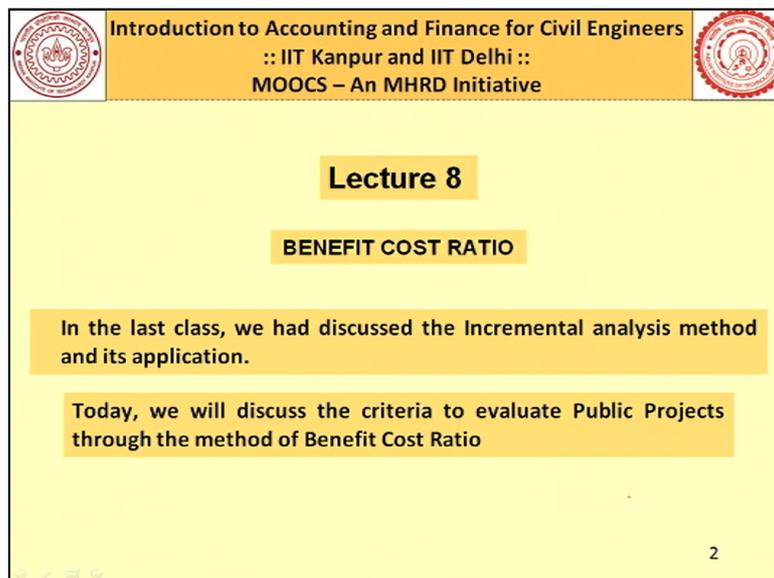**Introduction to Accounting and Finance for Civil Engineers**
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Module No. #02
Lecture No. #08
Benefit Cost Ratio

Good morning, and welcome to this lecture on, Benefit Cost Ratio, as part of Lesson 8 in this course on, introduction to Accounting and Finance for Civil Engineers. In the last class, if you remember, we discuss about the Incremental Method of Analysis, and its Application.

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In this lecture, we are going to cover, the evaluation of public projects, and the method that we are going to learn is, Benefit Cost Ratio.

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So far, whatever method we have learnt, you might remember that, they are mainly utilised for evaluation of private projects. Now, there are differences between, private and public projects. In the private project, your profits, and tangible considerations, are of prime importance.

Whereas, in the case of public projects, we are here to provide the goods and services, to the public. But, we have to make sure, that they are provided at the minimum cost. Now, we also understand that, these public projects are, primarily funded by government, whether it is a state or centre.

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Now, you understand that, any government for that matter, whether it is the state government, or a central government, they have a responsibility towards public welfare. Now, some

examples of public projects are, dams, it could be defence projects, highways, education, healthcare, and so on. Now, you also understand that, these government projects cannot be evaluated, strictly in commercial terms.

When I say commercial terms, we say that, profit, the taxes, the pay off, all these terms take backseat. Because, the primary purpose of executing government projects is to make sure that, the benefit reaches to everyone.

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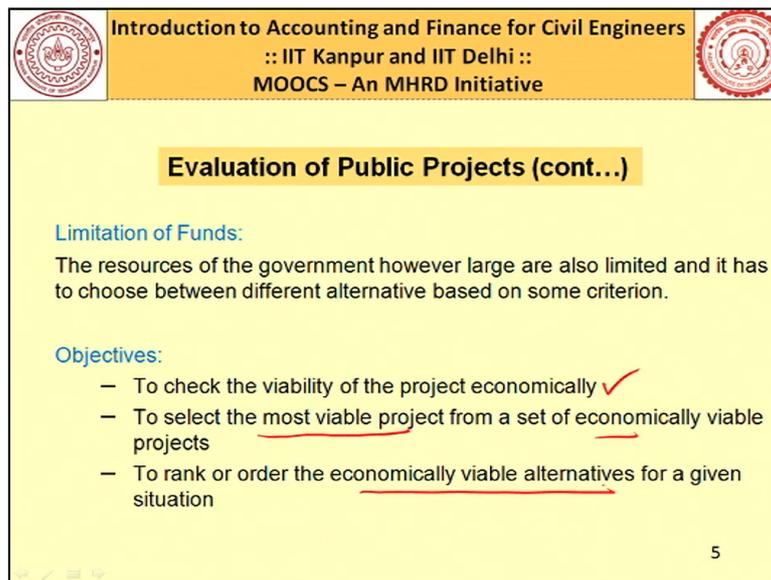
So definitely, we are going to employ some method. Because, you understand that, government also has got limitation. Because, it does not have infinite money, at its disposal. So, the objectives of evaluating public projects, is to check, the viability of the project economically, to select the most viable project, from a set of economically viable projects. And, if needed, sometimes we also rank, or order the economically viable alternatives, for a given situation.

