,Economics of Banking and Finance Markets
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Lecture - 17
Principles of bank management - III

Welcome to this session. In the last session we had discussed various principles of banking. We discussed the principles of how a bank manages interest rate risk. So, in the previous class, we little bit started discussing various methods for measuring the interest rate risk. At that time, I had introduced to you the basic gap and duration analysis.

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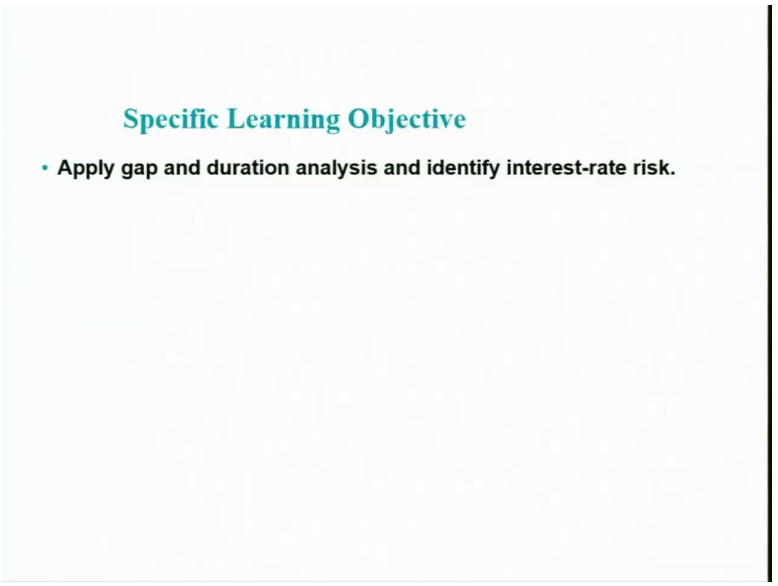

So, in today's session we will go little bit in-depth to discuss gap and duration analysis, and how to measure interest rate risk.

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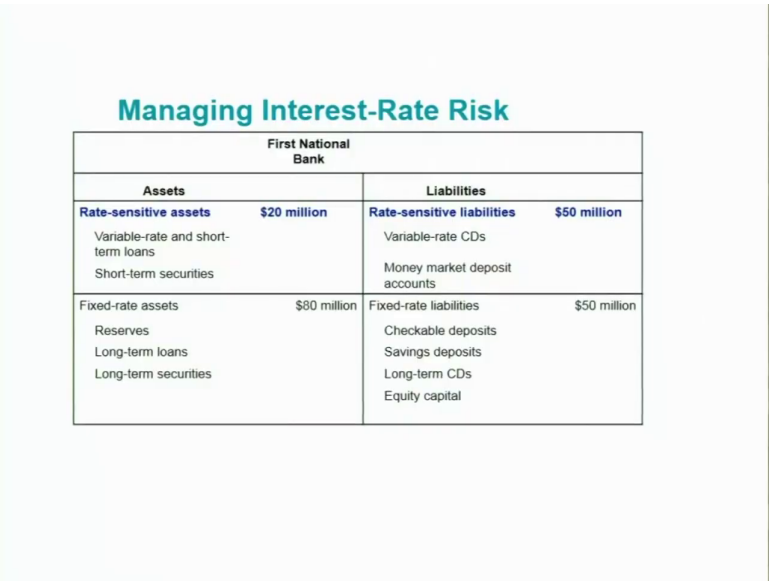

This slide I have shown you in the previous class. Look at the balance sheet of this bank. We classify it into two groups: the assets and liabilities. One we call it assets, we call it rate sensitive assets, and the other one we call it fixed rate assets.

Similarly, about the liabilities, we make it rate sensitive liabilities and fixed rate liabilities. The main point here is when there is an interest rate change, it mainly affects the rate sensitive assets and rate sensitive liabilities.

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So, again as the illustration, just relook into this; you can see here that the total assets is 100 million and of which we can see that rate sensitive assets is 50 million and rate sensitive liabilities are 50 million.

So, look at scenario 1, what if there is an increase in interest rate? So, suppose that interest rates rise by 5 percentage points on average from 10 percentage to 15 percentage, and in this scenario suppose a bank has a balance sheet, something like this, and what would happen to the net worth of this bank. So, let us look into this. So, look at the income on the assets, you know that, it will increase by 1 million because the interest rate has risen from 10 percentage to 15 percentage.

You can just make a simple calculation here; 5 percentage of the 20 million rate sensitive assets. You can see that the payment that the bank going to get from the increase in the rate of interest is 1 million. But, at the same time, you also know that the liabilities, the payments the bank must make, that will increase; that the 5 percentage of 15 million rate sensitive liabilities that is the payment bank must make, it is 2.5 million.

In the simple example here, you can see that the banks received the increased revenue by 1 million, but the liabilities, that the payments in the liabilities, increased by 2.5 million. So, the net worth of this bank, that you can see that, actually declined by 1.5 million from this example. So, the same thing we can calculate using some simple formula called basic gap analysis.

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Similarly, same example, suppose there is a decrease in interest rate. So, you can see in the same calculation that if that happens, what happened to the revenue and as well as the payment. So, you can see that in this example, the scenario 2, when there is decrease in interest rate, you can see that the net worth of this bank increased by 1.5 million.

