Energy Resources, Economics and Environment
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Lecture 5 P2
Energy Economics – Part 2

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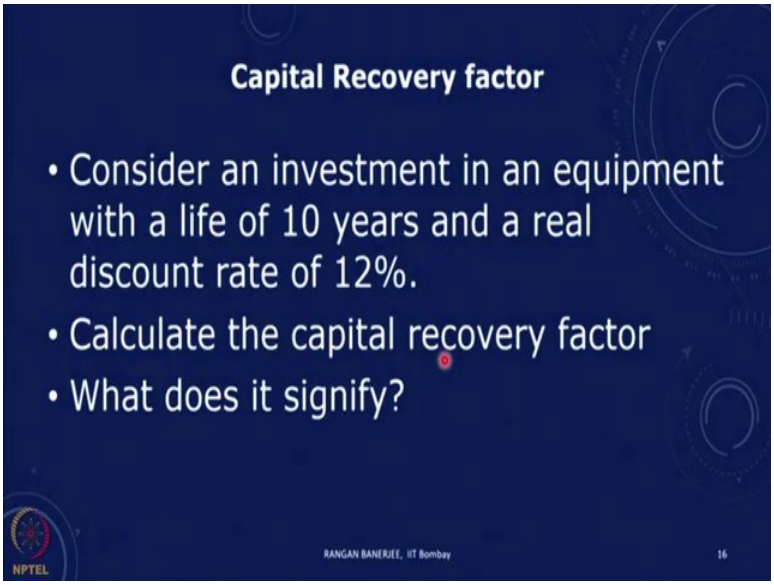

$CRF(0.12, 10)$

¿ $\frac{d(1+d)^n}{(1+d)^n - 1}$

$\frac{0.12(1.12)^{10}}{(1.12)^{10} - 1}$

¿ 0.177

So, consider an investment in an equipment with a life of 10 years and a real discount rate of 12 percent.

So, question is what does this signify, what is this 0.177? So, this is to give you an idea let us think in terms of investing a 1000 rupees in an equipment or a project which has a life of 10 years and the company, or the individual making the investment has a real discount rate of 12 percent.

This will mean that, that thousand rupees is equivalent to an annualized the investment of 177 rupees each year over the life of the equipment, that is what this 0.177 means, which means that if in this project if I am getting a benefit of 200 rupees every year, then it is worthwhile to go for it. So, I can compare this annualized investment with the actual benefit that we are getting. So, this is the significance of the capital recovery factor.

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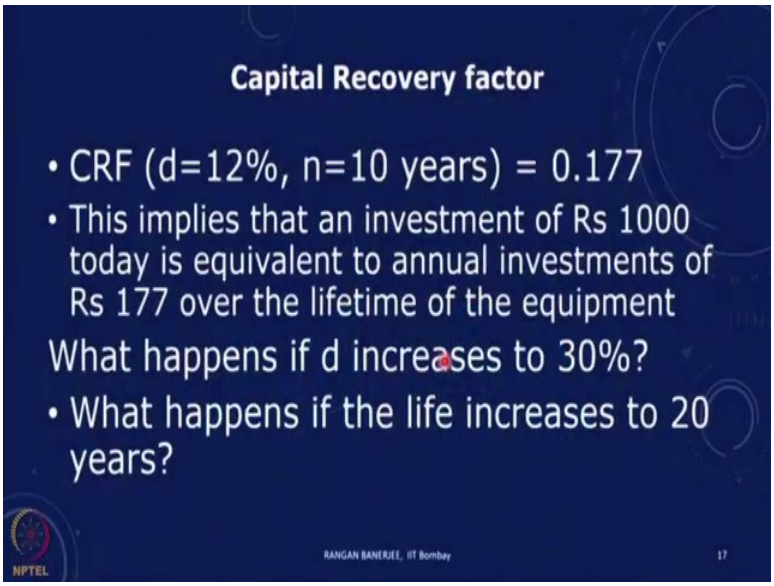

