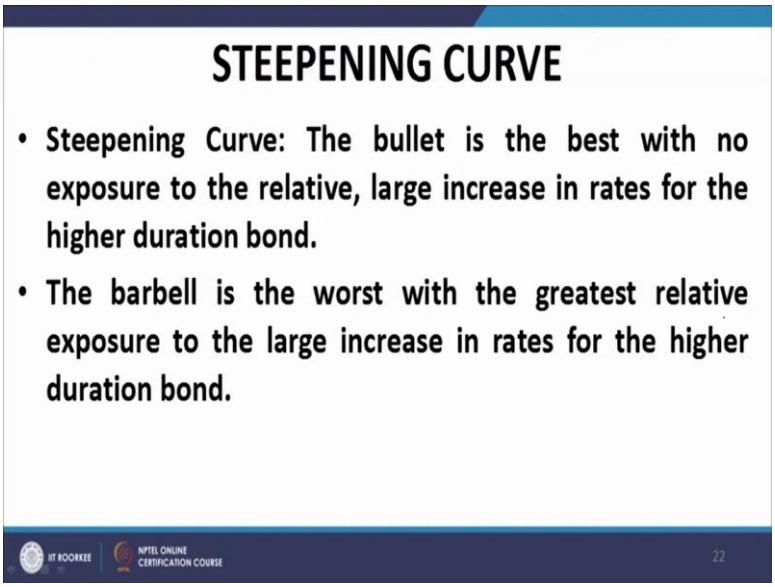

So, if there is a steepening curve, then what happens the near end rates decrease and the far end rates increase with the intermediate remain unchanged. So, because the near end rates decrease the near, the short term or the L portfolio the lower maturity low duration portfolio will increase in price but the increase in price will be marginal because the duration is less.

And as far as the long end rates are given they will increase and therefore the price decline of the edge component of the barbell will be more because this duration is more therefore the barbell would not be the optimum strategy. The bullet would be the optimal strategy.

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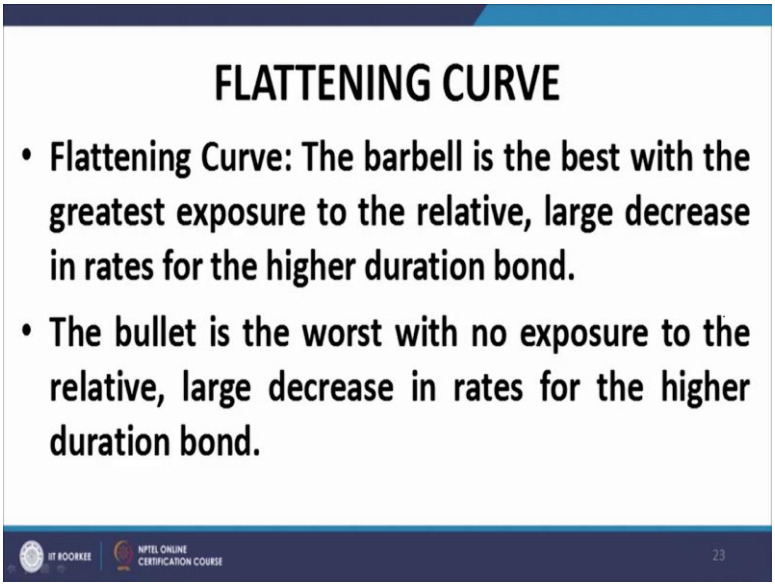

If it is a flattening curve, it is pretty much the inverse of the theme. The near end rates tend to increase and the far end rate tends to decrease. And therefore, it is the inverse of the strategy of the steepening strategy and the process would imply that the barbell strategy is the optimal strategy in this case, and that bullet strategy turns out to be the worst strategy because, see, what happens is that the far end rates decrease and when the far end rates decrease the price at the far end, the price of the long maturity portfolio will increase and the increase will be the most conspicuous, the increase will be the most prominent why because the duration of that portfolio is the maximum.

