

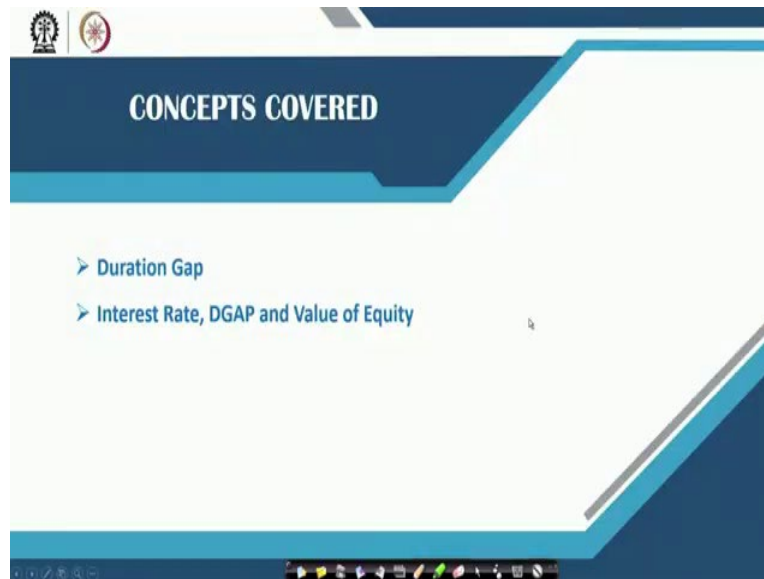
Management of Commercial Banking
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Lecture 24
Duration Gap Analysis 1

So, in the previous class we discussed about the earnings sensitivity analysis and as well as dollar gap analysis and in these two particular case what we have observed, the basic objective of the commercial bank is to manage the interest rate risk to maximize the interest income. But what we have seen that whenever we are talking about the limitations of the dollar gap, the major limitation is the dollar gap analysis or the earnings sensitivity analysis, do not consider the or do not take into account the shareholders value maximization.

That means we are not talking about the net equity values or the net worth of the banks how it is going to be affected. We have mostly concentrated on that how this change in interest rate is going to affect the interest income and those particular income how we can maximize by the adjustment of the asset and liabilities that was our basic objective whenever we are talking about the dollar gap or the earnings sensitivity analysis.

But in the true sense the another objective of the commercial bank is also to maximize the shareholders value or in general sense we can call it the net worth of the commercial bank should be maximized. Whenever the net worth concept comes the dollar gap analysis or the earnings sensitivity analysis whatever we have discussed that basically has not trying to analyze the significance of the valuation of the shareholder or the equity valuation of the particular stock or particular banks stocks which basically is very much required for maximizing the shareholders value. In this context we have another concept we use that is called the duration gap analysis.

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So, in today's discussion we will be covering up, what do you mean by the duration gap and how the interest rate, duration gap and value of equity are linked. So, if we know the duration gap, so if there is a change in interest rate then how it is going to affect the value of equity? So, if the value of equity gets affected then what kind of strategy we have to adopt to minimize that particular risk or to increase the value of equity in that particular bank. So, this is today's topic or today's discussion what we are going to make.

(Refer Slide Time: 02:59)

The slide is titled 'Duration Gap Analysis' in blue text. It contains three bullet points: 'Duration is defined as the weighted average time to receive all cash flows from a financial instrument', 'Duration of a portfolio is defined as the weighted average of each of the asset's duration with the weights being the proportion of investment funds allotted to each asset (w_i)', and 'Duration gap is the difference between the duration of a bank's assets and liabilities'. Below the second bullet point, the formula $D_p = \sum w_i D_i$ is displayed. The slide has a light blue background with decorative icons of gears, a tree, and a molecular structure. At the bottom, there is a footer with the NPTEL logo and the text 'NPTEL Online Certification Course' and 'TIT Thiruvananthapuram'.

So, let us discuss first, what do you mean by the duration gap? The duration concept already we know in the fixed income security part we have discussed this, the duration is nothing but a weighted time average to receive the all cash flows from the financial instrument. So here what we have done that, we have the series of the cash flows which are available.

