Security Analysis & Portfolio Management
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Lecture 22
Price Sensitivities, Key Rates

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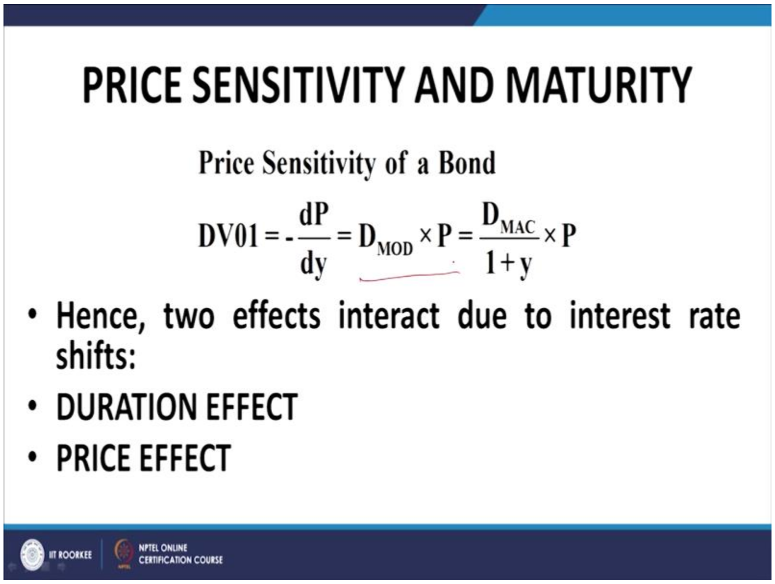

Welcome, back. So, before the break I was talking about price sensitivity and I defined price sensitivity to be synonymous with the DV01, the dollar value per basis point that is the negative slope of the yield price curve at any given point and it is mathematically written as dP by dy.

Now, if we use the definition of modified duration, we can write DV01 as D mod into price because, if you recall the definition of modified duration is in terms of the percentage change in price corresponding to a unit change in the YTM of the bond or we can say that the dP by dy that is the slope of the yield price curve, negative of the slope of the yield curve is given by D mod into the price.

Let me repeat the percentage change in the price of the bond per unit YTM or per unit change in YTM rather, is given the modified duration. Therefore, the change in price of the bond per unit YTM will be given by the product of modified duration and the price of the bond. And that can also be written in the form of Macaulay duration as the expression in the right-hand corner of the slide.

Now it is clear from this figure, it is clear from the intermediate equation that DV01 or the price sensitivity of the bond is dependent on two factors, that is the duration of the bond and number two, the price of the bond. The product of the two gives you the price sensitivity and therefore, there are two factors that come into play in determining the price sensitivity of the bond.

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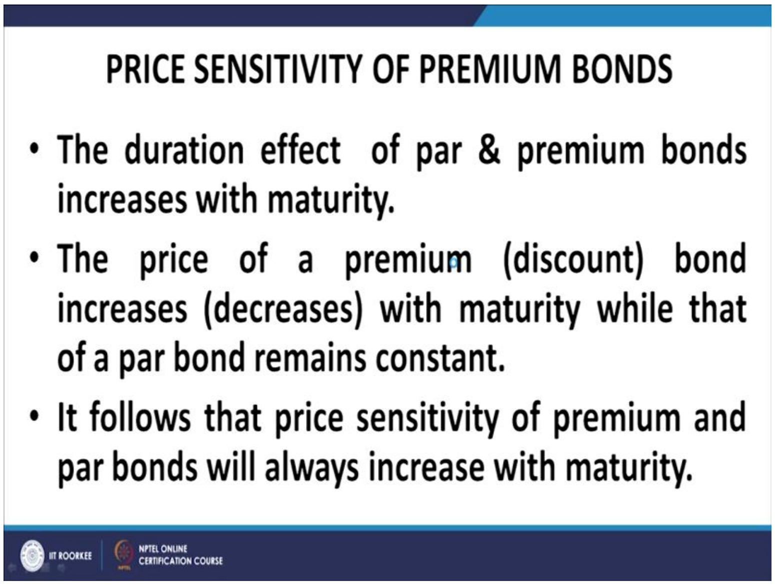

Now, as far as par and premium bonds are concerned, the price effect implies that the price of the bond increases or remains the same, increases in the case for premium bond and remains the same in the case of the par bond, if the maturity of the bond increases; the duration of premium and par bonds also increases as the maturity of the bond increases. So, it is obvious from this that for premium bonds as well as par bonds, the price sensitivity of the bond increases with maturity.

Let me repeat, the price effect or the price of a bond, if it is a premium bond or a par bond either increases in the case of a premium bond or remains the same in the case of a par bond as the maturity of the bond increases. And number two, as far as the duration is concerned, the duration of premium and par bonds both increase with increasing maturity of the bond.

Therefore, the consequence is that the price sensitivity of the bond invariably increases in the case of premium and par bonds. However, in the case of discount bond the situation is slightly different. As I mentioned a few minutes back before the break in fact, that the duration of discount bonds first increases and then decreases whereas, the price of a discount bond decreases as the maturity of the bond increases.

So, what happens is that initially as we reach a certain critical maturity of the bond the, for short maturity bonds, that is the duration effect predominates over the price effect and as a result of which DV01 increases initially for short maturities. However, as the maturities increase the price effect also and the duration effect both operate in the same direction. The price effect involves a decrease in price and the duration also starts decreasing after a critical value.

So, after a certain point in time as far as maturity is concerned, the price sensitivity of the bond DV01 of the bond decreases with maturity. So, let me repeat, for discount bonds initially, the price sensitivity increases for short maturities and then after a certain critical value corresponding to the parameters of the bond the DV01 or the price sensitivity starts decreasing.

So, that is a special feature of discount bonds. As far as par and premium bonds are concerned, the price sensitivity invariably increases with the maturity of the bond. I have already explained this price sensitivity of discount bonds.

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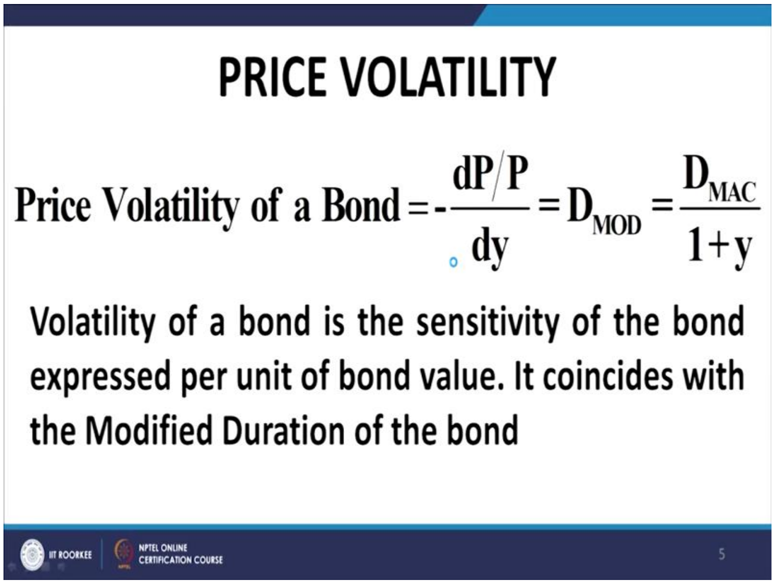

Then we come to another similar term which is price volatility, the price volatility of a bond is the percentage change in price corresponding to a unit change in YTM with a negative sign of course, I repeat the price volatility of a bond is the percentage change in price of the bond corresponding to a unit change in YTM.

So, this corresponds to the modified duration of the bond, it is anonymous with the modified duration of the bond. So, volatility we can also define as the volatility of a bond is the sensitivity of the bond expressed per unit of bond value because we are dividing by price in the numerator dP upon P.

Therefore, it is the change in value of the bond per unit of the bonds value or the change in value of the bond per unit of the bonds value per unit change in the YTM, it coincides with the modified duration of the bond. So, volatility of duration coincides with the modified duration of the bond number one and number two, it is the percentage change in the value of the bond corresponding to a unit change in YTM with a negative sign.