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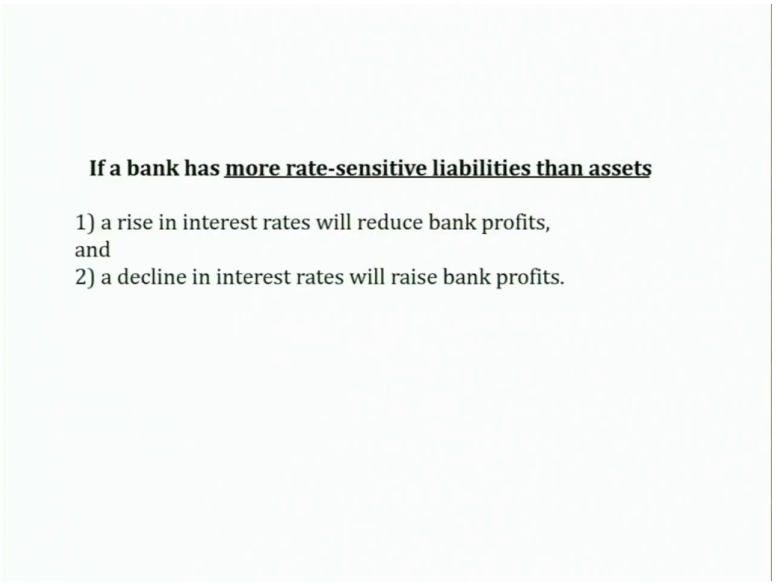

In these things what we can infer that if a bank has more rate sensitive liabilities than assets, a rise in interest rate will reduce bank profits that is what we discuss in scenario 1 and a decline in interest rates will raise bank profits that we have seen in scenario 2.

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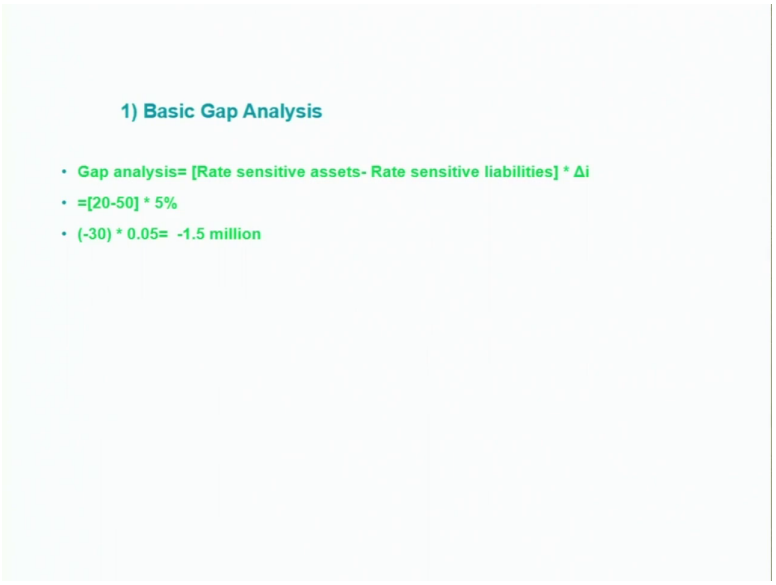

This idea we can translate into a formula called basic gap analysis. The gap that we mentioned here is based on the rate sensitive assets and the rate sensitive liabilities.

So, the gap analysis measures that the rate sensitive assets minus rate sensitive liabilities multiplied by change in rate of interest. So, you can see here that the gap is 20 minus 50, that is, minus 30 is the gap. So, the change in the rate of interest is 5 percentages, that is, 0.05.

By applying this one, you can see that if there is an increase in rate of interest, the bank net worth will be declined by 1 minus 1.5, because we have put the change in interest rate as 5 percent, that is, positive. So, similarly if you apply negative change; obviously, you will get plus 1.5 million, that is the change in the net worth of this bank.

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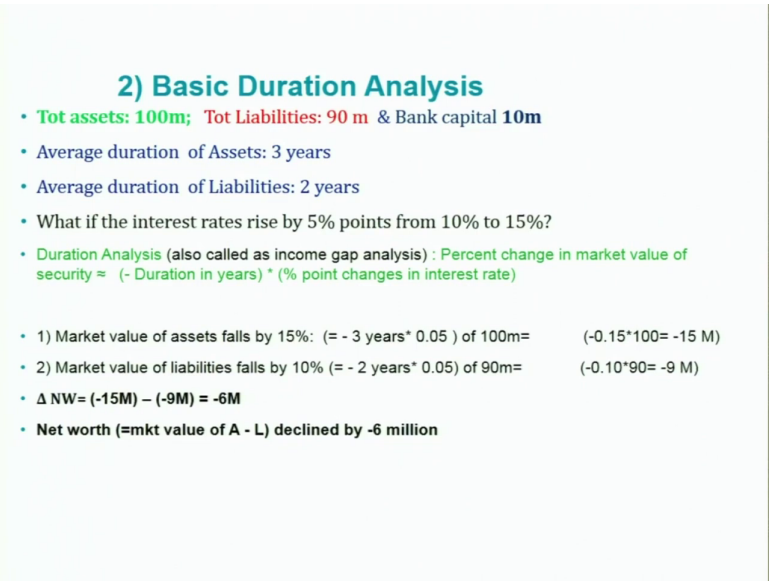

Here, in this balance sheet, we did not mention the duration of assets and liabilities, but you know that most of the assets and liabilities, by just looking at the banking principle, that is, banks borrow short and lends long. The duration of assets and liabilities vary considerably. So, lending means mostly the assets of the bank, and the liabilities of the bank is the borrowing and the deposit. So, we need to look into actually both the assets and liabilities.