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Benefit Cost Ratio

- One of the most commonly used criteria to evaluate public projects is Benefit-Cost Ratio (B/C).
- B/C ratio is defined as the ratio of benefit to public and cost to the government.
- B/C ratio can be obtained using any one of the PW analysis, FW Method, AE method.
- However if the definition is clearly understood the ratio can be correctly obtained. When comparisons of several alternatives are to be made, basis of incremental analysis should be made.

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Now, one of the major methods, that we used to evaluate public projects, is known as Benefit Cost Ratio. Sometimes, it is also known as B/C method. Now, this B/C, when you call this ratio is defined as the ratio of, please note these terms, benefit to public, and cost to the government. So, in the numerator, we are evaluating, what are the benefits to the public, and in the denominator, we have got cost to the government.

Now, there are very thin lines between, classifying whether something belongs to the benefit to public category, or whether something belongs to cost to the government category. Accordingly, as one of the limitations of the B/C ratio, which we will see little later. You will find that, these B/C ratios can be manipulated, very easily. If you are not very careful in identifying, what is benefit to the public, and what is cost to the government, these B/C ratios, can vary to a large extent.

Now, when it comes to B/C Ratio calculation, we can employ, anyone of the methods, which we have already learnt. Present Work Method of Analysis, Future Worth Method, or Annual Equivalent Method. So, all these methods, whatever methods, we have studied so far, using those methods, we can derive the B/C ratio. Now, as I told you, if we do not understand, the benefit to public, and cost to the government, these two terms carefully, you will be landing up in problem.

It may so happen that, a project which may have a B/C, greater than 1, you may wrongly calculate it to be, B/C of less than 1. Now, here also, when you have got to evaluate more

than two alternatives, suppose you have more than two alternatives to be evaluated, in that case, what you need to do is, you need to employ the concept of Incremental Analysis.

Because, here also, if you remember, the concept of Incremental Analysis, has to be used. And, you remember that, every Rupee is, as good, or as bad, as the other Rupee. So, if we are getting of B/C ratio, more than 1, for let us say, first 100 Rupees, we must also ensure that, we get a B/C ratio, more than 1, for any additional money, over and above that 100 Rupees.

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Now, when you talk of B/C ratio, it is basically, benefit to cost. And, as I told you, it is benefit to the public, and cost to the government. So, when you say B/C is, let us say 1.5. So, what does this mean. That means, for every 1 Rupee of cost to the government, remember the term, cost to the government, for every 1 Rupee cost to the government, we are getting, the public is getting, a benefit of 1.5.

So, this is what, B/C Ratio means. And, anything less than 1, say for example, B/C Ratio is 0.85, what does this mean. That means, for 1 Rupee investment, or for 1 Rupee cost to the government, the public is getting a benefit of, only 85 Paise.

Now, to illustrate the concept of B/C ratio, and incremental Benefit Cost Ratio method, we straight away start with a small problem. Now, in the problem, it is given that, a government is planning for a hydro-electric project. Remember, this is a public project. And, this will provide, flood control, irrigation and recreation benefits. The established benefits, and cost of three alternatives, are given in the table, which I will show, a little later. The interest rate to be used for the analysis is, 5%. Life of each of the alternatives, X, Y, and Z, is to be assumed as 50 years.

So, in most of the civil engineering projects, you will find, life would be in excess of 50 years. Now, the question is, out of the three, which one is the best alternative. So, we have three alternatives, X, Y, and Z. And, we are to choose, the best out of this. Now, as you can see here, we have got more than two alternatives here. So, the analysis has to be performed necessarily, on the basis of incremental method. Because, if you do on the basis of B/C Ratio alone, without employing the mental method, you might land up in wrong answer. So, let us see, to the table.

