Introduction to Accounting and Finance for Civil Engineers
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Module No. #02
Lecture No. #09
Sensitivity Analysis (Part – 1)

Namaskar, Good morning, and Welcome to the course, once again. In this lecture, we are going to cover, a very important aspect of this particular course, which is Sensitivity Analysis.

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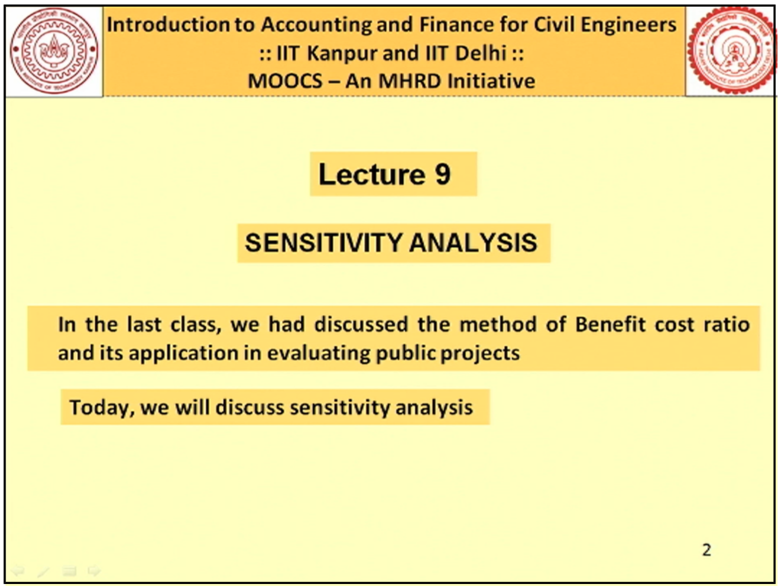

But, before that, we would like to recapitulate, what we learned in the last lecture. If you remember, in the last lecture, we covered various evaluation methods, for evaluating public projects, which are now you understand, different from the evaluation of private projects. We understood the concept of Benefit Cost Ratio. And, we said that, any project qualifies for further round of screening, if it passes that B/C criteria of more than one. We did one example.

And, with the help of that example, we understood, all the steps of Benefit Cost Ratio, which we have to follow. Now. In this lecture, we are going to cover, Sensitivity Analysis. Now, just to give you the background of this particular lecture, you might remember that, one of the assumptions that we made, for solving all our problems so far was, the variable values were supposed to be constant and accurate.

So, whether it was incomings, or whether it was outgoings, whether it was salvage value, whether it was interest rate, or for that matter, whether it was the life of the asset, we assume them to be constant. However, as you know, in real life situation, these variables may undergo changes. For example, you may find that, you might have assumed an annual income of 1 Lakh, from some investment plan. But, it may so happen that, instead of 1 Lakh, now you may be getting 90,000, or it may go to 105,000.

Salvage value, you might have estimated 50,000. But, now you find, when at a time of disposal of that equipment, you find that the salvage value is coming to be only 25,000. So, we would like to know, because of the changes, is my original decision going to change. You would also like to understand, the impact of changes made in one or two variables, and their impact on the final decision. So this is the topic, for today's lecture.

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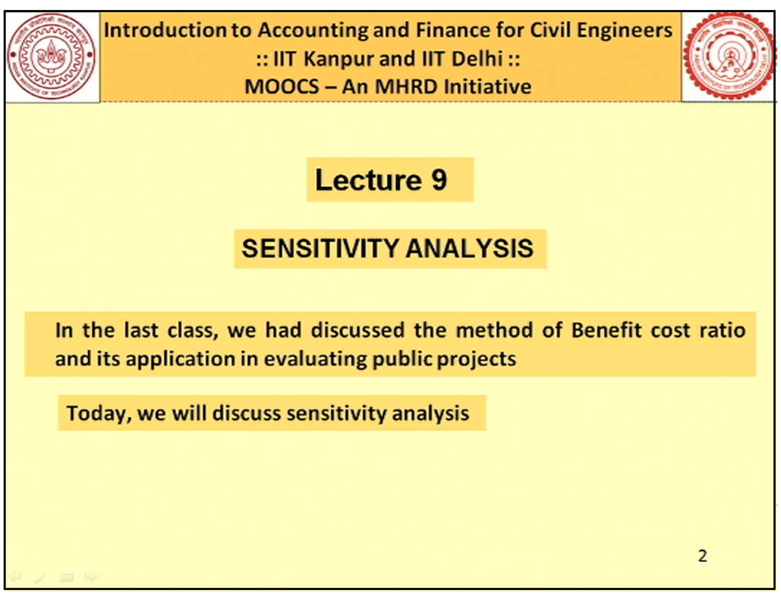