The duration varies and the rate sensitivity also varies within assets based on the duration. So, we need to bring that one into our discussion. So, here we introduced another approach of calculating, that is incorporating the duration of assets and liabilities. So, we discuss here the

basic duration analysis. So, in this example, look at the balance sheet, the total assets we can see that it is 100 million.

Total liability is 90 million and bank capital is 10 million. So, from this we also say that the average duration of the assets is 3 years and average duration of liability is 2 years. So, in this case what if the interest rates rise by 5 percentage points from 10 percentages to 15 percentages?

It measures the percentage change in market value of securities by using this formula. That means, the inverse of duration in years times the percentage point changes interest rate. We calculate it separately for assets and separately for liabilities, then we apply this one, and then we will put in the gap analysis. But this is the duration, the starting point for that. So, look at this, here for example, the first part of the assets side.

So, from this, given all this basic information, what if interest rate rises from 10 percentages to 15 percentages? You can see from here that the market value of assets falls by 15 percentages, how come? Because the duration is 3 years. So, we take minus 3 years times the changes in the rate of interest. The percentage point changes in interest is 0.05 of 100 million. So, you can see that the market value of assets falls by minus 15 million.

And you can see the market value of liabilities falls by 10 percentages. You can get it that the average duration of the liabilities is 2 years. We take negative (inverse) that the minus 2 years times the percentage change in the rate of interest, that is 0.05 of 90 million, and you will be getting minus 9 million. So, from this what you can see the net worth of this bank has decreased.

Because, the decline in asset that is minus 15, that is, changes in the market value of assets is minus 15 and changes in the market value of liabilities is 9 million. So, when you take the gap of this duration, and you will be getting minus 6 million. So, from this example, you can see that the net worth of the bank, that is the market value of assets minus liabilities, declined by minus 6 million.

So, this is the basic duration analysis; however, there is a problem with this. The problem is that actually we are not taking the weighted part of this duration of these assets and liabilities. So, before we discuss that, let me also introduce you to how can we get the minus or the negative duration in years. Why are we putting minus duration in years?

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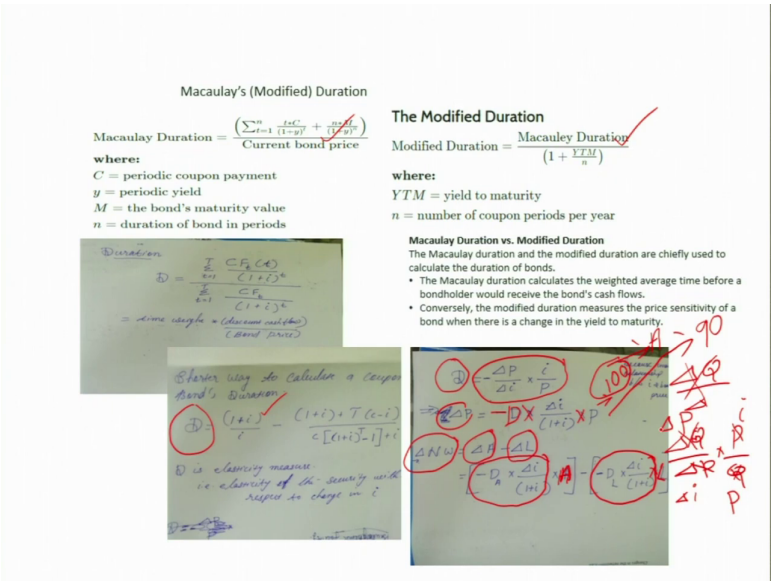

In order to answer, this formula was derived from Macaulay's duration analysis. So, what Macaulay's duration analysis say? This is the formula for that, this is widely being used in the financial calculation particularly in the bond market. I am just reproducing the content here: what is Macaulay formula duration. So, you can see that duration, that duration what we mentioned here, they calculate using this formula. It also has the Macaulay's modified duration.

This is the simple formula, initial formula, then the modified duration analysis also has been used. So, this has been widely used. What I am trying to say here is that why we are getting the inverse duration That is my main point.

And what here actually this D an elasticity measure. So, that is the elasticity of security with respect to change in i. So, when I say security, I mean assets or liabilities. So, simple formula here; this D is an elasticity measure and we can relate it with the elasticity of demand. for example, what if I use the exact formula of elasticity?

So, in this case assume that taking D as an elasticity measure. So, that the elasticity here is inverse because it is a negative elasticity, that is negative slope, and you can see here is that actually minus del P divided by del i the times i divided by P. So, applying that we get exactly the price elasticity of demand formula here. We replace it with putting delta P that is the delta Q, because elasticity price elasticity of demand is actually del Q divided by del price.

From this you can see that the duration is del P divided by del i times i divided by P. So, from this taking the del P on the left hand side, then you will get that minus D, that is the inverse duration times del i divided by 1 plus i times P. P here is assets, then suppose the value will be 100 from our example.

So, this is not the price, just remember that, this is the total assets. So, you can use this P also as liability. So, in our example, suppose here assets is P is equal to 100. So, if you take another security- the liabilities, in our example liabilities were 90 million. So, you can also use that value there. So, in our numerical illustration we will be using this formula.

This formula is mainly for one kind of securities, you can apply it, starting with assets and also you can repeat this calculation for liabilities as well. So, what is the net worth? Net worth is actually the changes in assets minus changes in liabilities. So, replicate this formula here, that is the first part. So, the P value we replace it with assets, that is 100 million in our example.