$CRF(0.12, 10)$

$¿ \frac{d(1+d)^n}{(1+d)^n - 1}$

$\frac{0.12(1.12)^{10}}{(1.12)^{10} - 1}$

¿ 0.177

$CRF(0.3, 10) = 0.323$

And this implies as we said, this implies that an investment of rupees 1000 today is equivalent to annual investments of 177 rupees, if the life, over the lifetime of the equipment. What happens if the discount rate is higher? If the discount rate for instance increases to 30 percent you can plug in the values, you will find that now the capital recovery factor increases.

So, that in this case when you say CRF 0.3 or 30 percent and 10 years you will find that that comes out to be 0.323, same investment 1000 rupees, same life n 10 years but discount rate is 30 percent. Which means that the same investment looks more costly because now the annualized investment is 323 rupees.

So, then in that case where if you are getting a benefit of 200 rupees per year, you will not make that investment because your capital is more scarce and you expect a higher return, you discount the future with the higher value and that is why this is. So, this is the, this is one parameter. The second thing is what happens if the life increases? If the life increases then obviously the capital recovery factor will decrease and because so that it gets distributed over a smaller point of time.

So, you can see that the capital recovery factor depends on the discount rate and the life of the equipment. So, now we are we have understood the concept of the discount rate we are now ready to look at the different indicators that we talked off, then we will start with these all these three indicators are coming from the same equation.

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$$NPV = PV\ of\ BENEFITS - PV\ of\ COSTS$$

$$¿ \sum_{k=1}^{n} \frac{A_k}{(1+d)^k} - C_0$$

$$NPV > 0$$

$$NPV = \sum \frac{A}{(1+d)^k} - ¿ C_0 ¿$$

$$¿ \frac{A}{CRF(d,n)} - C_0$$

The first indicator is the net present value, net present value is the present value of benefits minus the present value of cost, and this will be in money terms, in rupees, dollars, whatever is your currency. So, in the case where we had an upfront investments C0 and we had benefit stream which is AK this becomes sigma AK by 1 plus d, K is equal to 1 to N minus C0 and what is the criteria?

The criteria is that net present value should be positive, benefits must exceed cost, NPV greater than 0 is our criteria, if we now had a situation where the special case where A K is constant then NPV will be equal to sigma A by 1 plus d raise to K minus C0 which will be A by CRF dn minus C0.

So, this is the net present value and this is commonly used by many of the companies for the decision making, and so if you looked at these two examples that we talked of the way where we had A and B and A had a life of 3 years, and B had a life of 8 years, you will find that when we calculate the NPV, we find that the NPV of B is greater than A, of course it will depend on the discount rate but you can meet that calculation, have an example and you can do this yourself where you can do this calculation.

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$$\frac{B}{C}=\frac{PV\ of\ BENEFITS}{PV\ of\ COSTS}$$

$$\frac{B}{C}=1$$

$$\frac{B}{C}=\frac{\sum_{k=1}^{n}\frac{A_k}{(1+d)^k}}{C_0}$$

$$\frac{A}{C_0 CRF(d,n)}$$

Another possibility instead of looking at in the case of net present value it is B minus present value of benefit minus present value of cost, instead of that some companies use the indicator called the B by C ratio which is NP is the present value of benefits divided by present value of cost and the criteria is B by C must be greater than 1, benefits must exceed cost.

So, this B by C ratio will be nothing but AK by 1 plus d, K is equal to 1 to N divided by C 0 and in the case of constant cash flows, then this will become A by C 0 CRF d, n. So, these are the two indicators net present value, and benefit by cost ratio.