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Illustrative example – Benefit Cost Ratio

$250 \times (A/p, 5!, 50)$

All values are in million of rupees:

Alternatives	X	Y	Z
Initial cost	250	350	500
Annual power sales	10	12	18
Annual flood control	2.5	3.5	5
Annual irrigation benefits	3.5	4.5	6
Annual recreation benefits	1	2	3.5
Annual operation and maintenance	2	2.5	3.5

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So, in the table, it is given that, for X, we had to invest 250 Million Rupees. All the values here, are in Millions of Rupees. So, if you are pursuing option X, you have to invest 250 Million Rupees. In Y, 350. And, in Z, 500 Million Rupees. Now, the annual power sales, that you will be generating would be, 10 Million in X, 12 in Y, and 18 in Z. Same way, the flood control, the irrigation benefits, the recreation benefits, and operation and maintenance cost, are also tabulated.

Now remember, in most of the economic analysis, what we are studying, what we have already studied, and what we will be studying, in the subsequent lectures, you will notice that, solution is not a big deal, formulating the problem is a big deal. So, when you try to generate this sort of a small table, you will have to work, for many, many months. Because, these data are not very easy to generate. They take lot of time. And, they need, specialised knowledge.

For example, let us say, if some hydro-power project is coming, in a particular locality, how much benefit you are getting, in terms of recreational values, or in terms of flood control values, you have to do lots and lots of calculations. So, although I am giving you these data in a simple table, but believe me, in order to generate these data, they take large amount of time. Anyhow, we are not going into, the details of those. And, we are straightaway coming back, to this particular problem.

So, the initial cost, for each of these options, are given. The power sales, flood control, irrigation benefits, recreation benefits, operation and maintenance cost, each of these values

are given, for all the three alternatives. Now, as I told you, you have to be very, very careful in choosing, what goes in numerator, and what goes in denominator. Numerator, we are writing benefit to the public. And, denominator, we are writing cost to the government.

So, looking at the table, can you tell me, which one will go in the benefit side, or the numerator side, and which one will go in the denominator side, that is cost side. Now, one thing you might have noticed that, from here onwards, that is, power sales, flood control, annual irrigation benefit, everything is given in the annual terms, except for this initial cost. So, it would be better, if we convert these values also, into annualized value.

So, what we do. We can very easily convert this present value, into annualized value, by going in with this formula. You can multiply 250 with, we want a value, so I want A, we are given P. Now, interest rate given is 5%, and duration is 50. So, if you multiply this factor A given P, for 5% interest rate, for 50 years, we can very easily get the annualized value, for this initial cost, for alternative X. Likewise, I can calculate it for Y. Likewise, I can calculate it for Z.

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So, this is how it is done. You can see here; this factor values A given P 5% for 50 years is coming to be 0.0548. So, if you multiply it with 250, we are getting 13.7. So, that means, 215 Million Rupees, investing at time T is equal to 0, is equivalent to, investing 13.7 Billion every year, for next 50 years. So, this is what it means. Likewise, I can convert this 350 also, in terms of annualized value, it is coming to be, 19.18. This, for Z, we are getting 27.4.

Now, these are all cost values. So, operation and maintenance cost is given to be 2, from the previous table, for this 2.5, for this 3.5. Now, receipt on power sales. So naturally, when the power is sold, government benefits. So, it will get deducted from the cost. So, government is selling power worth 10 Million, every year. So, 10 will be deducted. So, it is minus of 10 here, minus of 12 here, minus of 15 here.

So, if you calculate the total annual cost, it would be 13.7 + 2 − 10. So, this is going to be, 5.70 for X, 9.68 for Y, and 12.9 for Z. So, we have already calculated the denominator, for each one of them. Right. Now, I have to calculate the benefit, so that, I can calculate B/C ratio.

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So, for calculating B, we do it like this. So, annual flood control, in terms of annualized value, it is 2.5, irrigation benefit 3.5, recreation benefit 1. So, total benefit is, 2.5 + 3.5 + 1 is, 7 for X, for Y it is 10, for Z it is 14.5. Total cost from the previous slide, already we got is, 5.7, 9.68, and 12.90. So, I can calculate the B/C Ratio. So, 7 divided by 5.7. So this, we are getting 1.23.

So, we are getting 1.23 for X, 1.03 for Y, and 1.12 for Z. Now, all these B/C Ratio you will find, it is more than 1. So, that means, for every 1 Rupee the government is investing, the public is getting a benefit in excess of Rupee 1. So, that means, all three of them, can be taken to the next stage of analysis. Now suppose, there would have been some other alternative, W here. And, for which, the B/C would have come to be, let us say 0.85.