Similarly, here minus duration times del i divided by 1 plus i times l, l means in our example that 90 million in our illustrative example. So, this is how we derive this inverse duration value here.

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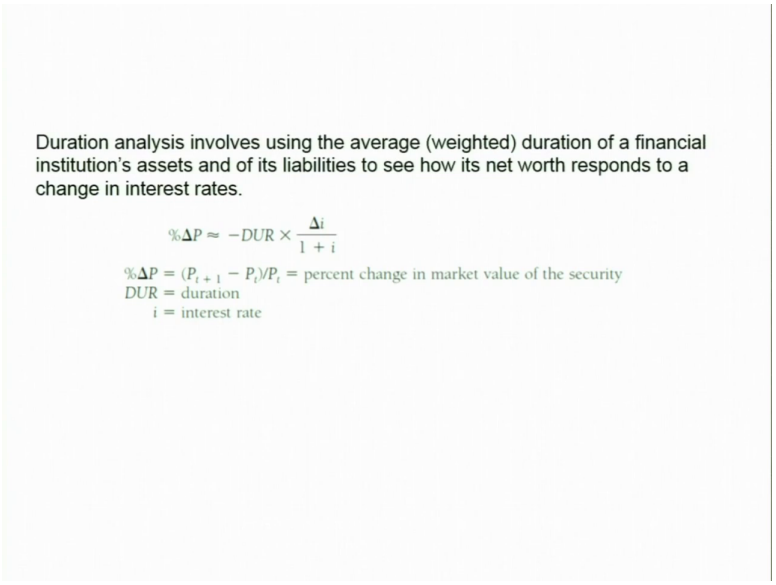

Let us now use some numerical values. One of the issue that we discussed in the previous slide is that we take the assets duration.

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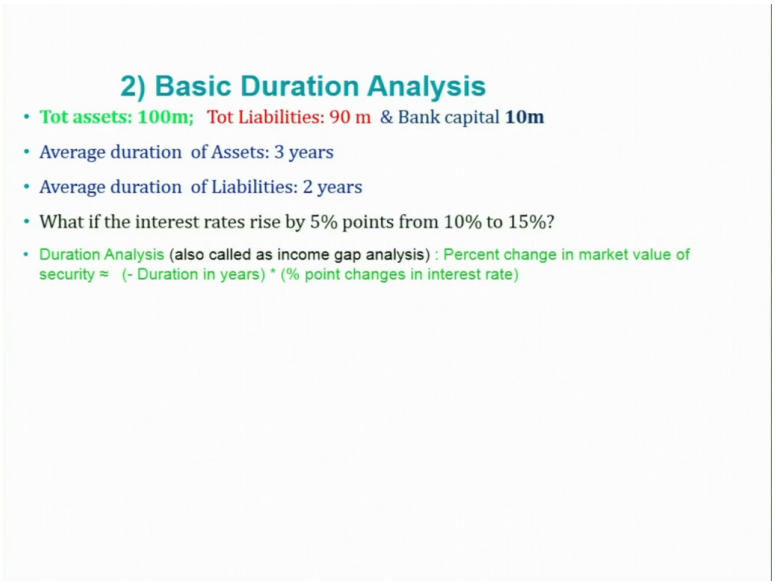

And liability's duration; we have taken without assigning any weight, we just assumed that the total duration of the assets is 3 years. And the total duration of liabilities is 2 years. But you know the bank's balance sheet has diverse items of assets with different durations and diverse items of liabilities with different durations. So, what we need to do that, we need to take the weight for each of the sub components of assets and liabilities, that is, we need to calculate a weighted duration of these assets and liabilities.

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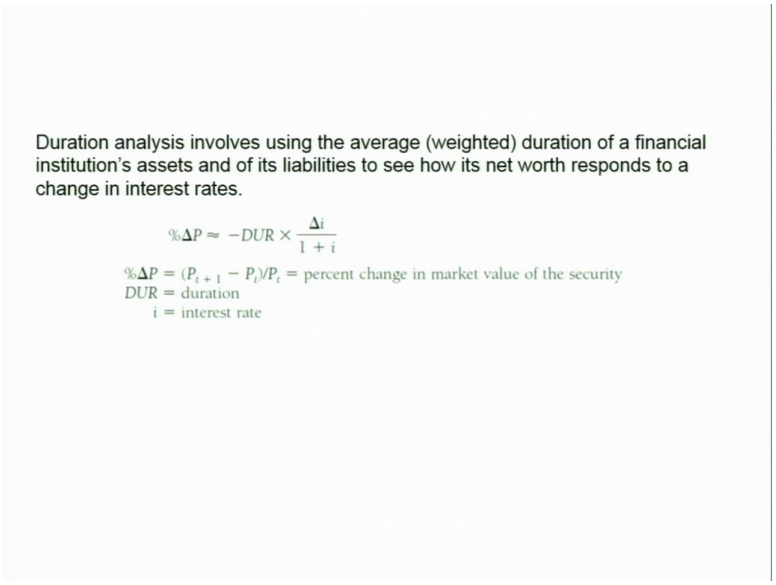

So, in this case what we need to do is that we need to calculate the weighted duration of each and every components or sub items in the assets and liabilities.