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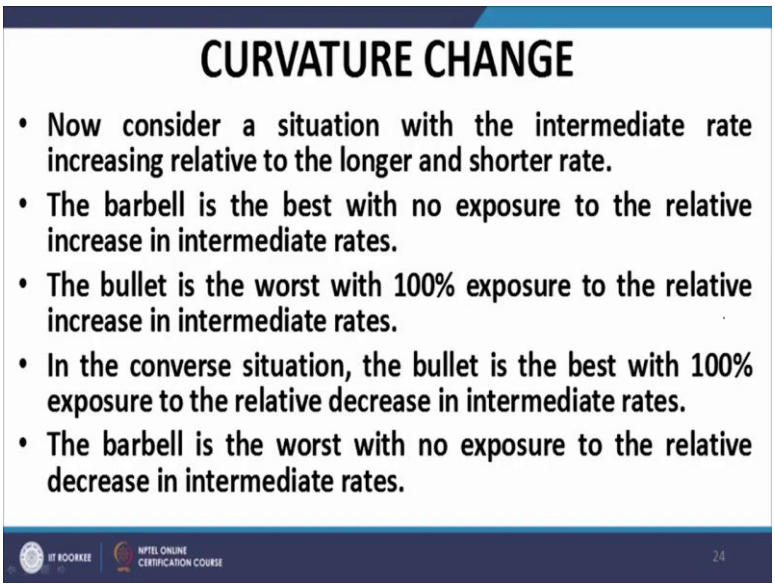

Now curvature change, we consider the situation where the intermediate rate increases relative to the long and shorter rate, the intermediate rate is increasing the long and short rates are decreasing or unchanged, let us say, or it is quite obvious that the value of the bullet will decline. And whereas the value of the barbell will remain unchanged because the far end and the near end rates are unchanged. And in this situation clearly the barbell is the best strategy.

In the converse situation where the far end rates and the near end and the far end rates increase and the intermediate rates decline, the bullet will obviously become the best strategy.

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Now we will talk about butterfly trades, see whatever I have been talking about whatever strategies I have been discussing, can be used to construct more complex strategies, which which comprise of both the near short maturity bonds, the far maturity bond and the intermediate maturity bond, we can have portfolios comprising of all the three maturity bonds short, long and intermediate maturity bonds, and consider the strategy in such a way that we can extract profits if our perception turns out to be correct in the context of the curvature of the yield curve changing.

So, if that is the situation, what we strategy that I am talking about, is called the butterfly strategy. The butterfly strategy can manifest itself as a long body butterfly or the short body butterfly. Now, how, what is the composition of the long body butterfly? Let us see, butterfly trades are a leveraged way to capture value when curvature changes. So, these strategies become relevant when curvature changes.

Now, in the long body strategy, what do we have, we have a long position in the bullet which is of intermediate maturity, and we are offsetting sought positions in the short and long maturity portfolio that comprise the barbell. So, we have a long bullet in the intermediate point. For example, let us say the 5 year point and we have short wings comprising of a barbell or a short barbell you may say, say 1 year and 9 year maturities or 1 year and 9 year duration.

So, that is a typical example of a long body butterfly, long position in the intermediate risk portfolio, intermediate maturity in the form of a bullet and a short position in the barbell comprising of equal distance or equal maturity distance from the bullet on either side. Thus a butterfly portfolio shorts the barbell portfolio that is borrows at the combination of shorter and longer rates and invest the proceeds in intermediate term bonds. So, that is what I said long position in intermediate term bonds and short position in the near and far term bonds, this can be called short the wings and long the body, the intermediate part is the body and the two extremes are the wings.

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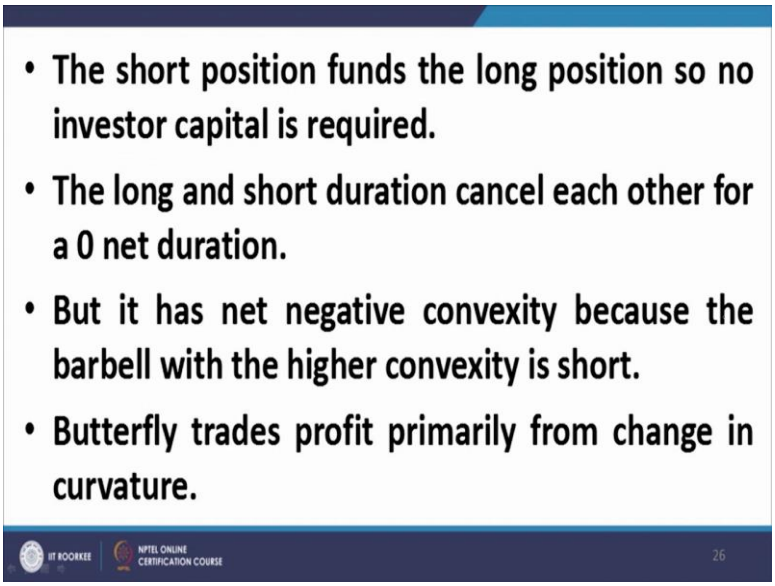

The short position funds the long position and therefore the investor, no investor capital is required to set up this strategy, the long and short duration cancel each other. So therefore, the net duration of this combined portfolio is 0. But what about convexity? Will it be positive or negative? The convexity of the barbell is greater than the convexity of the bullet please note this point but the barbell is short, the bullet is long and the convexity of the barbell is longer in magnitude, is larger in magnitude.