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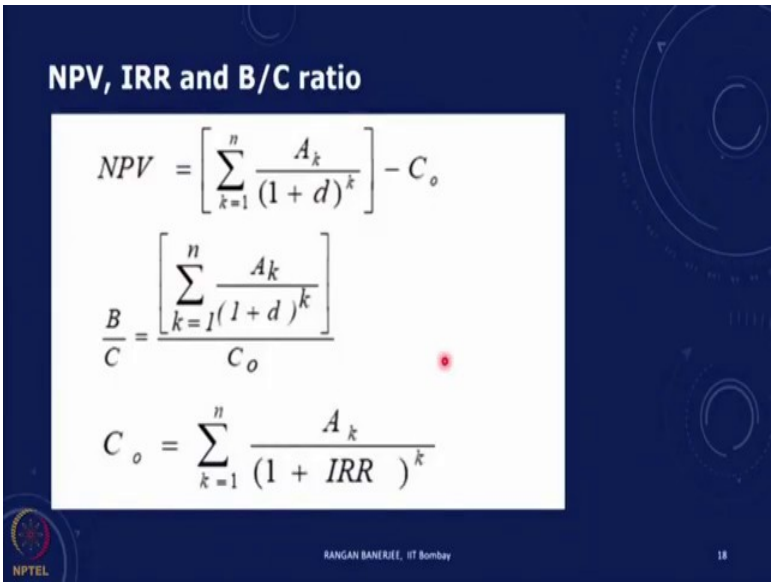

There is a third indicator which comes from the same equation but slightly different. So, in the case of net present value or benefit by cost ratio we have to take what is the discount rate of the company, or the individual who is making the decision and based on that then we make the calculation based on that discount rate and find out what is the net present value of the project, or the benefit by cost ratio, then we check if that net present value is positive or the B by C is greater than 1 and use that to take a decision on a yes, no kind of decision.

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$$NPV = 0 = \sum_{k=1}^{n} \frac{A_k}{(1+r)^k} - C_0$$

$$0 = \frac{A\left[(1+r)^n - 1\right]}{r(1+r)^n} - C_0$$

In the case of the internal rate of return we do not make an assumption of a discount rate, we look at that equation of the cash flows which are coming from the project and we say what is if we take that equation and we solve for the rate of return that means we set NPV is equal to zero and solve for.

So, if you see this, instead of taking the discount rate we make this as an unknown, we set NPV is equal to zero and we solve for r, the r value that we get is called the internal rate of return, and then we compare this internal rate of return to the minimum return which the company expects on the projects which is equivalent to its discount rate, it is also called the hurdle rate.

So, in effect IRR should give you the same result as the NPV or the B by C ratio, but the calculation is different, this is a polynomial equation. So, if you see, now we can simplify this in the case suppose we take the special case where AK is constant that means this is now A by if we write down the equation it is r into 1 plus r raise to n 1 plus r raised to n minus 1 minus C0.

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$$C_0 = \frac{A}{r}\left[1 - \frac{1}{(1+r)^n}\right]$$

$$r_{j+1}\frac{A}{C_0}\left[1 - \frac{1}{(1+r_j)^n}\right]$$

$$\left|r_j + 1 - r_j\right| \leq TOL$$

Now, we can simplify this by putting this as C0 is A by r, I can divide this and I can get this as. So, now I can solve this equation is a polynomial equation in r, we can do it one of the simplest ways, of course you can use bisection method, you can find many ways in which you can solve this through but one of the simplest method is I can take this as r and put this as r is equal to A by C0, 1 minus 1 by plus r raise to n.

So, we can start with this equation and start with an assumed value of r, so let us take rj and then update it to get the new value of rj plus 1 and keep iteratively solving this till the modulus of this difference is less than or equal to sum tolerance value. So, this is one way in which we can solve and get the internal rate of return.

Of course in many of you know you have the IRR even in your excels, there is an IRR function, you can actually calculate and see that it brackets the roots and do this but this is a simple way of

doing this. So, we have seen now the three methods the net present value, benefit by cost ratio, and internal rate of return, and now let us do one example.