And in the series of the cash flows we are trying to basically find out the present value of that, then finally we get the market price on the basis of the maturity. Then we get the weights with respect to the present value and as well as the market value. Then that particular ratio can be multiplied with time to find out the weighted average of that particular or this weighted value of that particular time.

Finally we take the summation of that of all those periods whatever data we use then finally we can calculate the durations. That already all of you know depending upon the maturity we can find out the duration and duration and maturity are positively related if the maturity period is more, then obviously their duration also will be more. But if you talk about the duration of a portfolio? Duration of the portfolio is nothing but it is a weighted average of each of the asset duration, with the weights being the proportion of investments of the funds allotted to each asset.

So if you know the duration of each asset then how much money is basically spend or invested in that particular asset? So on that basis we can give the weights, we can assign the weights and finally the weighted average of all those durations of all those assets if you calculate then the duration of the portfolio can be consider, can be calculated. And whenever you talk about the duration gap of a commercial bank, the duration gap of a commercial bank is nothing but, it is the difference between banks assets and liabilities.

Basically duration of the bank's assets and duration of the bank's liabilities. So if you can calculate the duration of bank's assets and duration of bank's liabilities then your, what we can say that the banks duration gap can be calculated.

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Duration Gap Analysis Cont....

- It is a measure of interest rate sensitivity that helps to explain how changes in interest rate affect the market value of a bank's assets and liabilities, and also the net worth (NW)

$NW = A - L$

NW = Net Worth
A = Assets
L = Liabilities

$\Delta NW = \Delta A - \Delta L$

Δ = change in value

- Duration Gap (DGAP) = $D_A - W D_L$
- D_A = Average duration of assets
- D_L = Average duration of liabilities
- W = Ratio of (TL/TA)

Assets - available + eq
Owners' equity
Networth

$\frac{TL}{TA}$

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So if you see that in general case then how it is basically calculated? This duration gap is basically is a measure of interest rate sensitivity that helps to explain how the changes in interest rate affect the market value of the bank's assets and liabilities and as well as the net worth. So the net worth is nothing but already we know that, the net worth of the bank of any organization is nothing but the assets minus the liabilities which is nothing but the owner's equity.

So whenever you talk about the assets minus, total assets minus total liabilities, the owners' equity is nothing but the net worth that basically already we know. So in this case if you go by this your NW, which is consider as the net worth, net worth is equal to assets, total assets minus total liabilities. Though, if you want to calculate the change in net worth, then obviously it is nothing but the change in assets minus change in the liabilities.

Your delta represents the change in value. Your change in the net worth is nothing but the change in the value of the assets minus the change in the value of the liabilities. So that basically already we know. And what is the duration gap in this case? Duration gap is calculated in this way, if you can calculate your duration of the assets, this is duration of assets minus some weight into W into DL.

And what is this W? W is basically is nothing but your total liabilities divided by the total assets, this is the weight. And why there is a difference between total liabilities and total assets? That is

the difference is nothing but the equity, how much equity the particular bank is holding that basically is the difference between the total liabilities and total assets of the commercial bank. So accordingly if you know your DA here if you see your duration gap is equal to DA minus W, DL and your W is nothing but I said that it is DL by TA.

TL represents the total liabilities, TA represents total assets and DA is equal to the average duration of the asset and DL is equal to the average duration of the liabilities. Then from there we can find out the once we get the duration of total assets and duration of the total liabilities, then we can find out the dollar gap because total assets and total liabilities data we have. If you see in this case, how basically this works?