In other words, the combined convexity of this butterfly portfolio will be negative because larger magnitude of the barbell convexity combined with the fact that it is a short position would mean that the net convexity of this combination is negative, butterfly trades profit primarily for changes in curvature.

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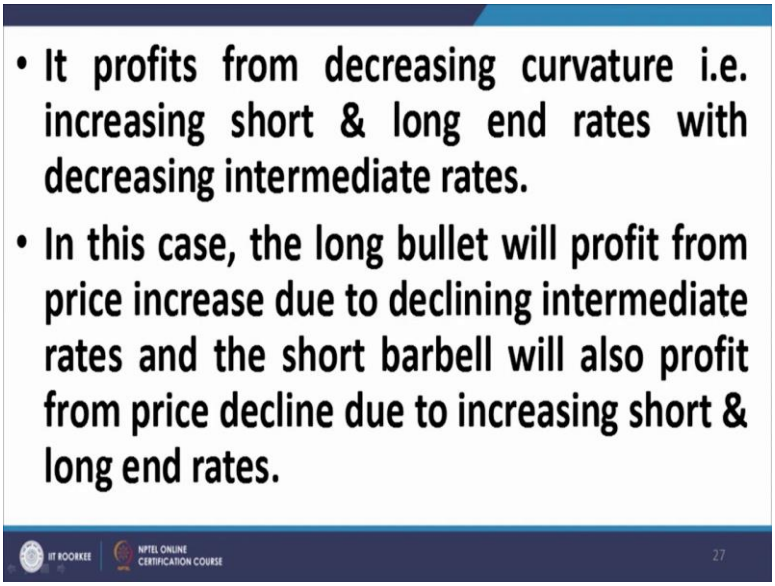

It profits on decreasing curvature, increasing short and long and interest rates and decreasing intermediate risk, because if the intermediate rates are declining, the value of the bullet will increase and your long in the bullet. So, you will profit from there. And similarly, near and far end rates are increasing, what happens the near and far end bonds will tend to decrease in price but you have a short position in those bonds and therefore you will again profit from that.

Let me repeat again you see what is happening here is that the middle end rates are decreasing and middle end rates, middle intermediate rates are decreasing when the intermediate rates are decreasing the value of the bullet that is the middle part of the butterfly will increase in value but if the near and far end rates are increasing, near and far end rates are increasing means the value of the wings will decrease but you are short in the wings and because you are short in the wings a decrease in value will give you profits.

So you are profiting on both counts, you are profiting on the count that the intermediate rates are decreasing and you are also profiting on the count that the near and far end rates are increasing. So it profits from decreasing curvature that is increasing short and long end rates and decreasing intermediate rates, in this case the long bullet will profit from price increase

due to declining intermediate rates and the short barbell will also profit from price decline due to the increasing short and long end rates.

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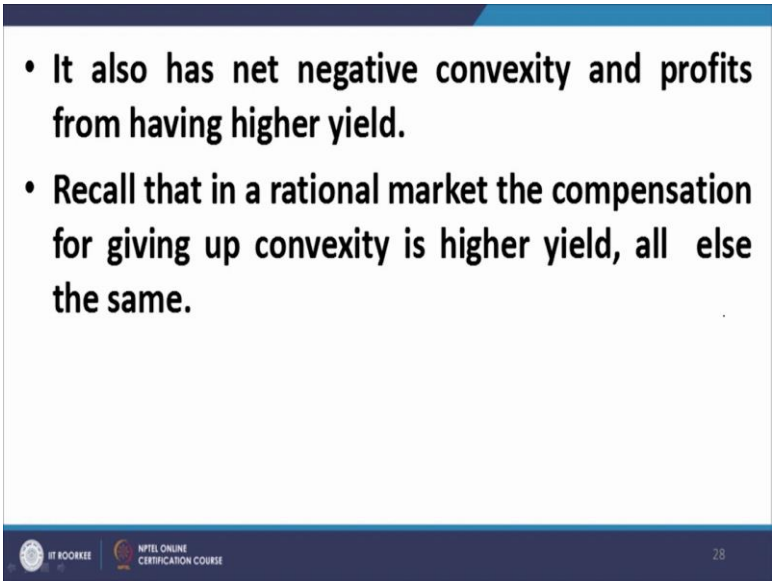

It also has negative, net negative convexity and profits from having higher yield, another important point, recall that in a rational market the compensation for given up, giving up convexity is higher yield all else being the same.