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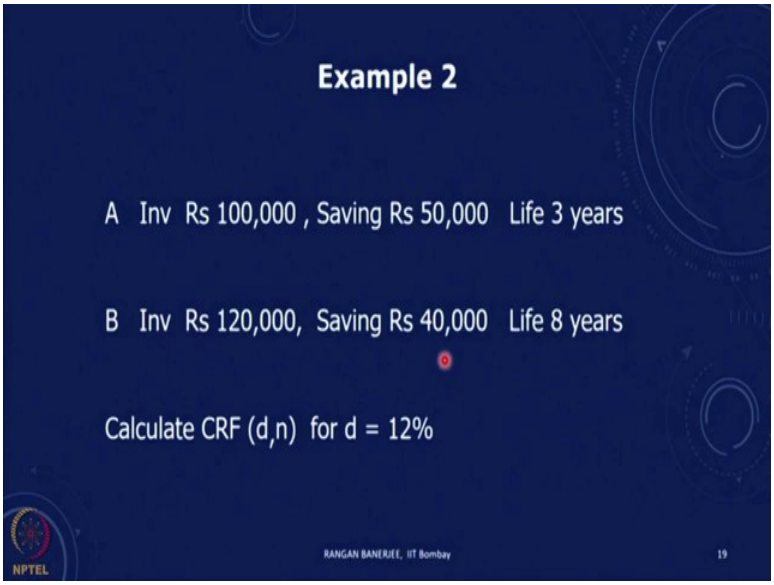

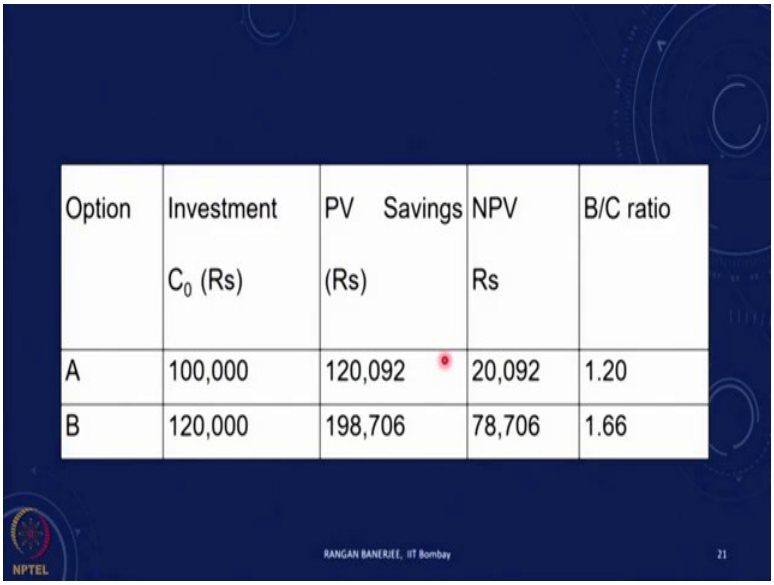

So, this is a I had already told you about the other case where suppose we said A and B which we talked about the life of 3 years, and 8 years and we could calculate the CRF values, use the CRF values and you can find that this is the B by C ratio for B and the net present value for B comes out to be higher, you can cross check these numbers.

Before we do an example let us now talks about sometimes people confuse the discount rate with inflation. So, the point is that there are situations even if your prices remain constant we still discount the future, so even if there was no inflation, we generally prefer money today compared to money in the future. So, this whole concept of discounting is independent of inflation but let us touch upon what we understand by inflation.