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Example: Duration of Asset and Liability

Asset	Value (Rs. Million)	Duration (Years)	Liabilities	Value (Rs. Million)	Duration (Years)
Cash	100	0.00	Certificate of deposits	400	1.00
Business loan	400	2.00	Fixed deposits	400	6.00
Other loan	500	6.00			
Total Assets	1000		Total liabilities	800	
			Equity	200	
			Total	1000	

Duration of assets = $0.1 \times 0.00 + 0.4 \times 2 + 0.5 \times 6 = 3.8$ years
 Duration of liabilities = $0.5 \times 1 + 0.5 \times 6 = 3.5$ years
 DGAP = $3.8 - 0.8 \times 3.5 = 1$ yr

$DA - W \cdot DL$
 $W = \frac{TL}{TA} = \frac{800}{1000}$

If you see this example, it is a simplistic example whatever we have taken. Let this is a balance sheet of a commercial bank, all the items are not considered. Already you know that in the assets side we have many way of investments, we have loans, we have fixed assets and other kinds of things. We have not considered those, here we have taken a very simple example.

Let in the asset side we have consider cash, we have consider business loan and also we have consider the other loans. We have taken loan as the major assets of this particular bank. So in the liability side we have taken this certificate of deposits one of the instruments and we have the fixed

deposits. And in third column if you see that we have reported the duration of this particular different type of instruments on the basis of the maturity.

All of you know that the cash has no kind of maturity period that is why the duration is 0, then if you talk about the business loan. Let depending upon the maturity period of the loan your duration varies. Let for the business loan is relatively short term in nature, we have consider here. So that is why we assume that the duration is led to 2 years. For other loans like the house loans and other loans which are relatively long term in nature, then here we have taken the average duration is 6, whatever assets they have the average duration is 6.

So for certificate of deposits the maturity period we have consider very less relatively short term maturity period that is why the duration we have consider 1 year and for the fixed deposits which relatively long term in period we have consider that the duration is the 6 years. So in this case what basically we have seen that your total assets become 1000, $500+400+100$. Your total liabilities become 800, $400+400$ and the company or asset is particular bank has an equity of 200, then the total become 100.

Because the liabilities also we can say that equity also liability but it is not rate sensitive or there is no such kind of maturity period for that; that we have basically separated it from the other type of liabilities whatever we have. So that is why we have 1000, here also 1000 because that should be matched. Then already we know that we have to find out the duration of that particular all the assets and we have to find out the duration of all the liabilities.

Already duration of the individual assets are given, then how the weights should be given? The weight should be given on the basis of the proportion of that particular value of that particular asset which is existing in that particular system. Now your cash is 100 then obviously what is the proportion? The proportion is $100/1000$, then obviously it will be 10 percent, 0.1. Then we have the business loan, which is 400 then it will be 0.4 which is nothing but the $400/1000$ and for other loans it is 500, then $500/1000$ that is 0.5.

And now what we do? We know the duration of individual asset, so 10 percent or 0.1×0 anyway that will become 0 only plus 0.4×2 , 2 is the duration of the business loan plus 0.5×6 it is a 3.8 years. If you add up it will coming, your weighted average become 3.8 years. In the same way we

are calculating the liability side. In the liability side for the certificate of deposits we have 400 and duration is 1, for fixed deposit 400 duration is 6 then total liability is terms of certificate of deposits and the fixed deposits it is 800.

Then obviously your, this is effectively 50 percent, 50 percent because we have not consider the equity. So this particular proportion has to be made on the basis of the liabilities with respect to this other instruments not equity is the part of that. So because of that our proportion is $400/800$ that is 0.5. Then your duration of the liabilities has become 3.5 years, 0.5×1 , 0.5×6 that become 3.5 years.

So, now your duration of asset become 3.8, your duration of liability become 3.5. So, if you want to calculate the duration gap form this already we know that duration gap is what? Duration gap is your $DA - W \times DL$. We are talking about, your W is equal to total liabilities upon total assets, and here liabilities means, it is a part from equity. So here if your liability become $800 / 1000$, so obviously it is 0.8.

So our duration of assets was 3.8, $3.8 - 0.8 \times 3.5$, which is the duration of liabilities that has become 1 year. So the duration gap for this particular bank, considering this balance sheet has become 1 year. So, now this particular duration gap is going to be used? That is basically our focus.