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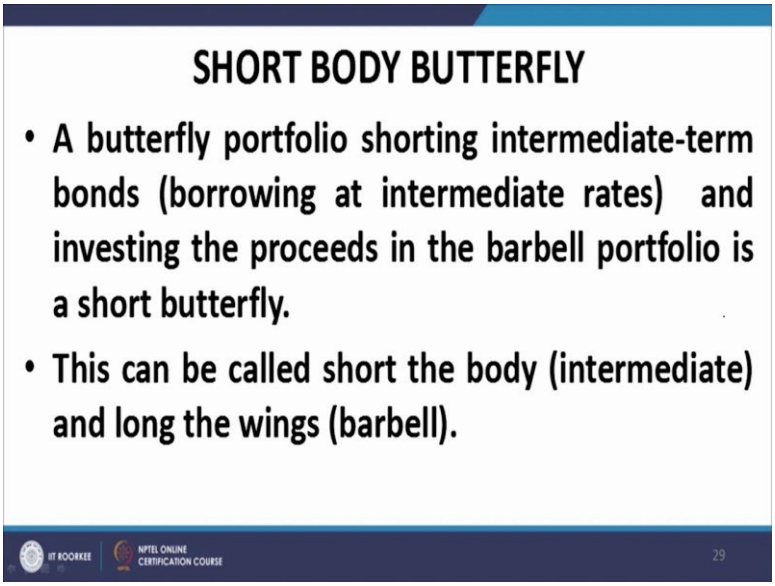

The short body butterfly it is pretty much the inverse of the long body butterfly in this case the intermediate bonds are short and the proceeds of the short position in the intermediate bonds are used to take up a long position in the barbell short and long maturity bond, so let

me repeat the body of the butterfly that is the intermediate rate, intermediate range or intermediate maturity bonds is short and the barbell that comprises of the short maturity bond and the long maturity bond that is long.

So if the interest rates, extreme interest rates the shortened and the lower, long end interest rates decline and the intermediate rates increase then you are going to profit from this strategy that is a short butterfly. A butterfly portfolio shorting intermediate term bonds borrowing at intermediate rates and investing the proceeds in the barbell portfolio is a short butterfly, this can be called short the body intermediate and long the wings.

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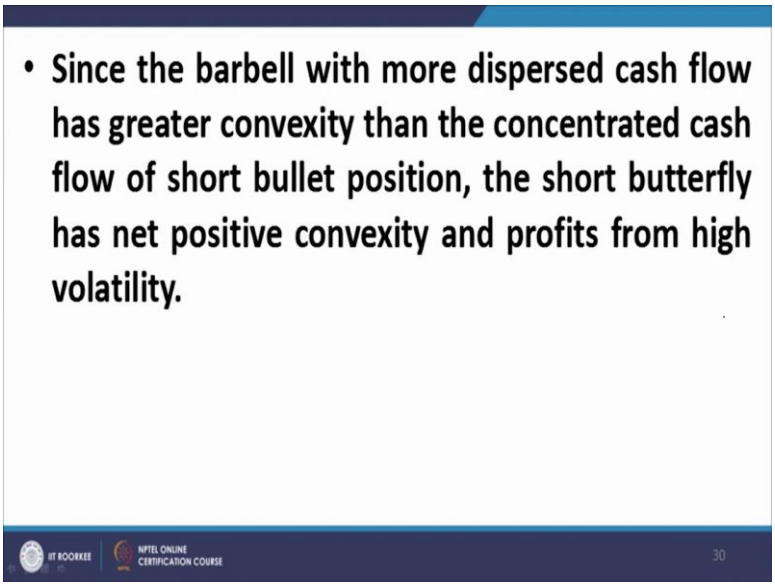

Since the barbell with more dispersed cash flow has greater convexity than the concentrated cash flow of the short bullet position this, the short butterfly has net positive convexity and profits from high volatility.