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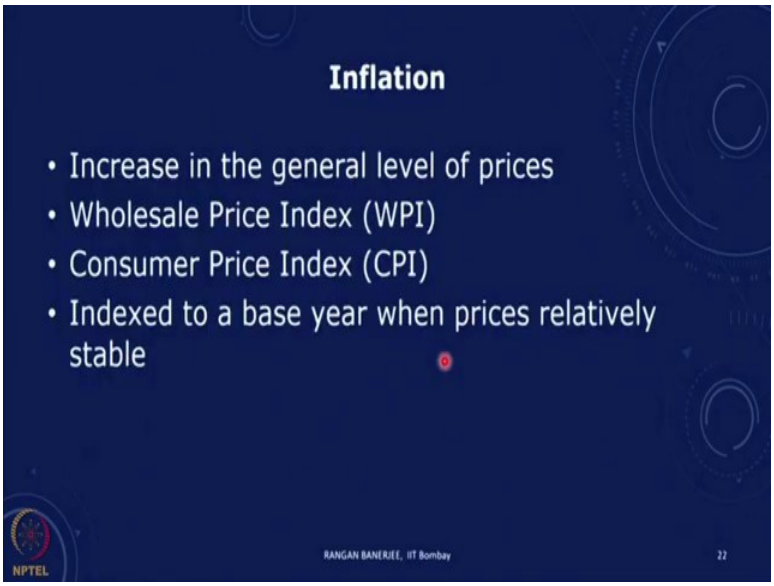

So, an inflation is a change in the general level of prices and the inflation could be inflation means increase in the general levels of prices and we have a term called deflation which is a decrease in the general level of prices. In the context of India we have been fortunate to have always prices have always been increasing. So, we have only seen inflation but there are other countries where prices fluctuate and you keep having inflation and deflation and in which case the decision making becomes very difficult.

So, typically the way in which we characterize inflation is we look at a basket of goods and services and we see that for that basket of goods and services in a particular year if you were to buy the goods and services, how much would it cost and you take the last if you take 2019 it costs a certain amount, in 2018 it costs another value, the ratio of these two prices will give you the inflation rate.

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2019 P_1

2018 P_2

$$\frac{P_1}{P_2} = (1+i)$$

So, basically what will happen is if you say in 2019 the price is P1 and for the same set of goods and prices in 2018 if it was P2 then P1 by P2 will be 1 plus i, where i is the inflation rate between 2018, and 2019 and in typically. So, typically what happens is this is called the inflation rate.

The inflation rate as you can understand this is the prices fluctuate in different regions, prices fluctuate in different seasons, and the prices and inflation are sensitive issues. They are political issues and you sometimes want to show that it is the inflation is less or more and, so typically what happens is if you look at the Reserve Bank of India, or the International Monetary Fund, go to their website you will find that these are indexed.

They are indexed usually to a base year when the prices are relatively stable. In that base year that price is kept as, that base year price is taken as 100 and compared to that other prices, other years are index in terms of that 100. So, we have two indices one is called wholesale price index, and the second is the consumer price index, the wholesale price index is important for companies who are buying electricity, urea.

So, you see what are the things that companies buy and what have the prices, how of those prices change. Consumer price index is a prices that are seen by individuals in households and so we are talking of electricity, we are talking of some fuels, you talk of food items in each of these cases the there is a definition of the basket of goods in terms of how many kgs of what and then what are the weightages, we then make this calculation and you will see tables like this.

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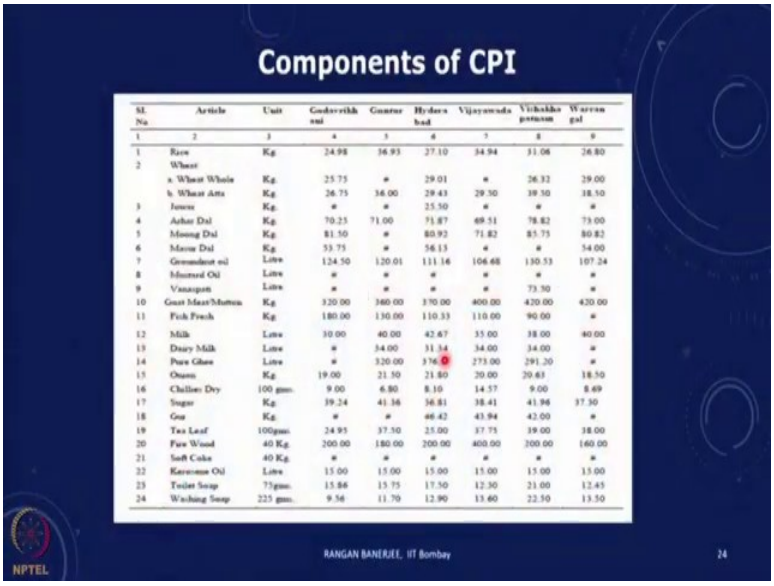