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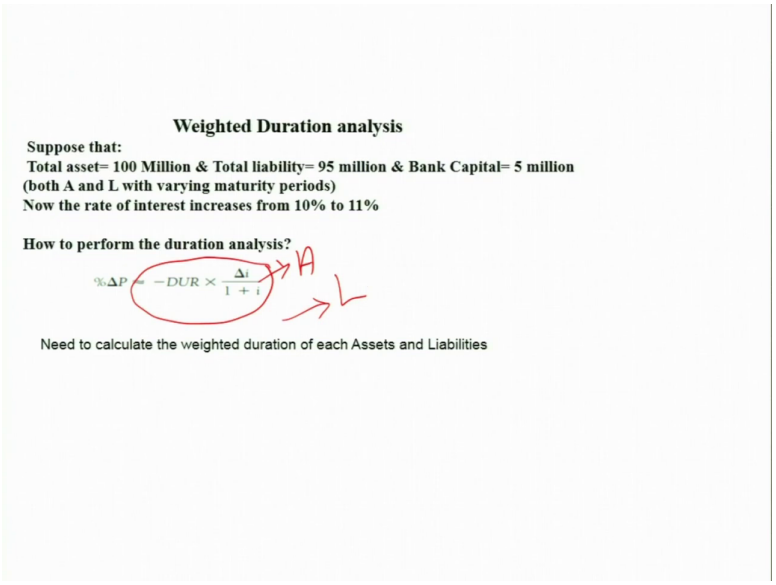

So, in this case we calculate a weighted duration analysis. So, in this look at here, the total asset, we are taking the same example. Here we assume that the total asset is 100 and total liabilities is 95 million and we take bank capital as 5 million, both assets and liabilities with varying maturity of periods.

Now the rate of interest increases from 10 percentages to 11 percentages in our example. So, in this case how to perform the duration analysis. Here we are going to use the same formula; first this is for the asset we calculate, and then also calculate separately for liabilities, then we take the difference. So, prior to that we need to calculate the weighted duration. How to calculate it?

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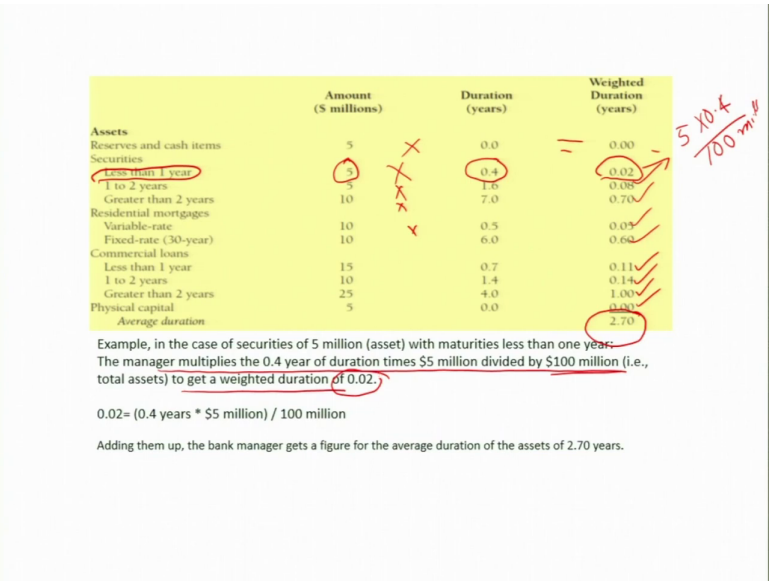

So, look at this bank's balance sheet. First we are presenting here the assets. So, in this assets, as I mentioned stated just before that, there are different components or different sub items. We need to take the duration. For example, reserves and cash items. It does not have any duration it is a 0 duration right.

The reserve is that they kept with the excess reserve with the central bank and the cash item is the cash with the bank itself. So, in this case you know that the weighted duration is actually, you are getting this times this, you are getting 0. So, take a case for example, securities of in the case of securities of 5 million with maturities less than 1 year, take this case.

How to calculate the weighted duration? So, here you know that the manager multiplies the duration because the duration is here 0.4 years, that is the duration for this. Then bank manager multiply that the total amount of less than, this asset that is less than 1 year, 5 times 0.4 then you are getting 0.02.

So, this is one item. So, similarly perform this exercise for each and every component. That means, multiply this with this, and this with this, then what you are getting? Then you will be getting, when you sum it up, a weighted duration, you will be getting 2.70 that is the weighted duration for the entire assets. So, similarly repeat this exercise for liabilities as well.

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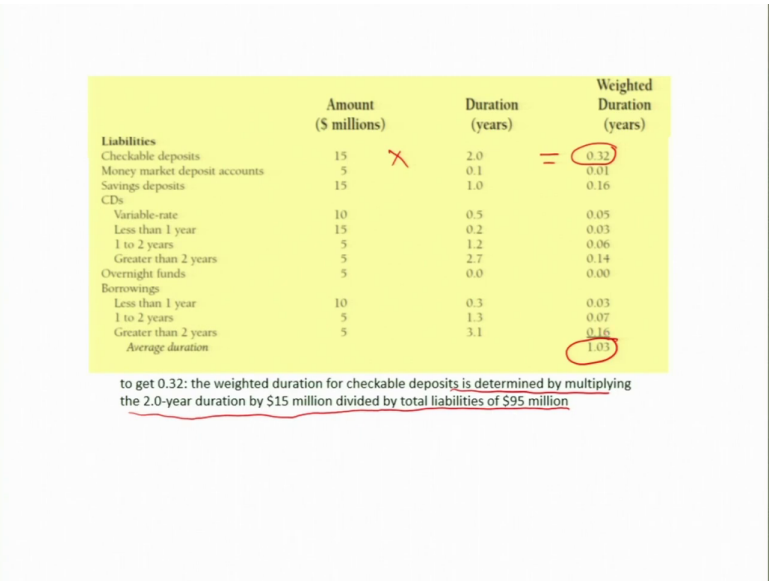