As I told you, we are going to cover, Sensitivity Analysis.

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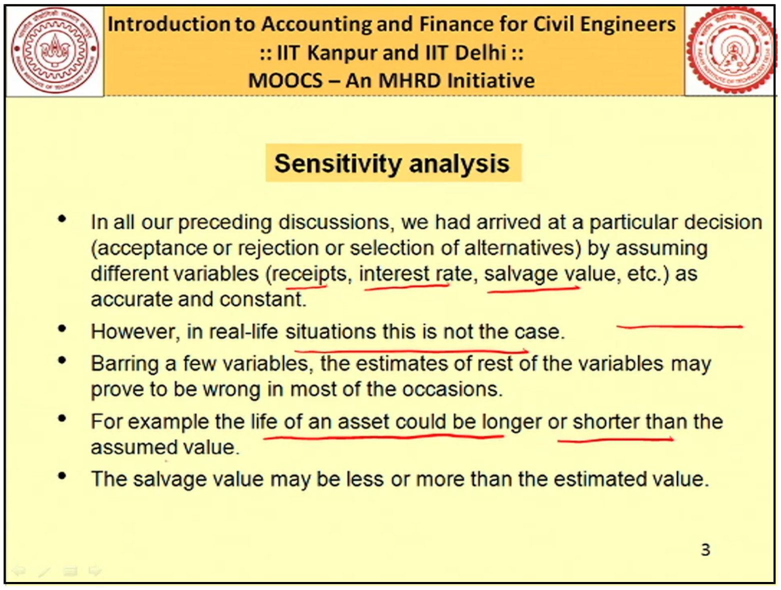

Now, as I have told you already, the various variables that we assumed in our analysis so far, for example, the receipts, the interest rate, the salvage value, all were assumed to be constant. They were also supposed to be accurate. But, as you know, in real life situation, this is not the case. Some variables find, for example, at time T is equal to 0, if you are investing something, that is known for certainty, that is going to happen for certainty.

But, what happens to your forecast for incomes? What happens to your forecast for expense? What happens to your forecast for interest rate? These things are likely to be, changing in future. So, we would like to know, whether our decisions are going to change. Right. So, as I told you, further you can understand that, the life of an asset could be, either longer or the shorter, than the assumed value. The salvage value may be, less, or sometimes even more, than your estimated value.

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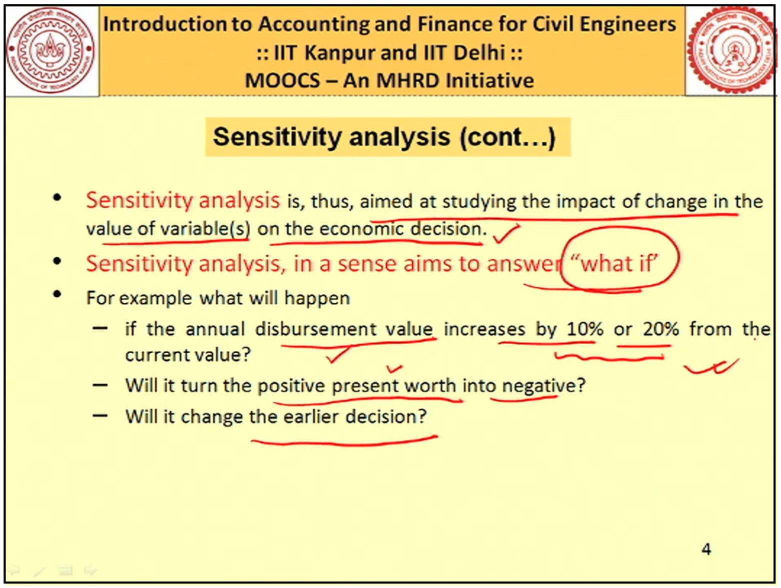