If you see these are the components of the consumer price index and you see in all of these there are food products, there are some electricity, there are other things and each of these has some amounts and then you can see in different locations what have been those prices.

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In the case of wholesale price index, you can see that the quantities and the commodities are different again their weightages. So, these are things which are reasonably transparent, you can go to this website, see how these wholesale price indices are calculated and then we can use this and calculate.

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So, as I told you in our country we had essentially we had a inflation which has been there and constantly prices have increased. There is only one year where prices decrease and this was between 1975 to 1976 and that was the year in which there was a emergency had been declared and that has resulted in this decrease in prices, but in general overall this is how this is computed.

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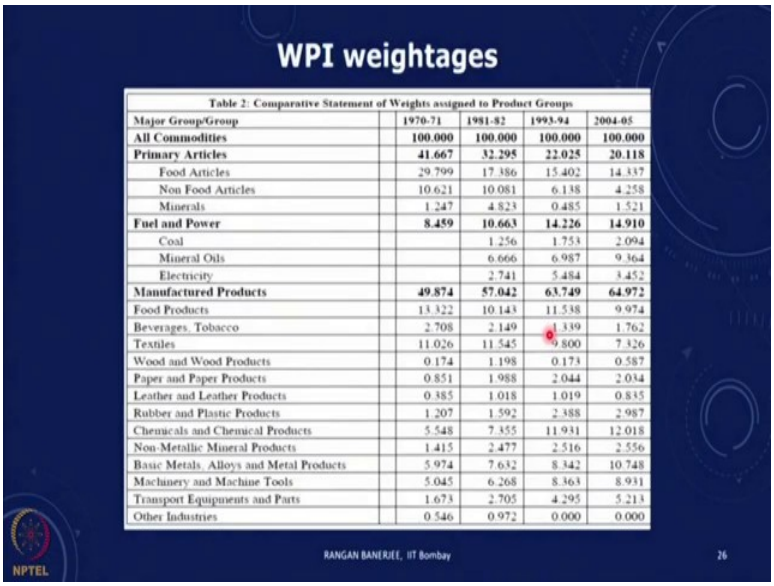

So, let us now look at a simple, so based on this there are weightages, which are given and these weightages can be used to make this.

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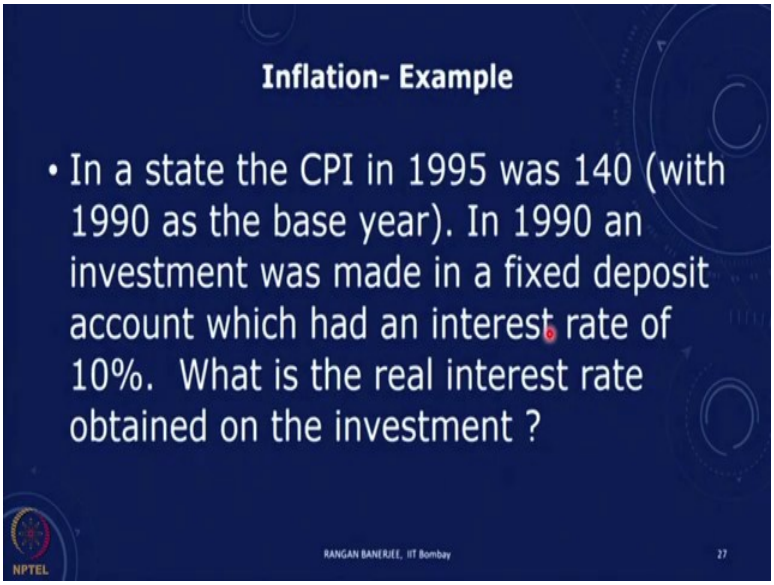