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Application of Duration Gap

- How will the value of assets and liabilities and value of network change as interest rate change?
- The effect of changing interest rates on the net worth is related to the duration gap

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So once you got the duration gap then what we have find out from this? There are 2 things we are trying to find out. How will the value of assets and liabilities and value of net worth change as interest rate changes? Because here your mostly concentrating on the value of the equity.

So, the value of the equity is nothing but net worth that already we know. So you read it net worth, it is 'the effect of changing interest rate on the net worth is related to the duration gap. And how the duration gap is related to the net worth that basically we have to see? So in this context, how basically this mechanism works, that is basically our objective.

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Interest Rate, DGAP and Value of Equity

- We know $\Delta NW = \Delta A - \Delta L$
- $\Delta NW = [-D_A * (\Delta/(1+i)) * A] - [-D_L * (\Delta/(1+i)) * L]$
 As $\Delta A/A$ is approximately equal to the product of asset duration times the change in interest rates $[-D_A * (\Delta/(1+i))]$ & $\Delta L/L$ is approximately equal to the liabilities duration times the change in interest rates $[-D_L * (\Delta/(1+i))]$
- In other words: Change in value of net worth = $[-$ average duration of assets * $[\text{change in interest rate}/(1 + \text{original discount rate})]$ * total assets] $-$ $[-$ average duration of liabilities * $[\text{change in interest rate}/(1 + \text{original discount rate})]$ * total liabilities]

So, that interest rate, duration gap, and the value of equity, if you want to establish a relationship between these 3, then we already know that change in the net worth is equal to your change in the assets minus the change in the liabilities. Your $\Delta A - \Delta L$, that already you know. ΔA represents the change in the total assets, value of the total assets and ΔL represent the change in the total liabilities that is your delta NW. So, here the delta NW if you want to relate it with respect to the duration then this is the way basically this works.

Now, how this works? Your ΔNW is equal to $-D_A$, D_A means duration of the assets into your ΔI , ΔI means change in interest rate $+1 + I$, the $1 + I$ is basically what? The I means it is the original interest rate or the original discount rate which was there before into A , the total assets, then minus

duration of the liabilities into same your ΔI divided by $1 + I$, I is the original discount rate or original interest rate into L .

So, this is basically the difference and why we are talking about this, your $-DA \times \Delta I / 1 + I$? Because already you know the duration is nothing but it is the change in the value of this particular asset with respect to that particular change in the interest rate that already we know. So, here we are aggregating that particular thing, so your $\Delta A/A$ which is basically change in the assets to the total assets is nothing but the product of the asset duration times the change in the interest rate.

The logic is basically brought from the definitions of the durations. So the durations basically nothing but your $\Delta P/P$ is whenever we are talking about try to find out the first order derivative of this particular price then we get this duration from this. So, using that concept already we know that, that $\Delta A/A$ is nothing but $-DA \times \Delta I / 1 + I$ and here you are A , if you are trying to find out the ΔA which is nothing but multiplied by A .

So like that your $\Delta L/L$ is equal to $-DL \times \Delta I / 1 + I$, then now if you are multiplying delta, you are finding the ΔL then that basically has to be multiplied with L there, divided by into $1/L$ means it is into L . So, because of that the net worth of the particular bank is linked to the duration of the assets and liabilities through this way on the basis of the concept of the duration that relationship has been established.

So, already I have explained this things, the change in the value of the net worth = [average duration of assets \times [change in the interest rate / (1 + original discount rate)] \times total assets] - [the average duration of liabilities \times [change in the interest rate / (1 + original discount rate)] \times total liabilities], that already what we have written here and we have explain it here.

Through that we are trying to establish the relationship between the change in the interest rate which is your ΔI , your interest rate in today's period that is I , then your duration of the assets and the duration of liabilities and the net worth. So, this is the way the particular relationship has been linked or the duration and the value of the net worth are basically linked.

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Interest Rate, DGAP and Value of Equity Cont...