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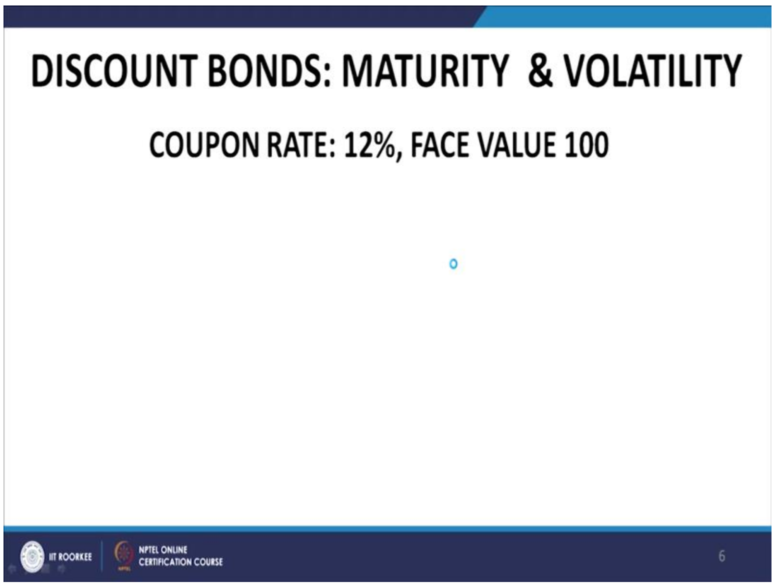

And as far as discount bonds are concerned, maturity and volatility relationship, as far as premium and par bonds are concerned, the situation is similar to that of price sensitivity, but for discount bonds also, we have a similar situation as you can see in this particular table.

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YTM	MATURITY	PRICE	PRICE SENSITIVITY	PRICE VOLATILITY
40	01	88.57		
41	01	87.94	63	0.71
40	02	71.84		
41	02	70.88	96	1.33
40	10	32.83		
41	10	31.93	90	2.75
40	100	30.00		
41	100	29.27	73	2.43

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In this table, what I have considered is a bond with a face value of 100 units and a coupon rate of 12 percent. And then I have worked out the price sensitivity and price volatility corresponding to a YTM change from 40 percent to 41 percent in each case, for different maturities.

I repeat, you have a bond of a face value of 100 units and a coupon rate of 12 percent annual bond and I have worked out the price sensitivity and the price volatility corresponding to a YTM change from 40 percent to 41 percent for different maturities, you can see as that both the price sensitivity and the price volatility increase initially 63, then 63 for one year maturity, 96 for two year maturity, 90 so it starts decreasing.

Please note this is the discount bond, the YTM is 40 percent and the coupon rate is 12 percent. So, it is a massively discounted bond. So, 63 is the price sensitivity at t equal to one year maturity of one year. If it is a two year bond, then the sensitivity is 96. If it is a 10 year bond, the sensitivity is 90. And if it is 100 year bond, the sensitivity is 73 which is a limiting value. And similarly, here we have the case of price volatility increasing first from 0.71 to 1.33 to 2.75, and then it starts decreasing, for the 100 year bond it is 2.43.

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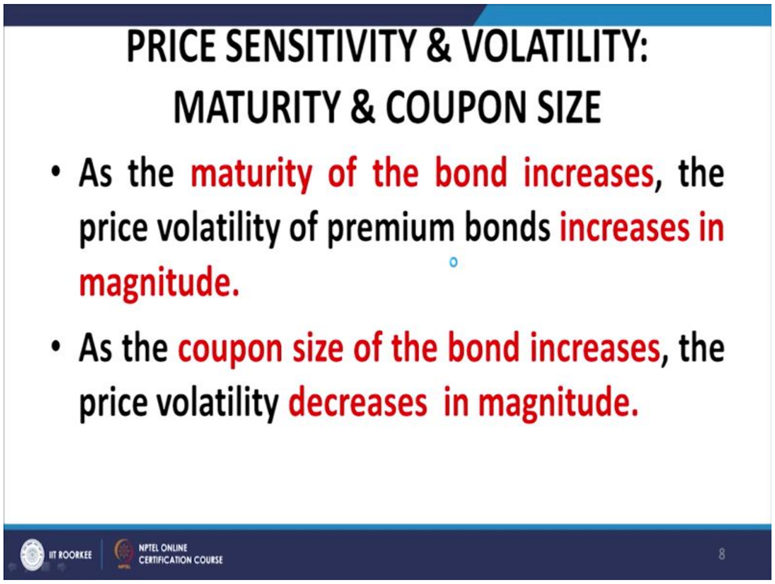

So, then we talk about price sensitivity and volatility versus coupon size. As far as the maturity of the bonds is concerned, I have already discussed that point, as far as coupon size is concerned, irrespective of whether it is a premium, par or discount bond, an increase in coupon rate will manifest itself as a decrease in the sensitivity as well as the volatility of the bond. I repeat an increase in coupon size results in a decrease in the sensitivity and volatility of the bond.

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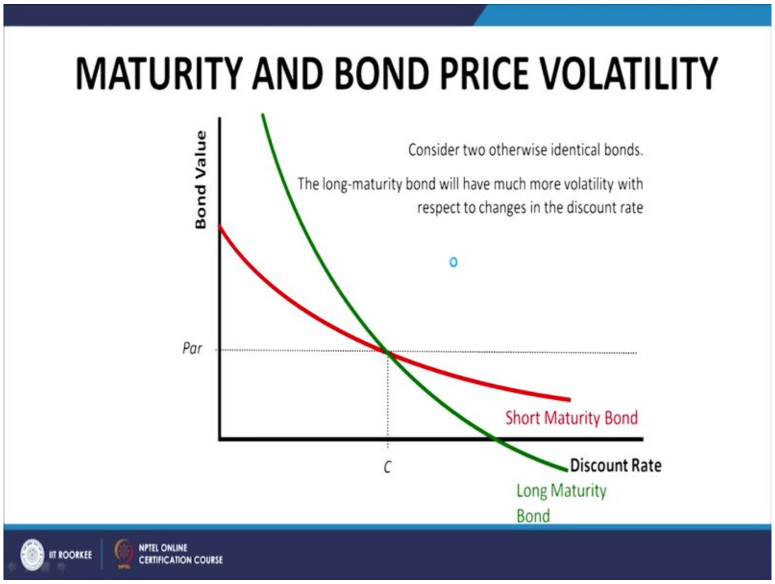

These are the diagram, the graphs, which represent the inferences that I have already explained a short maturity bond, the slope is less, the magnitude of the slope, excuse me, the magnitude of the slope is less; for a long maturity bond, the magnitude of the slope is more clearly showing that the DV01 figure for the long maturity bond is higher compared to the short maturity bond, this for a premium bond.

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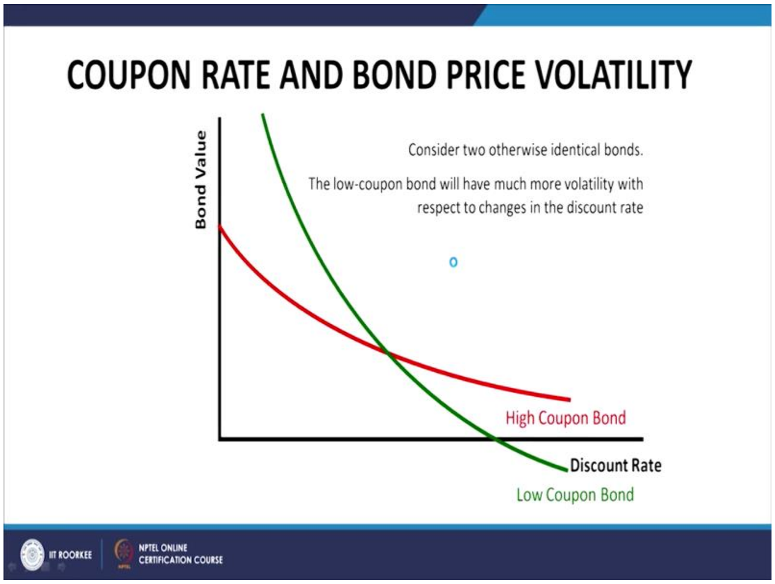

And this is the expression for the coupon rate. The higher coupon rate is again less sensitive, the magnitude of the slope is less and the low coupon rate bond is more sensitive, the slope is more as I elucidated a few minutes back.