	Amount ($ millions)	Duration (years)	Weighted Duration (years)
Liabilities			
Checkable deposits	15	2.0	0.32
Money market deposit accounts	5	0.1	0.01
Savings deposits	15	1.0	0.16
CDs			
Variable-rate	10	0.5	0.05
Less than 1 year	15	0.2	0.03
1 to 2 years	5	1.2	0.06
Greater than 2 years	5	2.7	0.14
Overnight funds	5	0.0	0.00
Borrowings			
Less than 1 year	10	0.3	0.03
1 to 2 years	5	1.3	0.07
Greater than 2 years	5	3.1	0.16
Average duration			1.03

to get 0.32: the weighted duration for checkable deposits is determined by multiplying the 2.0-year duration by $15 million divided by total liabilities of $95 million

Multiply this one, for example, one then you will be getting 0.032, that is for checkable deposits, just to go back here. So, here the we got that; 0.4 year duration times 0.5 million. Then you also need to divided it with a 100 million, that I forgot to mention, to get a weighted duration of 0.02. sorry I am forgot to mention that.

So, this you need to multiply for example, this you will get by multiplying this one with 0.4, then dividing this one with the total assets, that is, the 100 million. So, then you will be getting 0.02. So, similarly you need to do separately for each and every items, and then repeat this exercise for each of the liabilities component as well. So, just to say here that to get 0.32 the weighted duration for checkable deposits is determined by multiplying by the 2-year duration by 15 million divided by total liabilities of 95 million. So, finally, you will be getting 1.03 as the weighted duration of the liabilities.

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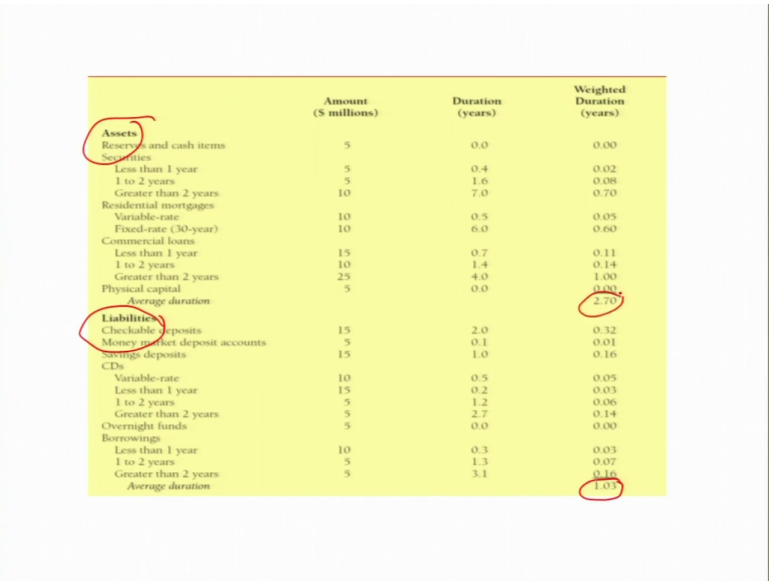

	Amount ($ millions)	Duration (years)	Weighted Duration (years)
Assets			
Reserves and cash items	5	0.0	0.00
Securities			
Less than 1 year	5	0.4	0.02
1 to 2 years	5	1.6	0.08
Greater than 2 years	10	7.0	0.70
Residential mortgages			
Variable-rate	10	0.5	0.05
Fixed-rate (30-year)	10	6.0	0.60
Commercial loans			
Less than 1 year	15	0.7	0.11
1 to 2 years	10	1.4	0.14
Greater than 2 years	25	4.0	1.00
Physical capital	5	0.0	0.00
Average duration			2.70
Liabilities			
Checkable deposits	15	2.0	0.32
Money market deposit accounts	5	0.1	0.01
Savings deposits	15	1.0	0.16
CDs			
Variable-rate	10	0.5	0.05
Less than 1 year	15	0.2	0.03
1 to 2 years	5	1.2	0.06
Greater than 2 years	5	2.7	0.14
Overnight funds	5	0.0	0.00
Borrowings			
Less than 1 year	10	0.3	0.03
1 to 2 years	5	1.3	0.07
Greater than 2 years	5	3.1	0.16
Average duration			1.03

So, you can see this is the total balance sheet of this bank. I am just presenting everything in one slide and then you got, this is the weighted duration of the liabilities and this is the weighted duration of assets and plugging this value in the formula.

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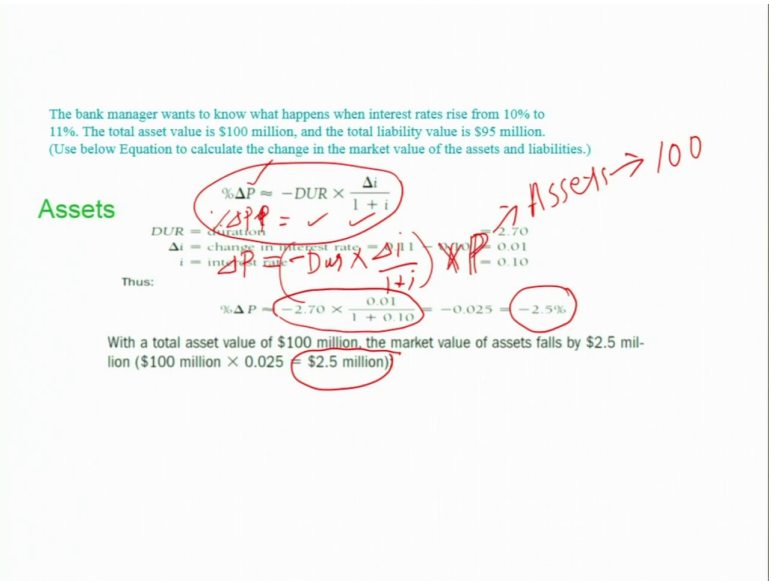