In other way it can be calculated as follows:

$$\Delta NW/TA \approx -DGAP \cdot \Delta_i / (1+i)$$

$$\Delta NW \approx [-DGAP \cdot \Delta_i / (1+i)] \cdot TA$$

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$$\frac{\Delta NW}{TA} = -DGAP \cdot \frac{\Delta_i}{(1+i)}$$

$$\Delta NW = -DGAP \cdot \frac{\Delta_i}{(1+i)} \times TA$$

Interest Rate, DGAP and Value of Equity

- We know $\Delta NW = \Delta A - \Delta L$
- $\Delta NW = [-D_A \cdot (\Delta_i / (1+i)) \cdot A] - [-D_L \cdot (\Delta_i / (1+i)) \cdot L]$

As $\Delta A/A$ is approximately equal to the product of asset duration times the change in interest rates $[-D_A \cdot (\Delta_i / (1+i))]$ & $\Delta L/L$ is approximately equal to the liabilities duration times the change in interest rates $[-D_L \cdot (\Delta_i / (1+i))]$
- In other words: Change in value of net worth = [- average duration of assets * [change in interest rate/(1+ original discount rate)] * total assets] - [- average duration of liabilities * [change in interest rate/(1+ original discount rate)] * total liabilities]

Other way, the other formula for this same thing you can calculate also. The ΔNW which is the change in the net worth divided by the total assets is nothing but the duration gap minus the duration gap into delta I by 1 plus I. Then obviously your $\Delta NW = -\text{your duration gap} \times \Delta I / 1 + I \times TA$, which TA means total assets. So, either you can directly go from here you can, previous case what we have seen that is basically talks about the relationship between the durations of liabilities, duration of assets and as well as the interest rate and equity.

From there we can also directly find out your change in the $\Delta NW/TA = -\text{the duration gap} \times \Delta I / 1 + I$. So here what we are trying to see or if you directly you are trying to find out your delta NW, your delta NW is equal to minus the duration gap into delta I by 1 plus I multiplied by TA.

So, either you can directly use that one where the duration of assets and duration of liabilities is everything will be used or you can also go by this way if you know the duration gap then you can find out how the net worth is going to be changed, if there is a change in interest rate.

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Example Cont..

Continuation with the previous example: Assume there is a 1% change in interest rate and original discount rate is 11%.

$$\begin{aligned} \Delta NW &= (-3.8 * (0.01 / 1.11) * 1000) - (-3.5 * (0.01 / 1.11) * 800) \\ &= (-3.8 * 0.009 * 1000) - (-3.5 * 0.009 * 800) \\ &= (-3.8 * 9) - (-3.5 * 7.2) \\ &= -34.2 - (-25.2) \\ &= -34.2 + 25.2 = 9 \end{aligned}$$

Using the other formula we get:
 $-1 * 0.009 * 1000 = 9$

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Using the same formula if you are continuation with the previous example of the balance sheet whatever we have taken. Let assume that there is a 1 percent change in the interest rate and the original discount rate of the interest rate was 11 percent. So if you are going by the longer formula then you can find $\Delta NW = -3.8$, minus 3.8 is the DA, 1 percent is the change in interest rate, $1 + I$, I means it is 11 percent which is the original discount rate, here into A.

A means the total assets that is the 1000 - of duration of liabilities that is 3.5 in our example, same thing ΔI is equal to 1 percent, $1 + I$ is equal to 1.11 and your liabilities we have consider it 800 apart from the equity. So, then what we get that it is -3.8×0.009 that is $0.01 / 1.11 \times 1000$ minus this, then finally what we got it, that is 9. Your net worth will change by 9 million rupees. If your interest rate will changed by 1 percent.

If it will increase or decrease depending upon that your net worth will also increase and decrease. So already we know that your duration gap from this particular example was 1, so directly we can use it minus 1, -the duration gap $\times \Delta I / 1 + I$ that is your $0.009 \times$ your total assets that is basically

giving you the 9. So both the cases you can get the same answer because that is derived from there only.