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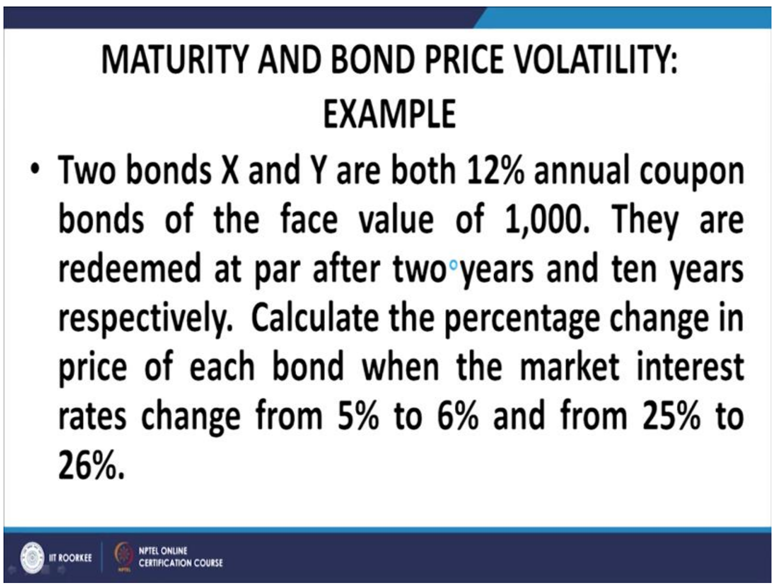

These are certain examples; I leave them as exercises for the students. Two bonds X and Y are both 12 percent coupon bonds of the annual coupon bonds of the face value of 1000 they are redeemable at par after 2 years and 10 years respectively, calculate DV01 and calculate the volatility also of the bond when the interest rates or the YTM changes from 5 percent to 6 percent.

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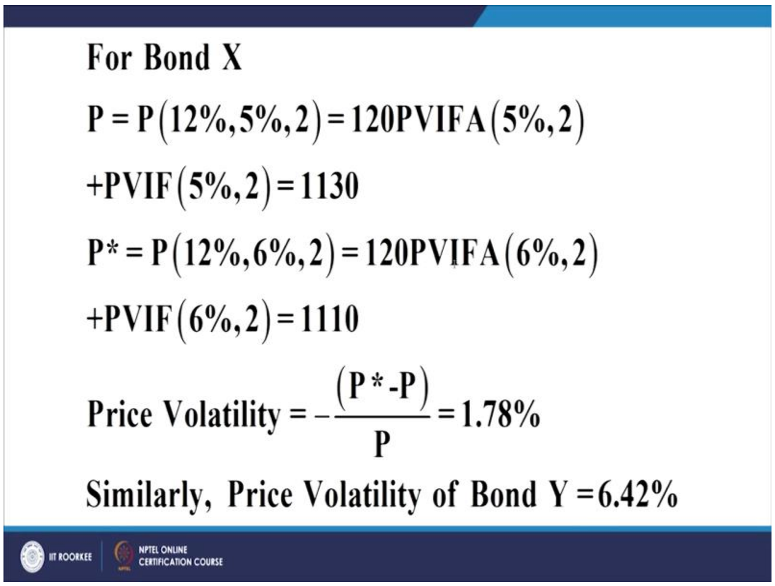

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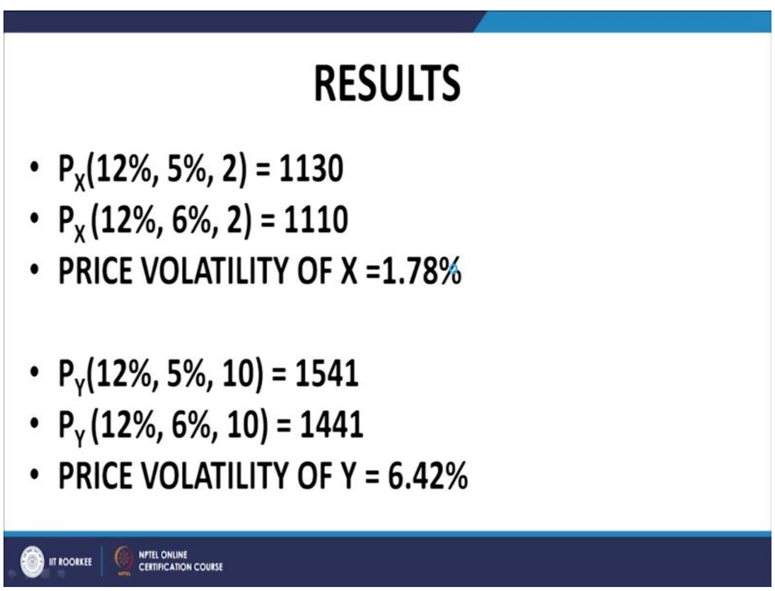

So, these are the calculations, look for the bond Q, for the bond X, the price as at a YTM of 5 percent remember the life of the bond is 2 years, coupon rate is 12 percent that is equal to 1130 and the price of the bond at a YTM of 6 percent is equal to 1110. And therefore, the price volatility, which is the percentage change in price is minus of P star minus P divided by P that is 1.78 percent.

And similarly, for the bond Y we have 6.42 percent clearly showing that as the maturity of the bond increases, please note this is a premium bond coupon rate is 12 percent, YTM is 5 percent. So, it is a premium bond and as you can see, the volatility is increasing with the maturity of the bond. So, these are the summarized results of this example.

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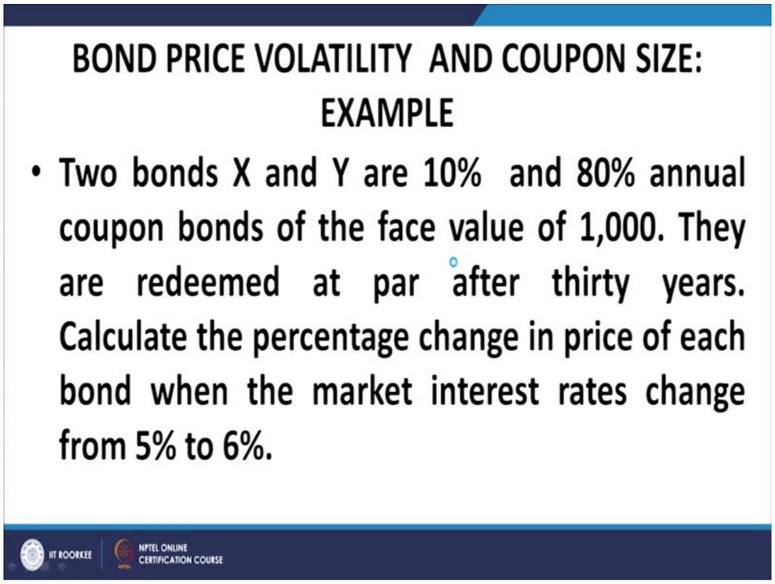

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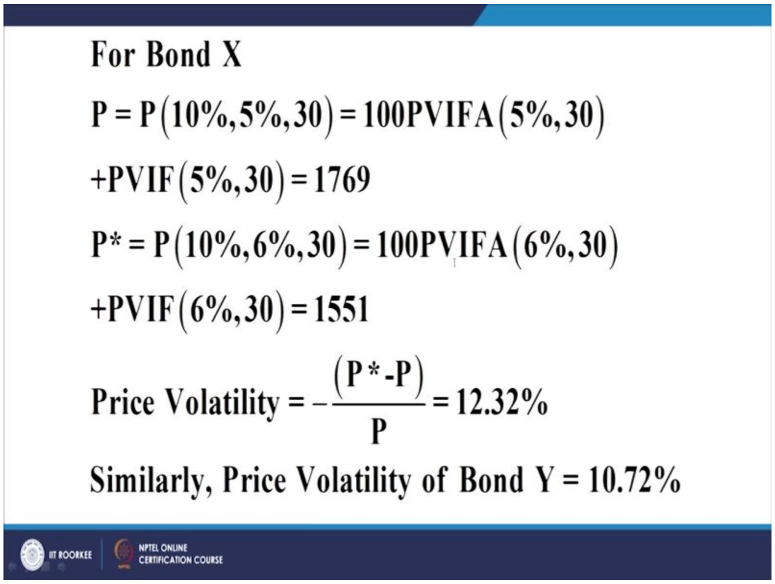