What we are doing here that, suppose the bank manager wants to know what happens when the interest rates rise from 10 percentages to 11 percentages. So, taking total value of assets value is 100 million applying this formula. So, here you can see that percentage change in the

value of this security, P means for here we mean assets. The price value of this assets, and you apply this then you will get the percentage points.

This is the percentage point, then you get exactly this formula, then when you want to get only the change in the value in absolute terms, that is, not in the percentage, then you need to get the minus duration times i divided by 1 plus i all multiplied by what is the total assets total asset.

So, suppose in this case, the total asset value is 100 million. So, the market value of assets falls by 2 point, sorry I forgot to mention this example here. So, in this example the duration percentage change in the del i and i, everything is given here. So, if you plug this value here, that is, the apply this one, you will get the percentage change in the asset as 2.5 percentage.

And when you multiply this with P, that the asset, that is 100; this one is 100, then you will be getting this 2.5 million, it is the change in the duration of this asset.

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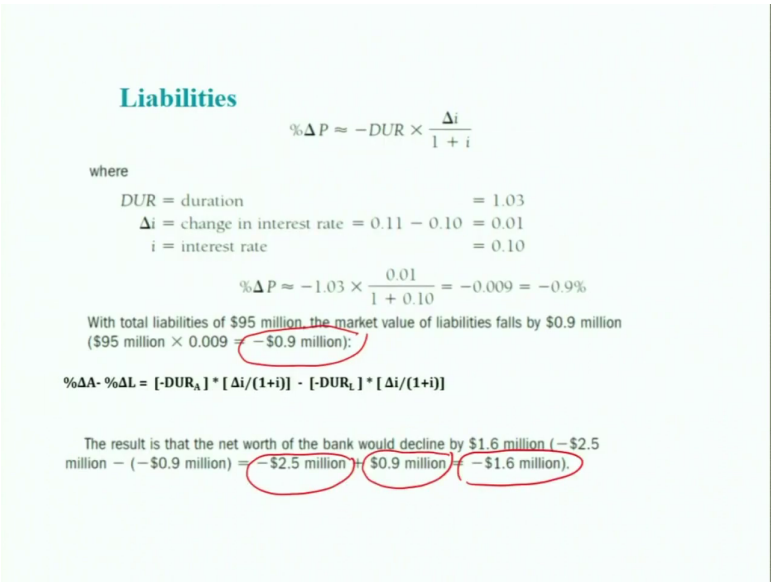

And similarly for liabilities also we can calculate. So, you can see here that the liabilities of the bank changes by this much. So, what you need to do now? So, we need to calculate, we can directly calculate the percentage change in assets minus liabilities when you apply this formula. Then, finally, you will be getting this value.

So, you can see that the changes in the absolute value of assets is 2.5 million, and this one is 0.09 million. So, finally, you can see from this exercise that the net worth of this bank, using

the weighted duration analysis, it declines by minus 1.6 million. So, this is the way you calculate the weighted duration analysis. Simply, you can calculate what is the change in the net worth of the bank due to the changes in the rate of interest.

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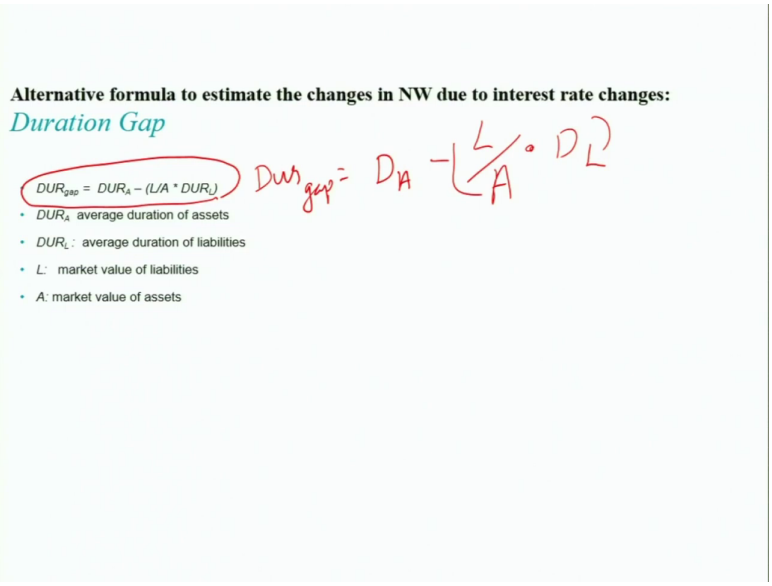

We can also do the same calculation using an alternative formula. I have seen, in many finance classes, they use this formula. Here the intuition is same. We slightly tweak it using some other formula. Here, first we calculate the duration gap using this way, that the duration of the assets and then divide total liability divided by total assets times the duration.