In that case, you would have dropped W, here itself. It would not have gone, in the next phase of analysis. But, in this case, as you can see, for all three X, Y, and Z alternative, B/C is more than 1. So, all the above alternatives are economically viable, and thereby, they will be taken for the next stage of analysis. Now, what I do. I arrange these X, Y, Z, in the ascending order of investment, or the cost to the government. So, already you can see, X, Y, Z, are already in the form of, ascending order of investment.

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So now, I take pairwise value. So, I do, what is the additional benefit I am getting, if I am investing in Y. So, if you remember in X, we were investing 250, and for Y, we had 350. So, the difference is 100. So, that also, I convert it into, equal annualized equivalent. So, 100 in to 0.0548, so this is 5.48.

So, that means, if I am investing in Y, over and above X, so it is resulting in an annual equivalent cost of 5.48 Million. Operation and maintenance cost, the difference is 0.5. If you just see, if you go back to the previous table, you can see here, here you have 2.5, here you have 3.5. Likewise, here you have 3.5, here you have 4.5, here you have 1, here you have 2.

So, the difference in benefit, we can calculate. And, you can see that, in operation and maintenance cost, we are saving 0.5, by investing 5.48 extra. Receipt on power sales, the difference is – 2. So, the total annual cost equivalent becomes, 5.48 + 0.5 - 23.98. So, this is cost. Now, we will compare the benefit. Right.

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Incremental analysis to identify the best alternative (cont…)

Annual **benefit (B)** computation	Y-X	Z-X
Annual flood control	1	2.5
Annual irrigation benefit	1	2.5
Annual recreation benefit	1	2.5
Total benefit	3	7.5
B/C ratio	3/3.98 = 0.75	7.5/7.2 = 1.04
Remarks	B/C <1; Reject Y	B/C >1; Accept Z

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Now, if you see the benefit here, annual flood control Y over X, we are getting a benefit of 1 Million, irrigation benefit 1 Million, recreation benefit 1 Million. So, total benefit we are getting in Y over X is, 3. So, B/C Ratio for this additional investment becomes 3. B is 3 here. And, C we had already got, which was 3.98 here. So, B/C becomes 3 by 3.98, which is 0.75. So, what you find here is that, B/C Ratio is less than 1. That means, additional investment of 100 Million Rupees, is not desirable.

So, we are saying, okay, reject Y. So, that means, stick with X. Now, I will compare this X, with the Z. So, here again, if you go back to the previous slide, now in X, we are investing 250 Million, in Z, we are investing 500 Million. So, the difference here is, 250 Million. So, 250 Million, we are investing extra, at time T is equal to 0. So, if we convert it into its annual equivalent, we are getting 13.7. So, this is the cost. In O&M, I am getting a difference of 1.5. In receipt on power sales, we are getting a benefit of 8 Million.

So, total annual cost equivalent, we are getting is 7.2. Now, I will do the benefit part. So, flood control, we are getting a benefit of 2.5, irrigation benefit 2.5. This is the difference between Z and X. Recreation benefit, we are getting 2.5. So, the total benefit that we are getting is, 7.5. And, the cost if you remember, from the previous slide, it was 7.2. So, the ratio is 1.04.

So, you find that, B/C is more than 1. That means, the additional investment of 250 Million is desirable. Because, it is resulting in a B/C Ratio of 1.04. So, we find here is that, out of X, Y, and Z, the most economical option, in terms of incremental B/C Ratio is, Z. So, we will

choose Z option, as the best option. So, this is how, we carry out the Incremental Analysis. Now, we will see some more points, regarding this B/C Ratio computations.

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As I told you, the classification of benefits and costs, they are liable to manipulation. Because, most of the time, they are done in an arbitrary manner, sometimes to favour some proposals, sometimes to avoid some proposals. And, most of the time, it causes confusion. However, since we do not have many other choices, we are still continuing to evaluate public projects, using B/C Ratio. As I told you, if you are not clear about, what should go in numerator, and what should go in denominator, this may cause confusion, and this may create problems.

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Now, in addition to this benefit cost criteria, sometimes, some government agencies, they follow some other criterion also. So, I will not go in too much detail, in those criteria. But, I will just highlight them, and discuss few key points. For example, some government, they would choose that project, which requires minimum investment. So, you have a minimum investment criterion. Some government, they like to go in for that project, which results in maximum benefit.