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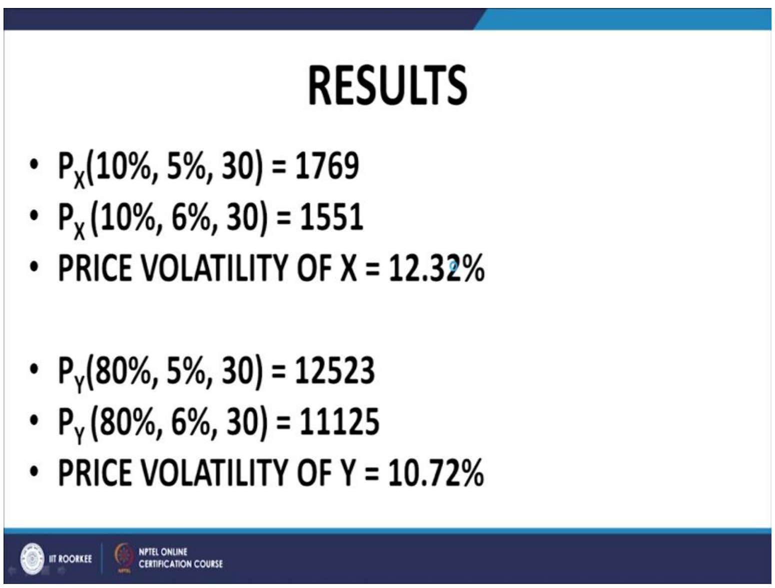

Then, this is an example which relates to the effect of coupon size on the bond and here again, what we find is that, as the coupon size increases the price sensitivity or the price volatility decreases. So, if you look at this, this coupon right here is 10 percent, the life of the bond is 30 years and at a 5 percent YTM, the price is 1769 and at a 6 percent YTM the price is 1551. So, the price volatility is 12.32 percent.

And if the coupon rate is increased to 80 percent, the price volatility decreases to 10.72 percent. So, as the coupon rate increases, the price volatility decreases as I mentioned, so this is a summary of the results.

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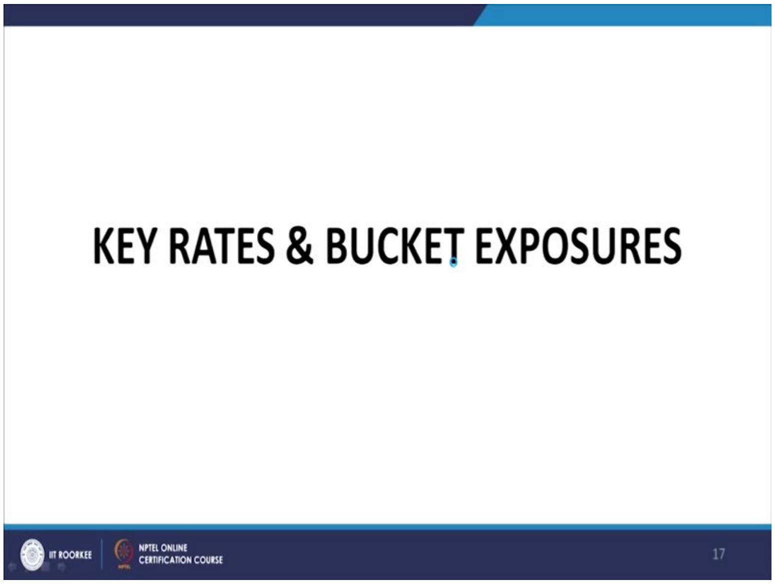

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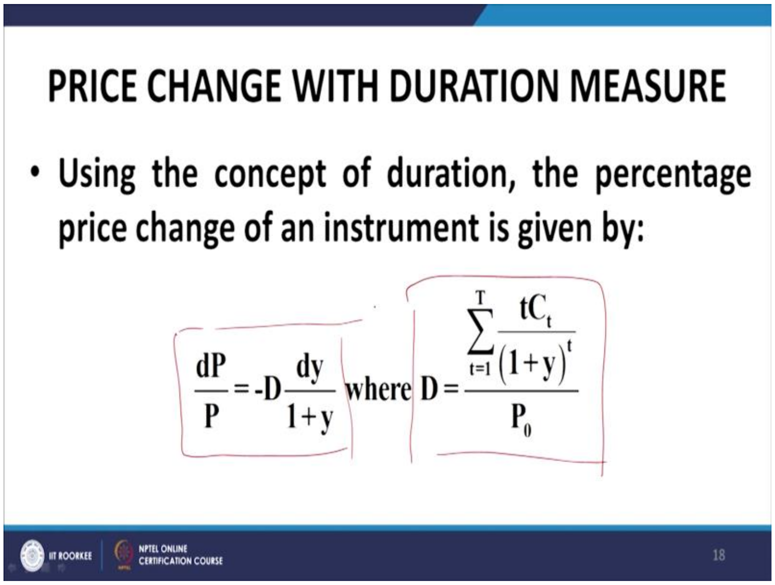

So, now we come to a new topic, a new interesting concept called key rates. What are key rates? Now, let us go back to the definition of duration, the definition of duration is given in on your slide. Look at this expression here. And in fact, recall the entire derivation of the formula for the duration, which is given here in the box.

Let me box it. So, this is what the expression for the duration is. And recall how we derived duration we differentiated the total cash flows with respect to a particular y or the YTM of the bond. And then we have equated it to zero and we arrived at this expression for the duration. And there are two very interesting features here.

Number one is, if you recall that derivation, we used y which was the YTM of the bond. Now, I have been emphasizing again and again that y is a single number, which encapsulates the entire term structure of the bond. In other words, I want to emphasize here that when we calculate the duration, we did not use separate interest rates for each maturity or each coupon date of the bond, we did not discount the coupon bond or coupon payments.

As you can see from this expression explicitly also, we do not discount the cash flows at t equal to 1 with a spot rate for 1 year, the cash flow t equal to 2 with the spot rate for 2 years, we do not do that. What we do here is, that we calculate the duration on the basis of a YTM and in fact this is the reason that this particular duration that we are working out here is sometimes called the internal duration of the bond, because it is worked out on the basis of the internal rate of return or the YTM of the bond.

So, the important, let me come back, the important thing is that we are not accounting for the different spot rates of the bond or the spot rate spectrum of the bond, we are taking a single rate which is the YTM rate agreed, but we are discounting all cash flows, the coupon at first year, second year, third year as long as the life of the bond, as well as the redemption value at the same rate, the single rate which is the YTM of the bond.

So, in other words, we are not accounting for the term structure of the interest rate, we are not accounting for the yield curve you may say, the curvature of the yield curve, which may be of course, convex or concave that is a different issue. But the important thing is we are not accounting for that we are assuming that the yield curve is flat, it is horizontal.

And therefore, we are assuming that the interest rate which is relevant to discounting the various cash flows during the life of the bond is independent of the maturity of the bond and that is equal to the YTM of the bond. So, this is a very fundamental assumption that goes into the calculation of duration and in fact, the competition of duration.

And in fact, the entire derivation of the properties, the fundamental property of derivation of immunization, this is one part. The second part is that if you look at the first formula here, if you look at this first formula here, in the first formula, what do we find, we find that we are shifting the yield curve by the YTM by a fraction by an infinitesimal amount of dy.

Now, here again this dy is also independent of this spot rate, it is a single value, it is a single value say 10 basis point or 5 basis points or 25 basis point as the case may be, but it is a single value, which is, which the entire yield curve over the entire spectrum of values is shifting. In other words, we are assuming number one a flat yield curve, and then we are working out the duration on the premise or working out the percentage price change on the premise that the entire flat yield curve shifts parallel to itself by a small infinitesimal value of dy.

Again, I repeat, we are not considering different shifts in different spot rates as is usually the case, in practice what happens is the 1 year spot rate may shift may change, the 10 years spot rate may not change, or the 10 years spot rate may change marginally, the 5 years spot rate may change by a smaller amount, and this shorter period spot rates may not change at all. So, we are not accounting for this phenomenon in this working, we are assuming that the entire yield curve, which for the first, in the first instance, which we assumed to be flat, which is actually not flat.

And the second thing is that we assume that the shift in this yield curve when we work out the percentage change in price is parallel to itself by an infinitesimal amount. In other words, all these spot rates and the entire spectrum of spot rates is shift being shifted by the same value. So, these are two fundamental assumptions that go into the duration measure. And which we (need) we now try to relax.