So you have to remember this one which will be major way we can use it that minus of the duration gap multiplied by the $\Delta I / 1 + I$ that will change in interest rate divided by 1 plus discount rate multiplied by the total assets, that will give you the how the change in the net worth is going to happen or ΔNW .

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The slide is titled "Observations" and features a background with various icons including gears, a lightbulb, a smartphone, a magnifying glass, a network diagram, and a chemical structure. The text on the slide is as follows:

- If interest rate will increase, the value of net worth will decline
- For rising interest rates, the value of assets would drop more than the value of liabilities and thus value of net worth drops
- For falling interest rates, the value of the assets would rise more than the value of liabilities and the value of net worth would increase

In the bottom right corner, there is a small video inset showing a man with a beard wearing a red shirt. At the bottom of the slide, there is a footer with the NPTEL logo and the text "NPTEL Online Certification Courses".

Now, we can see that what kind of observations we can draw from this, if interest rate will increase the value of the net worth will decline. So when the interest rate is going to increase, the value of the asset would drop more than the value of the liabilities, so the value of the net worth drops. So whenever the interest rate basically increases the impact of that particular interest rate on the value of the assets and the impact of that particular interest change and the liabilities are not same, these are different.

So for the rising interest rate the value of the assets should drop more than the value of liabilities than the value of thus the value of the net worth drops. But whenever there is a change in fall in the interest rate the value of the assets should rise more than the value of liabilities and the value of the net worth should increase. So, whenever there is a decline in the interest rate the value of

the net worth increases and whenever there is a decline, increase in the interest rate the value of the net worth declines this is the implications what basically observations we can draw from here.

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Defensive and Aggressive Duration Gap Management

Duration Gap	Change in Interest Rate	Change in Net Worth
Positive	Increase	Decrease
Positive	Decrease	Increase
Negative	Increase	Increase
Negative	Decrease	Decrease
Zero	Increase	No change
Zero	Decrease	No change

Anticipation of interest rate movement is a part of aggressive strategy

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So, here in this case also, like your dollar gap analysis we can have also defensive and aggressive duration gap management we can do. Whenever we can go for a defensive gap management, duration gap management, here in this case what we are trying to do, we are trying to make our, or keep our value of equity intact or same. So, whenever we are talking about this what basically we are trying to do? We are trying to make your duration gap 0.

So, in this context, if you can make a duration gap 0 then what happens that any change in the interest rate is not going to affect the change in the net worth, that basically we can, already we have seen also whenever we have discussed about the dollar gap. But if you are going for an aggressive strategy, here in the aggressive strategy what we are trying to do, first of all in the aggressive strategy we have to anticipate the interest rate movements, how the interest rate is going to move?

So our objective is if the interest rate is going to increase then obviously our net worth is going to decline. If the interest rate is going to decline then our net worth is going to increase that also depends upon the duration gap. So depending upon the positions of the duration gap and as well as the predictions of the interest rate we have to make some kind of adjustments with respect to

the structure of the balance sheet, so that is the basic objective. So, for example, if the duration gap is positive, the interest rate is going to increase, the net worth is going to decline.

Duration gap is positive, interest rate is going to decrease, the net worth will increase that already we have seen. But the duration gap is negative but interest rate is increasing then your change in net worth also is increasing. And if duration gap is negative and change in the interest rate is declining then net worth is declining, it is just reverse to the observations what we got it from the dollar gap, where we are trying to establish the relationship between the dollar gap and the net interest income.

And another one is 00, whether the increase or decrease that does not matter, that means perfectly the interest rate raise case is nullified due to the composition of the assets and liabilities and that strategy sometimes we call it the immunization strategy in the market, whenever there is any fluctuations anyway that particular fluctuations in the interest rate is not going to affect the value of the net worth as the value of the equity of this particular bank.

So, first of all already what we have seen that whether go for if you are going for a defensive strategy also we have to make a lot of adjustment with respect to the balance sheet, to make a duration gap equal to 0, if you are going for aggressive strategy also it is more complex in nature because first of all we have to predict the interest rate and once the interest rate is predicted or can be anticipated then accordingly depending upon the market conditions interest rate scenario, our duration gap has to be maintained accordingly.