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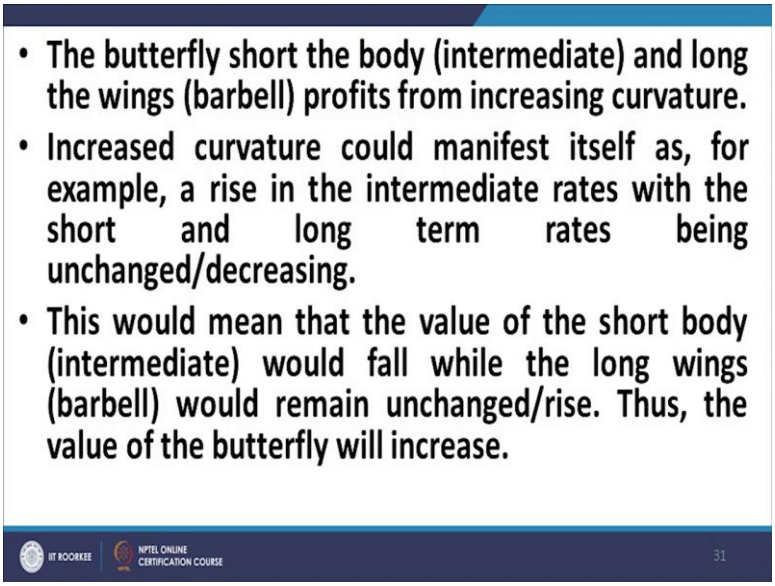

The butterfly short the body that is a short butterfly profits from increasing curvature, increased curvature could manifest itself as for example a rise in the intermediate rates with the short and long term rates being unchanged or decreasing, so rise in the intermediate rates that means the price of the intermediate body will fall and because they are short in that you will profit from that and if the long and short term rates decline the price of the short maturity part and the long maturity part that is the barbell will increase and you will again profit from that, so it should be decreasing here this would mean that the value of the short body intermediate would fall while the long wings barbell would remain unchanged or rise thus the value of the butterfly will increase.

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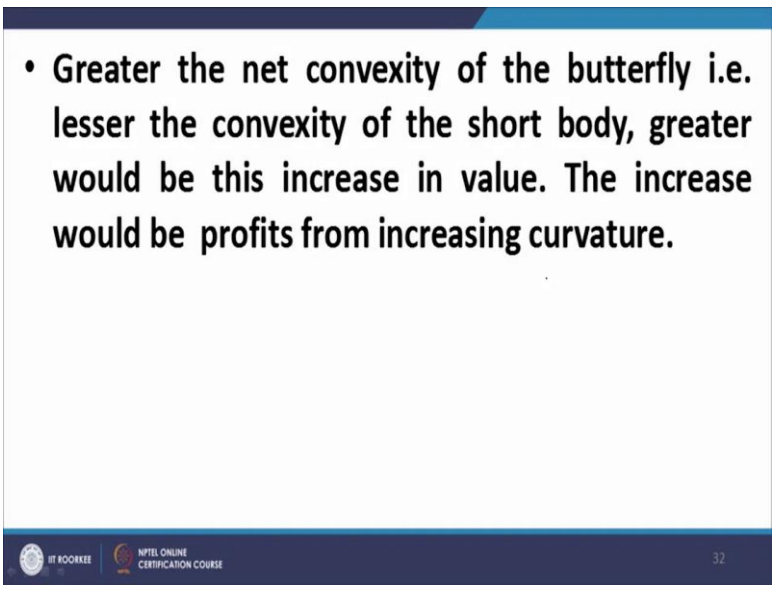

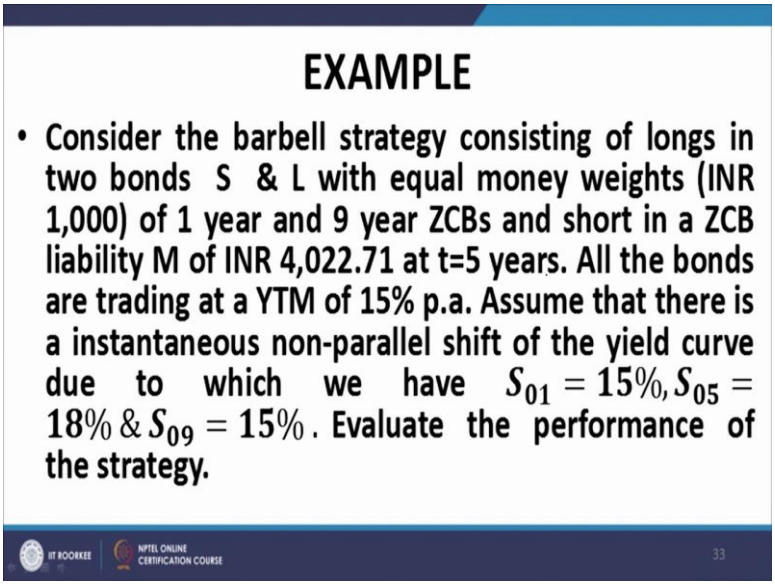

Greater the net convexity of the butterfly that is lesser the convexity of the short body, greater would be the increase in value, the increase would be profits from the higher curvature. So this is an example which you can take in the next lecturer, thank you.