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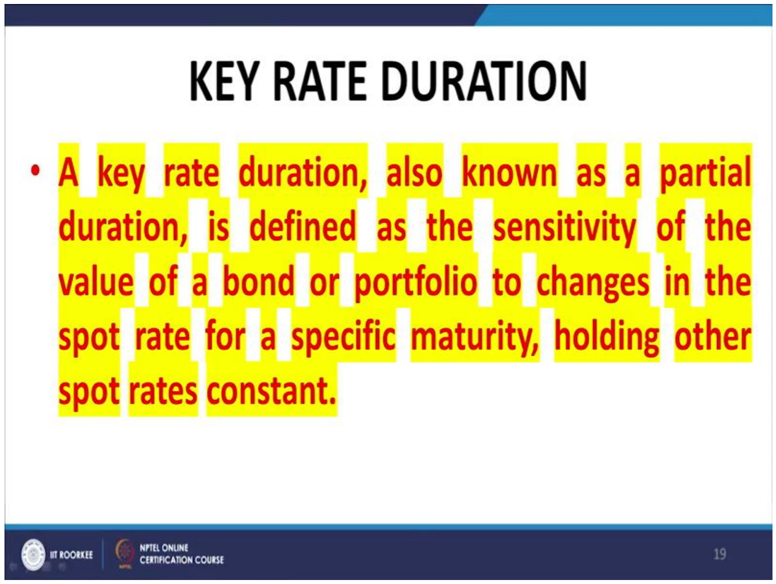

When we talk about the key rate duration, here is the role, here is where the role of key rate duration comes in. What we would do is suppose during the life of the bond is 10 years, we identify certain special rates, certain key rates, which are more relevant or which have a greater influence on the price volatility of the bond, on the price change of the bond.

Let us say we are, we believe that the bond is particularly susceptible to change in the 5 year rate or the 8 year rate or the 10 year rate, whatever you select. So, then we what we try to do is we work out the percentage change in the price of the bond or we work out the duration of the bond rather on the premise of the shift in the value of the bond corresponding to shift in that particular key rate, let us say the 5 year rate.

We assume that the 5 year rate changes by an infinitesimal amount increases or decreases, it changes by a small infinitesimal amount and on that basis keeping all the other rates without change. In other words, we assume that the entire yield curve is not shifted except for a particular point at which we are evaluating the key rate.

So, let us say if we are evaluating the key rate at the 5 year level, we assume that the 5 year rate is changed marginally upwards and downwards. And we work out the prior revised price of the bond after the change and on that basis, we arrive at a measure of the key rate duration. So, key rate duration identifies certain special rates, which have its, which we believe to have influence on the or significant influence on the value of our bond portfolio.

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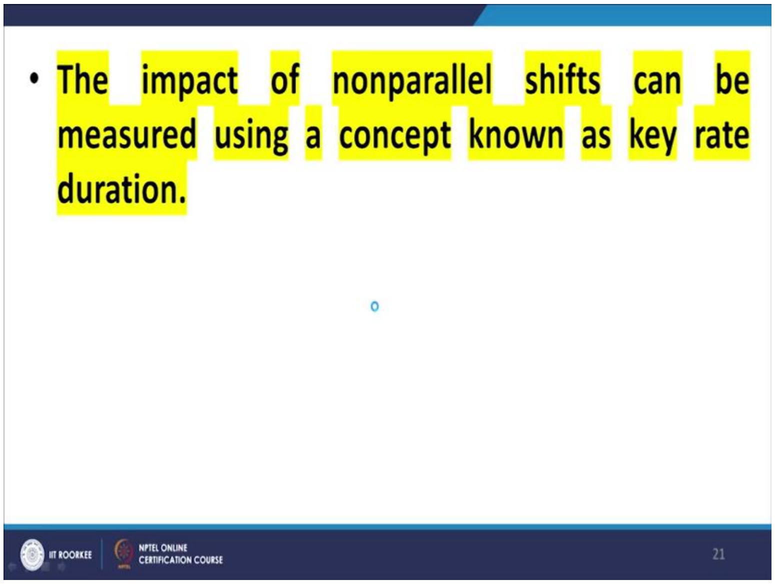

So, this I have explained, the impact of non-parallel shifts can be measured using a concept known as key rate durations, what is key rate duration? Let us define it formally. A key rate duration also known as a partial duration is defined as the sensitivity of the value of the bond or portfolio of bonds to changes in the spot rate for a specific maturity leaving all others spot rates constant.

So, that is what I said you identify certain special rates, and then with respect to each of those special rates, each of those spot rates, you evaluate the percentage change in the price of the bond and work out the duration of the bond accordingly. So, that it is not a universal shift of the yield curve.

It is a shift of the yield curve at one point and then you evaluate the duration, you evaluate the percentage price change, then you may take another point, work out another key rate duration, take another third point, work out another key rate duration. So, you first identify a set of rates which are relevant or which are strongly relevant, which are strongly influential on the value of your bond portfolio.

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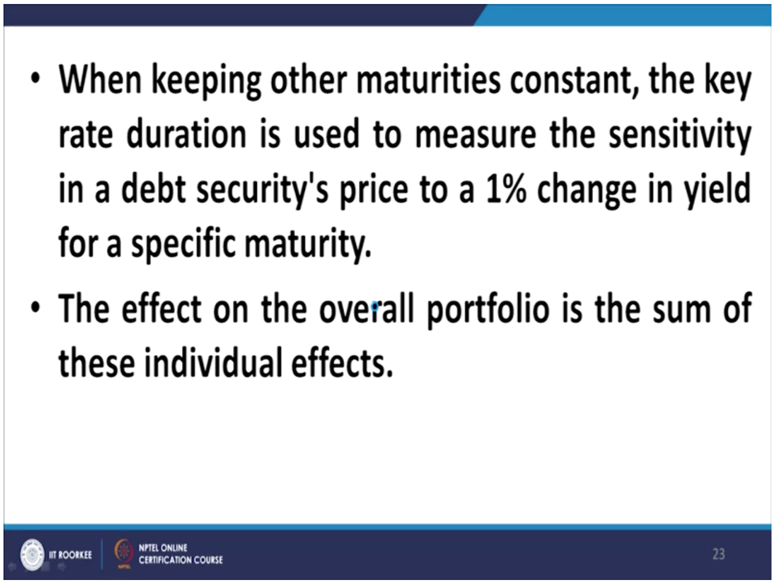

And then keeping other maturities constant, the key rate duration is used to measure the sensitivity in a depth security's price to a 1 percent change in yield for a specific maturity that is the definition of modified duration dP upon P minus of dP upon P divided by dy, but here dy is not the YTM, here dy is the infinitesimal change in a specific spot rate, in a spot rate of a specific majority. The effect on the overall portfolio is the sum of these individual effects.

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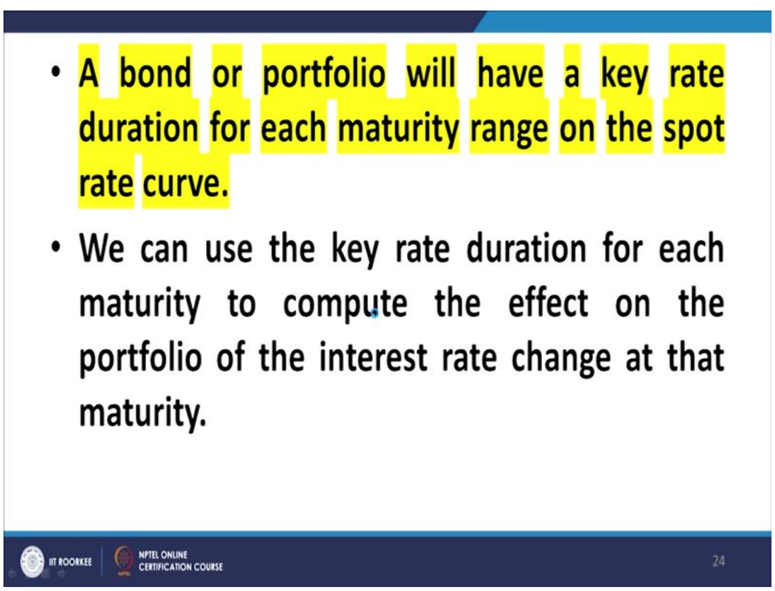

So, a bond or portfolio will have a key rate duration for each maturity range on the spot rate curve, it is for you to select the various maturities which are relevant for you, which you feel are influential and work out the key rates accordingly. Although obviously, a key rate duration will exist for every maturity or corresponding to every cash flow that the bond is going to release, bond is going to deliver during its lifetime. We can use the key rate duration for each maturity to compute the effect on the portfolio of the interest rate change at maturity.