That means if the interest rate is going to increase we have to make our dollar gap negative, if the interest rate is going to decrease, then we have to make the duration gap positive. So that basically we have to keep in the mind and how the duration gap can be made positive or negative, that already we know that we can reduce or we can increase the maturity period of the different type of assets and liabilities what the commercial banks are holding.

So, these are your strategy what we will, what basically we follow whenever the duration gap and net worth relationship is established to minimize the interest rate risk in the market or if there is a change in the interest rate how we can basically immunize our self, to our self for the fluctuations with respect to the fluctuations of the total net worth of the banks.

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CONCLUSION

- Duration gap is a measure of interest rate sensitivity that helps to explain how changes in interest rate affect the market value of a bank's assets and liabilities, and also the net worth (NW)
- For rising interest rates, the value of assets would drop more than the value of liabilities and thus value of net worth drops
- For falling interest rates, the value of the assets would rise more than the value of liabilities and the value of net worth would increase

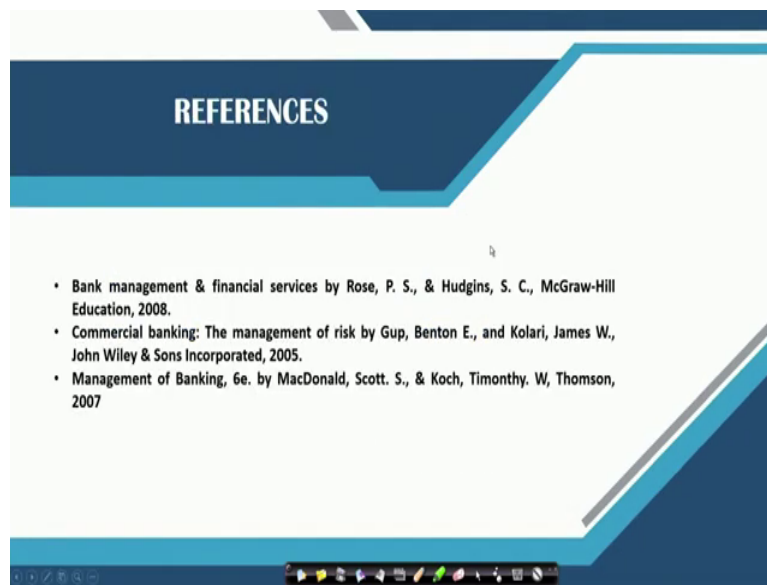
If you see the conclusion, what we can see that, the duration gap is a measure of interest rate sensitivity that helps to explain how changes in interest rate affect the market value of the banks assets and liabilities and also the net worth. For rising interest rate the value of assets would drop more than the value of liabilities. Thus, the value of net worth also drops and for falling interest rate the value of the assets should rise more than the value of liabilities and value of net worth will increase.

And another also thing we have observed from that whenever the duration gap is negative, if there is an interest rate is increasing then the net worth is increasing, but if the duration gap is positive, if there is a declining in the interest rate then the net worth is increasing. So, what basically the banks try to do, if they are predicting that the interest rate is going to up then they want to make their duration gap negative, if they are predicting that the interest rate is going to be down then they want to make their duration gap positive.

So, that is the strategy what basically they want to adopt if they are going for the aggressive strategy or if they do not want the aggressive strategy they want to make your duration gap 0, so in that particular condition also they make this particular adjustments in terms of balance sheet items like both assets and liabilities which finally can make the duration gap 0, by changing the maturity period.

Because at end of the day once the maturity period of the different assets changes the duration of the different assets and liabilities also will change. So, accordingly the commercial banks can make this particular duration gap 0, which is perfectly immunized from any kind of interest rate fluctuations in the market.

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So, these are the references what you can go through and further we can discuss about more the other kind of analysis which are used to manage the different kind of risks in the commercial banking system, thank you.