So, out of, let us say, three projects, they will see, what is the benefit you are getting in Project-1, what is the benefit you are getting in Project-2, what is the benefit you are getting in Project-3. So, whichever project gives maximum benefit, they will go for that. Sometimes, they go in with aspiration level. When you say, aspiration level, what actually is your vision, what actually you are aspiring for, that will decide, which project to choose.

Sometimes, you go in for maximum advantage of benefits over cost. So, that means, you calculate B – C, and then you decide, which alternative to choose. Sometimes, some government, they go for highest B/C Ratio. So, they will not go in to the Incremental Analysis. But, they will see, let us say, out of three proposals, whichever proposal has got the highest B/C Ratio, they will go in for that project. Then, some agencies, they choose the largest investment, that has a Benefit Cost Ratio, greater than 1.

So, you have to organise your proposals, in the ascending order of investment. And then, you have to also calculate, the Benefit Cost Ratio. And, you will choose that project, which has got the largest investment, yet it is giving you a B/C Ratio greater than 1. Some agencies, they go in for maximum incremental advantage of benefit over cost. This, we have already seen.

We have done the Incremental Analysis, just now itself. Then, some government agencies, they choose that particular project, which gives maximum incremental B/C Ratio. And, some agencies, they chose the largest investment, that has an incremental B/C Ratio, greater than 1.

So, these are different variants of B/C Ratio. Sometimes, they go in for, minimum investment. Sometimes, they go in for, maximum benefit. Sometimes, for different aspiration level. Sometimes, they go in for, the advantage of benefits over cost. Sometimes, highest B/C

Ratio. So, these are some of the variants, which one or the other government agencies normally adopt, for choosing the B/C ratio.

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Now, there are certain limitations, in this particular method. For example, whatever we are unable to express, in terms of money, we are excluding them. So, we call them as, intangible things. Right. Such as, recreation, and the saving of human lives. Suppose, some projects result in, saving of human life. But, it is very difficult to quantify, in terms of money, the value of human life. So, we normally, discard those benefits, and continue to evaluate, based on the tangible benefits only.

Then another limitation is to, choose the interest rate. Because, our time horizon is very large. Say, we are talking of projects, which are spanning, 50 years, 70 years, 100 years. Now, keeping interest rate fixed for that particular period, and choosing a right interest rate, is a very challenging task. Because, the moment you change the interest rate, you will find your decisions, might get influenced. So, selection of a proper interest rate, and the time horizon for different alternatives, is also a very challenging task, and one of the limitations in particular Benefit Cost Ratios.

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Now, the reference book, that you can go in for, this particular topic is, one by me itself. Its name, Construction Project Management Theory and Practice. It is published by Pearson. Then, there are some other references also. Of course, you can go in through, each of these textbooks, and you can try to evaluate, some alternatives, especially the public projects. So, just to quickly summarise, what we learnt in this particular lecture, we discussed about, evaluation of public projects.

All our lectures, prior to this, we discussed, evaluation of private projects. There, the profit was the main motto, the rate of return, these were the keywords. However, the public projects are not to be seen, only in the light of profit, or for that matter, rate of return. Because, these public projects are meant for upliftment of poor, to do some social services, and so on. However, we also know that, there are large number of public projects, which are competing against each other.

Any government for that matter, does not have infinite sum of money, at its disposal. So, it must also employ a very scientific method, through which it can evaluate, or it can choose one project, out of several competing projects. So, we studied the Benefit Cost Ratio, which is one of the widely used methods, in the evaluation of public projects. So, when I say B/C Ratio, B stands for benefit to the public, and C stands for the cost to the government.

Now, as I told you, there is a very thin line between, benefit to public, and cost to the government. And accordingly, this B/C Ratio is liable to be manipulated. But, despite these limitations, this is one of the best available methods, at our disposal. Whenever, you have got

more than two alternatives, you should again use Incremental Analysis method. And, you should check, whether the B/C Ratio for the additional investment also, is fetching you a B/C more than 1.

When you say B/C more than 1, or 1.5, let us say, it means, for every 1 Rupee cost to the government, what is the benefit that we are getting. So, if it is 1.5 B/C means, for every 1 Rupee of cost to the government, public is getting a benefit of 1.5. So, with this, I stop in this particular lecture, and see you sometime in the next lecture. Thank you, very much.