So, the cash flows will really determine which of the key rates are fundamentally important. You may, if the cash flows at a particular point are small or insignificant, you may ignore that, but if for example, if it is the redemption value of a short maturity bond, say a 5 year bond, then obviously, it will be highly sensitive to the 5 years spot rate and so on.

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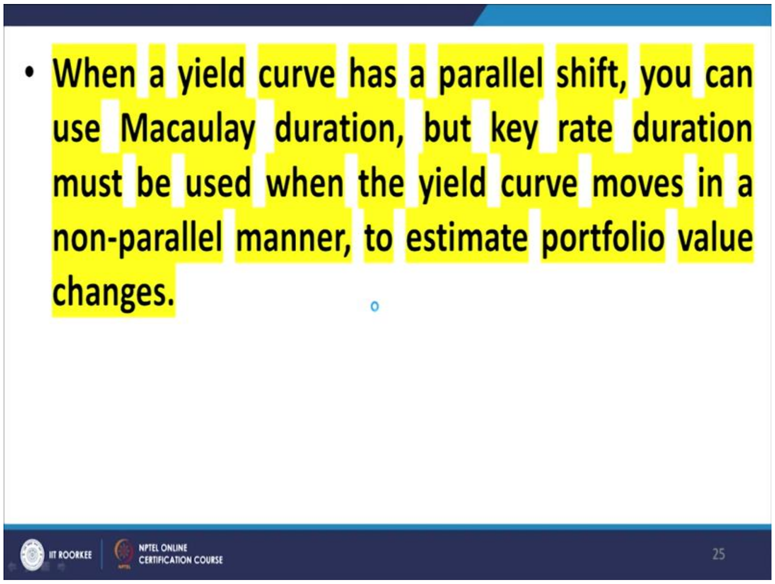

When the yield curve has a parallel shift, you can use Macaulay's duration but key rate duration must be used when the yield curve moves in a non-parallel manner to estimate portfolio value changes. So, that this particular statement simply reiterates what I said in the introduction, that whenever we talk about the duration or the internal duration.

Let me qualify that term now, internal duration of an instrument, we are talking about a flat yield curve, and we are talking about a parallel shift in that flat yield curve across the entire spectrum of spot rates. However, when we account, want to account for the non-parallel shifts in the yield curve, where different spot rates shift by different magnitudes, then we need to invoke, we necessarily need to invoke the concept of the key rate duration.

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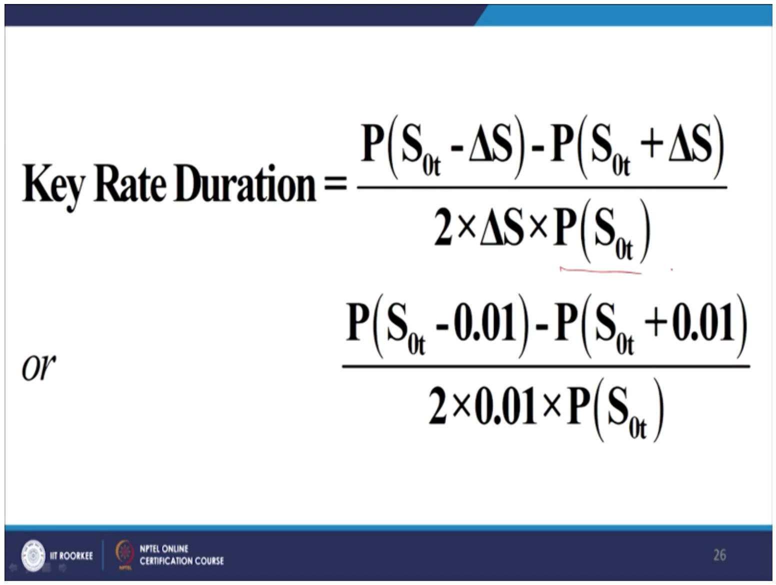

Here is the formula for the key rate duration, it is the formula that we, the abbreviated or the approximate formula for the modified duration that we arrived at earlier, it is a modified version of the modified version of the approximate modified duration formula. So, what does this say we work out the, we let us say we have a certain value of this spot rate and at that value of this spot rate, let us call it as 0t this rate corresponds to a maturity of small t years.

And corresponding to that maturity we have a certain value or certain price of the bond which we represent by P of S 0t. We keep all the others rates constant, all the others spot rates constant, except for this particular maturity rate as 0t. We assume that this, this rate has a small infinitesimal shift at to S 0t minus delta S, it shifts by a very small amount delta S.

And then corresponding to that the price of my bond portfolio, the value of my bond portfolio is given by P S 0t minus delta S. In fact, we use delta S on both sides of S 0t first we evaluated when the, there is a decrease, when there is an infinitesimal decrease in S 0t by an amount of delta S. That is the rate, new rate becomes S 0t minus delta S we evaluate, we work out the price of the bond at S 0t minus delta S.

And similarly, we assume an increase, infinitesimal increase in S 0t and by say delta S and we again work out the price of the bond at S 0t plus delta S and then we apply this formula because we have a negative sign in front of dP by dy, when we use the formula for modified duration. So, what we have here is P S 0t minus delta S minus P S 0t plus delta S because of that main negative sign.

So, this, the left-hand side version is coming first, the left-hand side price is coming first and the right-hand side price is coming second, because of the minus sign the signs get interchanged and we work out the average price change by dividing by P S 0t, which is the midway price and price corresponding to the mid ways spot rate or the original spot rate and then we divide it by the total change in the in the spot rate, which is 2 delta S.

So, we get the percentage price change of our bond portfolio corresponding to unit change in the spot rate of a, of a specific maturity and that is the key rate duration corresponding to the rate of that specific maturity. And the second formula gives you the same expression as the first, formula for a shift of delta S of 1 basis point in the spot rate.

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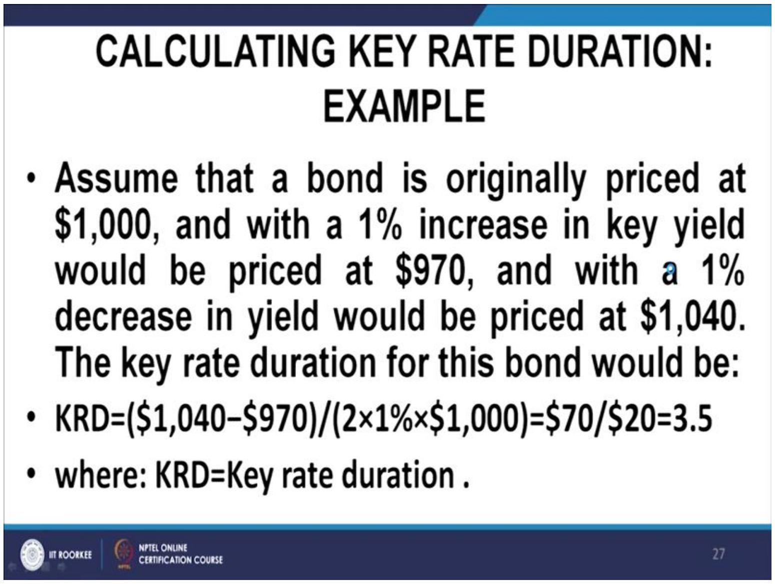

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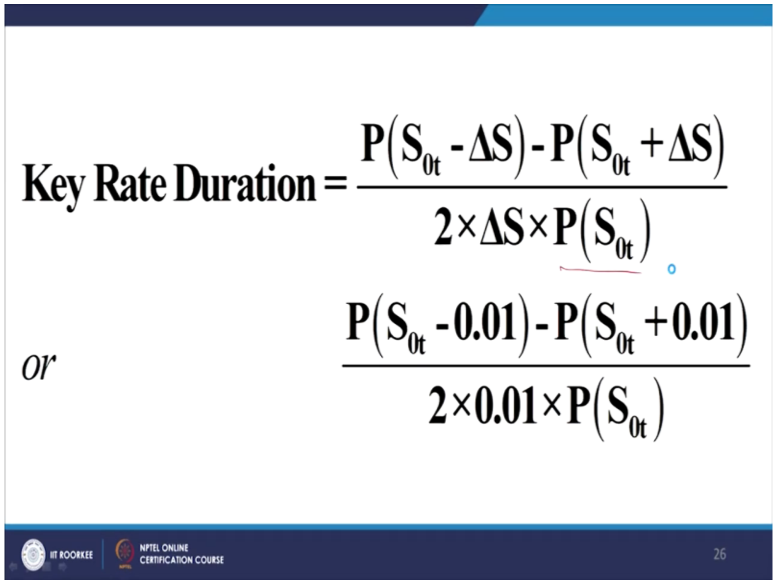

Let us do an example, assume that a bond is originally priced at dollars 1000, assume that a bond is originally priced at 1000 and with a 1 percent increase in key yield would be priced at 970 and with a 1 percent decrease in yield would be priced at 1040. Then the key rate duration is calculated as 1040 minus 970 that is how much?