Let us take a simple example of, in a state the consumer price index in 1995 was 140 with 1990 as the base year, in 1990 an investment was made in a fixed deposit account which has the interest rate of 10 percent. So, we want to find out what is the real interest rate obtained on the investment.

Because from 1990 to 95 the prices have increase, the value of that money has gone down and because the value has gone down, we want to know what is the actual amount of interest that you are getting.

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140 1995

100 1990

$\frac{140}{100} ¿ (1+i)^5$

$i \quad 7\%(0.07)$

$(1+0.1)=(1+0.07)(1+r)$

$r \quad 2.8\%(0.028)$

So, what we can do in this case is that we can take 140 is in 1995, the base year is 1990 by definition in the base year it will be 100. So, essentially what we do is we take 140 by 100 is the compound inflation rate raise to 5 and then you will find that i approximately 7 percent or 0.07, if you look at the interest that we are getting, we are getting 10 percent.

So, 1 plus 0.1 will be equal to 1 plus 0.07 that is the inflation and 1 plus the real rate of return and you find the real rate of return is approximately 2.8 percent, 0.028. So, in a similar fashion when we talk about the discount rate we are, we can think in terms of two discount rates, one is the nominal discount rate which you take based on the actual prices in that particular year and the real discount rate if you have adjusted for inflation.

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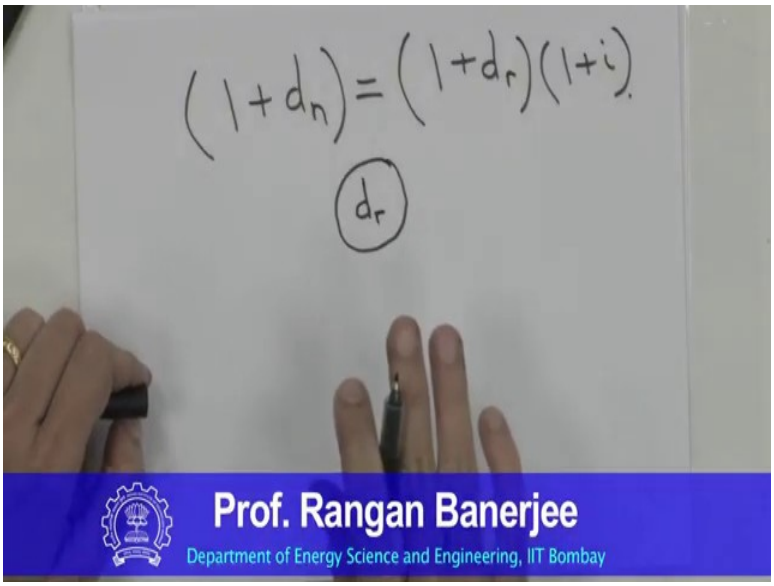

So, we say that 1 plus d nominal, typically what happens is that the when we make a calculation today for a project which is going for 20 years, 25 years, we do everything based on today's prices. So, often it is better to do the calculations in constant money terms, don't bother about inflation and talk about the real discount rate.

So, unless otherwise specified we have whatever we have be discussing have been on the real discount rate. In some situations where you have different commodities with in different kinds of inflation and you can have a projection of what will be the inflation and cash flows in the future we could use the nominal discount rate. But unless otherwise stated what we are talking of is the real discount rate.

The nominal discount rate will fluctuate based on the way in which the economy varies and the inflation happens, the real discount rate is more relatively more stable and reflects the scarcity value of capital.