The duration gap is equal to duration of the assets minus L divided by assets times duration of liabilities. So, you can also apply the same formula, this formula, to calculate the estimate that we got. Here, we got minus 1.6 million, that is the decline in the total net worth of the bank.

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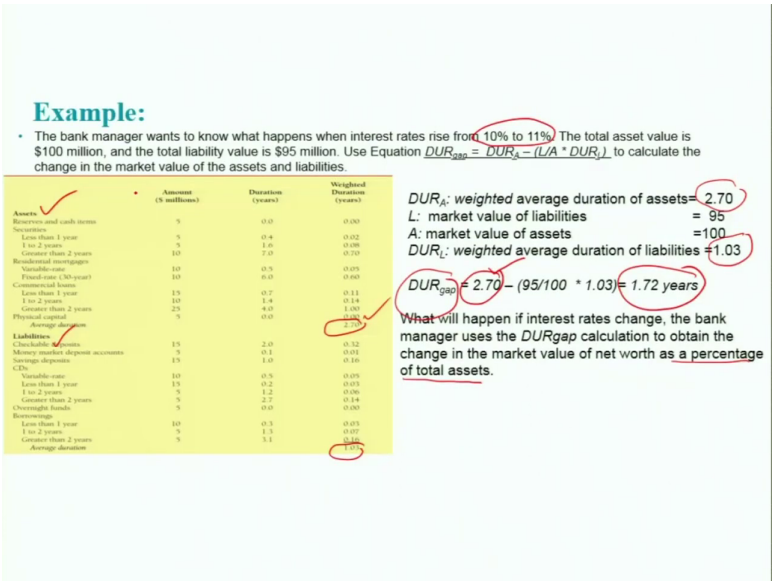

Suppose, what if we use this formula, and the bank manager wants to know what happens when the interest rate rises from 10 percentages to 11 percentages. The total asset value is 100 million, the total liability value is 95 million. So, use this equation to calculate the change in the market value of the assets and liabilities.

So, in this case, I am reproducing the same balance sheet. What we got from the previous estimate of weighted duration analysis, this is what we got. What when we apply this formula, what we are going to get this. So, look at this formula here you can see that the weighted average duration of the assets 2.7, the way we calculate.

We take the same weighted average duration of the liabilities, we get 1.03 and then you will get duration gap, then applying this one in this formula that the duration of the assets is this one, and then the liabilities divided by assets you will be getting 95 divided by 100 times the duration of the liabilities, then you will be getting 1.03.

So, finally, then you calculate from this, minus this, you will be getting 1.72 years as the duration gap, and the duration gap this one, what we need to do now to get the changes in the net worth, we need to multiply this one with the assets of the bank. So, what will happen if interest rates change? The bank manager uses duration gap calculation to obtain the change in the market value of net worth as a percentage. it is very important point here: percentage of total assets.

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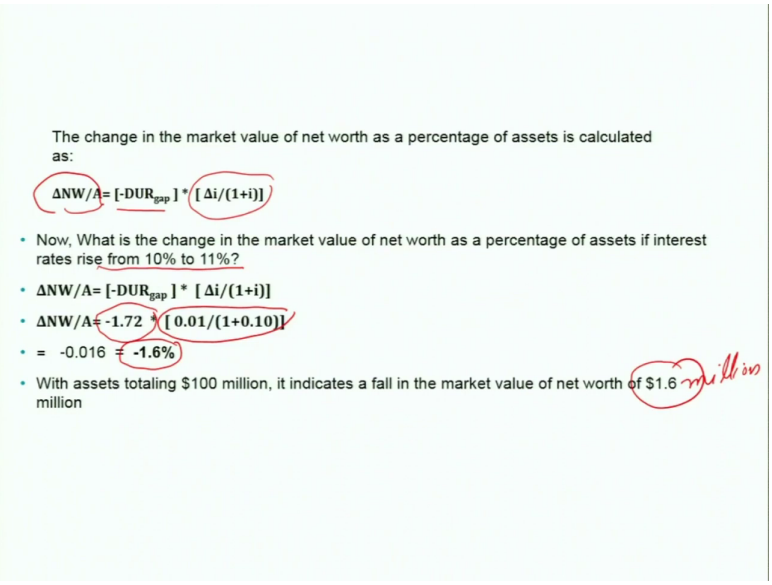

So, plugging this one, applying the same calculation here, we are going to get the following result. The change in the market value of net worth as a percentage of assets is calculated as using this one. This one, we calculate in this way. So, the minus duration gap, we already know, this value in the previous example, that is 1.72 years times del i divided by 1 plus i.

Now, what is the change in the market value of net worth as a percentage of assets if interest rate rise from 10 percentages to 11 percentages? So, you will be getting, like this that, the duration gap that we calculated from the previous formula, formula used in the previous slide is 1.72 and multiplied by this, then you will be getting minus 1.6 percentage.

So, from this you can see that with assets totaling dollar 100 million, it indicates a fall in the market value of net worth of 1.6 million. So, this value we also got from our previous estimates, that is, from the weighted duration analysis.

In this session, we have reviewed various methods of measuring the interest rate risk. we started with the basic gap analysis, then we discussed basic duration analysis and subsequently, we brought the duration of assets and liabilities each and every component of assets and liabilities. And, in order to incorporate that, we used weighted duration analysis, and then there we introduced a formula derived from Macaulay's and we also discussed the alternative formula to derive the same measure.

Thank you.

Key words: interest rate risk, basic gap, duration gap analysis, weighted duration analysis, net worth, assets, liabilities.