That is 70 divided by what is the original price that is 1000 and then this is divided by a 1 percent increase in yield, 1 percent to the left, 1 percent to the right. So, a 2 percent change in yield that is 0.02. So, we have 70 divided by 1000 into 0.02 that is equal to 70 divided by 20 and that is equal to 3.5 years. So, simple calculation using the formula that is given in this particular slide.

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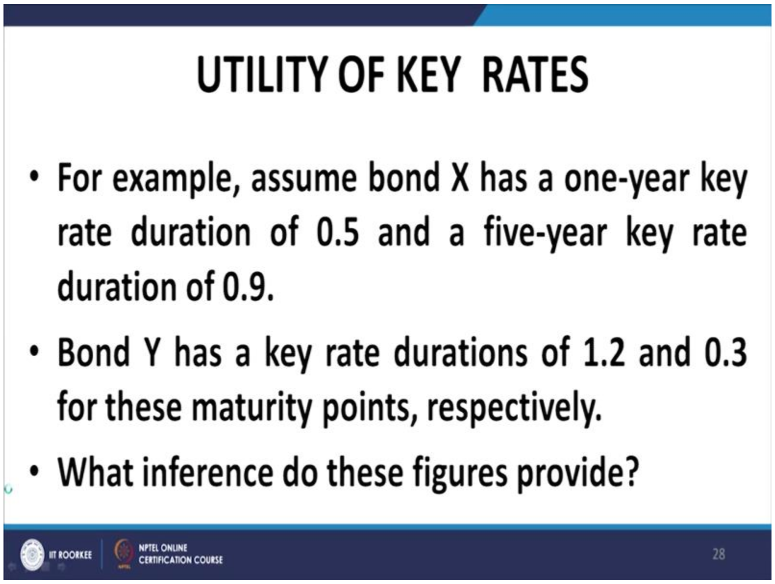

This utility of key rates let us take an example to illustrate the utility of key rates, assume that bond X, assume that bond X has a one year key rate duration of 0.5 and a 5 year key rate duration of 0.9. Bond Y has a key rate duration of 1.2 for the one year key rate, and a duration of 0.3 for the 5 year rate with respect to the five year rate.

Then, clearly what we infer is that as far as the short-term end of the yield curve is concerned the bond Y is more sensitive than bond X almost twice as more sensitive as bond X. And as far as the long end of the yield curve is concerned, bond X is more sensitive than bond Y almost three times as much sensitive as bond Y. So, this is useful inference that one can draw by the application of key rates.

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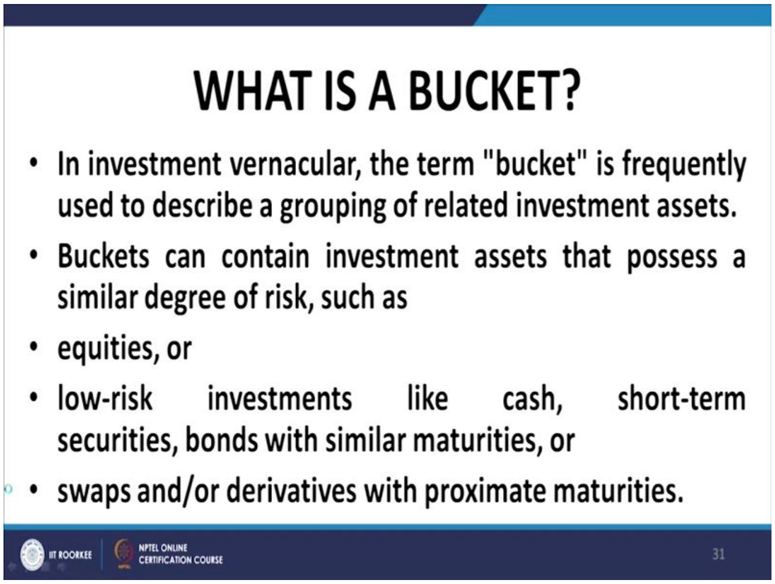

Now we come to another new topic, another interesting topic, which is called bucket exposures, what are bucket exposures? What is a bucket? So, in investment vernacular, the term bucket is frequently used to describe a grouping of related investment assets. Let me repeat, in investment vernacular, the term bucket is frequently used to describe a grouping of related investment assets.

In other words, it is a collection, it is simply a collection of assets which have similar risk return characteristics, which are similar in some form, some nature. And for example, let us illustrate this concept by an example. For example, we could have buckets comprising of equities alone, or we could have bond buckets comprising of bonds or we could have buckets comprising of low-risk securities, high liquidity securities, like cash, short term, marketable securities, and similar instruments.

Or we could have buckets comprising of different types of derivatives. So, a bucket is a very general term. It is a term which simply represents a collection of similar assets. Again, within equities, you can have buckets, you could have buckets of high growth stocks on the one hand, you could have buckets and highly liquidity stocks on the other hand, or for example, you could have bonds, bond buckets with different maturities, you could have bonds of different companies with maturities of three years.

In another bucket you could have bonds of different companies whose maturity is five years in another bucket, you could have treasuries with maturities of say 20 years and so on. So, buckets are nothing but a collection of similar investment assets, buckets are nothing but a collection of similar investment assets, that is the general definition of bucket.

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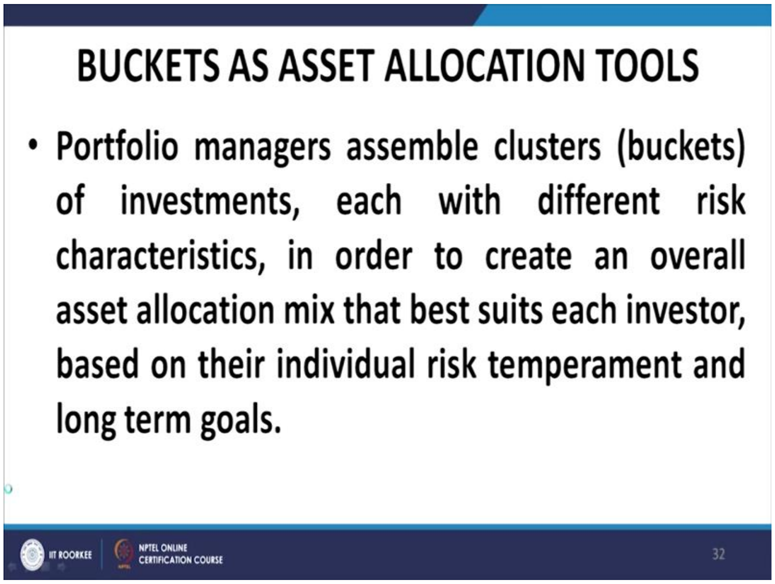

Now, buckets serve as useful asset allocation tools. In other words, you may, what you may do is you may first allocate say 100 units of money of investment into certain assets say 40 percent in equities, 20 percent in bonds and 20 percent in highly liquid table, highly liquid marketable securities and cash.

Then within those 40 percent and equities, you may have a bucket comprising of gross stocks and another bucket comprising of liquid stock, in bonds, you may have bonds, bond buckets with different maturities. And similarly, you may have a bucket of marketable securities. And you may have bucket comprising of more liquid instruments like treasury bills and cash.

So, buckets are basically simply tools of assets allocation, simply tools of investment management. And I repeat buckets are simply collections of objects or investment objects that have similar risk return characteristics.

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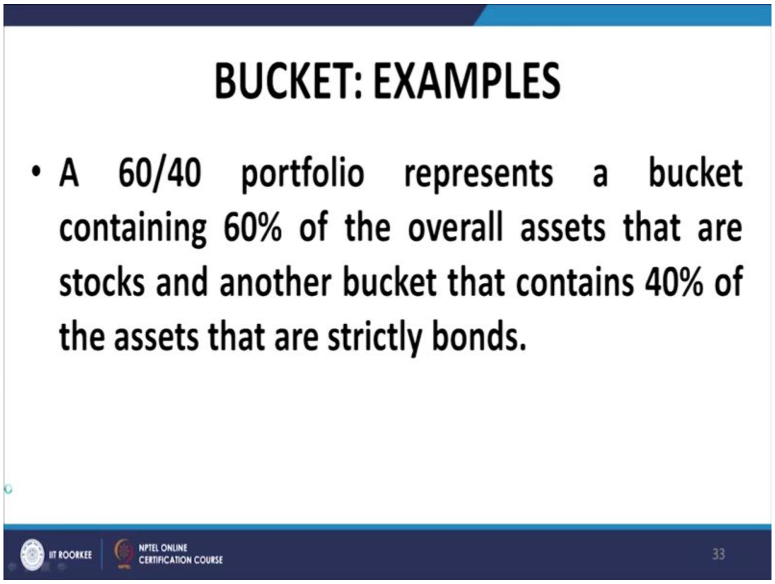

So, let us another, an example of a bucket similar to what I mentioned just now, a 60/40 portfolio represents a bucket containing 60 percent of the overall assets that has stocks and another bucket that contains 40 percent of the assets that are strictly bonds. So, you have a 60 percent and a 40 percent portfolio comprising a bucket, comprising of 60 percent of the total assets at stocks and 40 percent of the total assets as bonds.

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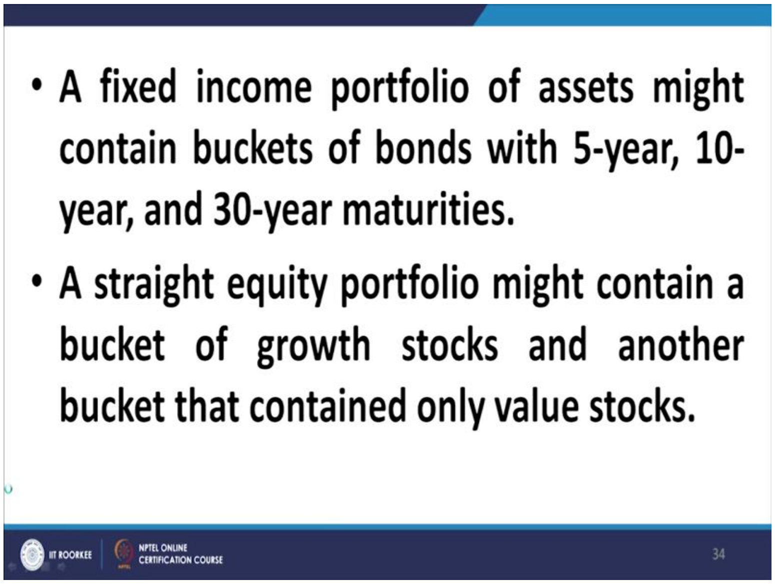

Similarly, a fixed income portfolio may consists of buckets with different maturities, we may have buckets of bonds with 5 year maturities, 10 year maturities and 30 year maturities. So, again, different collections, a straight equity portfolio may contain a bucket of growth stocks, and another bucket containing only value stocks and the third bucket may be consisting of liquid stocks.

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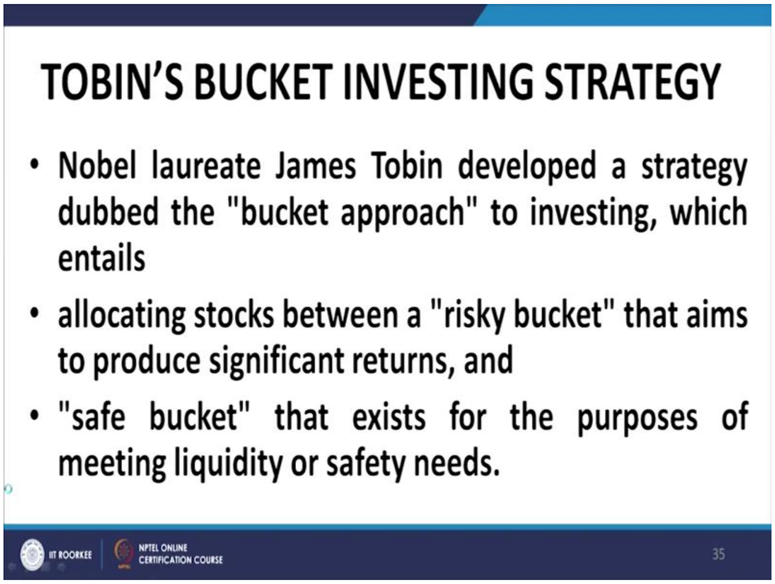

So, now, we come to the Tobin's bucket investing strategy. Now Nobel laureate James Tobin developed a strategy which is dubbed as the bucket approach to investing which entails allocating stocks between a risky bucket that aims to produce significant returns. Now, as you know, high expected return is accompanied by high risk.

So, with that maxim, you will have two separate buckets one bucket which has highly risky stocks, but because of their high risk they are likely to produce high expected returns and number two bucket or the second bucket, which may comprise of low risk highly liquid stocks, which may be kept maintained for the safety needs or the short term needs or short-term mismatches of the investors liquidity position.

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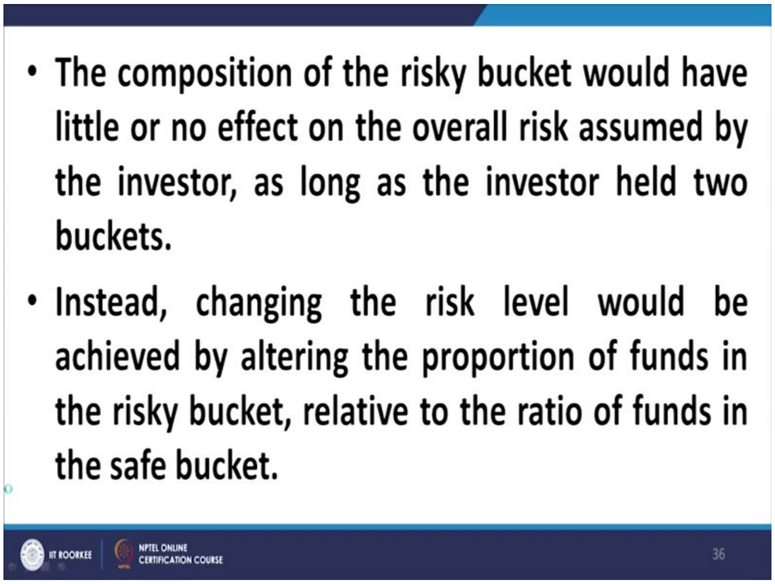

And the other bucket that is the growth bucket or the risky bucket may be used for long term investing. The composition of the risky bucket would have little or no effect on the overall risk assumed by the investor as long as the investor holds the two buckets. Now, you could play around with the stocks that are contained in the two buckets themselves without changing very much in the overall composition or the overall risk profile of the investment.

What you could do is you could in the first bucket, you could manipulate the stocks depending on the changes in the environment, changes in the market conditions or the changes in the performance of the company whatever the case may be, you could manage or manipulate that as a single portfolio.

And you could manipulate this second thing on the second bucket again as a single portfolio and if and this could be you know, Tobin's approach advocates approach similar to the CAPM, two fund theorem, which we shall come to in a later section of this course.

But basically, in the CAPM two fund theorem, what we do is, we allocate the investment portfolio of any investor between two assets, the risk-free asset and the market portfolio. And by adjusting the composition of the two assets, we can design any portfolio corresponding to the risk profile, an optimal portfolio corresponding to the risk profile of any investor.

Similarly, what Tobin says you have two buckets, one bucket of high-risk stocks, higher expected return stock and the other bucket for, with highly liquid stock, you play around in the composition of the two buckets, but and you manage the overall portfolio risk return characteristics or the total risk return characteristics of the combination of the two portfolios by manipulating the composition of funds or composition of investment in either of the two buckets.

So that is Tobin's approach to bucket investing. Same proponents of the bucket strategy recommend using up to five buckets, that is obviously a more detailed one, detailed investing strategy. So, this is what more or less the bucket investing is, or the concept of bucket exposures. In the next lecture, I propose to take up the term structure of interest rates and then move on to equity valuations and equity bond, I am sorry, equity stock evaluation and so on. Thank you.