So, if you try to find the objective of Sensitivity Analysis, basically it is aimed at, studying the impact of change, in the value of variables. The variables, as I told you, it could be incomings, outgoings, interest rates, salvage value, and so on, on the economic decision. So, decision was, let us say, if you are using Net Present Worth, and we were finding Net Present Worth of greater than 0, we said okay, we can accept this alternative. So, we would like to know, what we will be the impact of changes, in these variables, on the economic decision.

Sensitivity Analysis, is also sometimes referred to as, what if analysis. So, it is same as, what if analysis. So, we would like to see what happens, if I make this variable change, from this value, to this value. Say for example, if I say that, if my annual disbursement value increases by 10%, or maybe 20%, from the current value, from the estimated value, which are used in my analysis, what will happen to my decision.

Will it turn, the positive present worth, into negative? Suppose, for the given value, you find that, net present value is coming to be positive. So, by changing this, will my present worth change from positive to negative. And thereby, will it change my earlier decisions. So, in the earlier decision, you might have found that, it is better to go with this alternative. But, whether by making changes, up to this extent, will my decision still hold. That is the purpose of, reading the Sensitivity Analysis.

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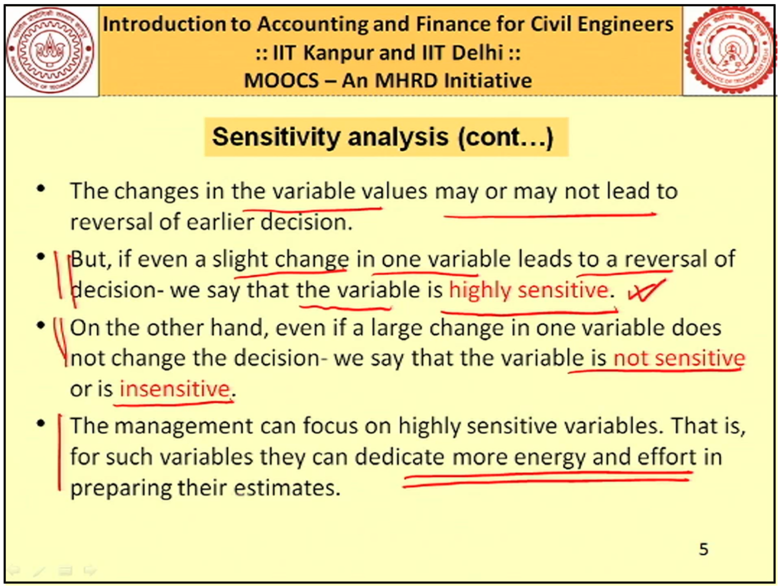

Now, you will find that, when we do certain problems, we will find that, when you make changes in different variables, it may or may not lead to the reversal of earlier decision. So, it may so happen that, NPW earlier also is positive, now also with the change, it is positive. So, you do not find, there is reversal of the decision. But, in some cases, you might find that, your decision may get changed. In some cases, you find that, even if there is a slight change, so maybe 5% change, or 10% change in your original value, in one variable, it might lead to a reversal of decision.

So, for such variables, we say that, they are highly sensitive variables. So, what are highly sensitive variables. Highly sensitive variables, are those variables in which, if you make even a slight change, may be of the order of 5% or 10%, that will change your original decision. On the other hand, there could be some other variables, which even if you change them by double, so 100 becomes 200, or 100 becomes 50, you find that, there is no change in your original decision.

And, such variables, we call them as, not sensitive variables, or sometimes you call them as, insensitive variables. Now, what is the implication of identifying these sensitive variables, or insensitive variables, or not so sensitive variables. You will find that, management can focus their attention on, those highly sensitive variables.

Because, even if there is slight error in forecast of these variables, you may find that, your decision may go wrong. Right. So, it is essential for the management, to concentrate on those highly sensitive variables. And, even if you do not put a lot of effort and energy on insensitive variables, it is also okay. Because, it is not going to change your decision, anyway.

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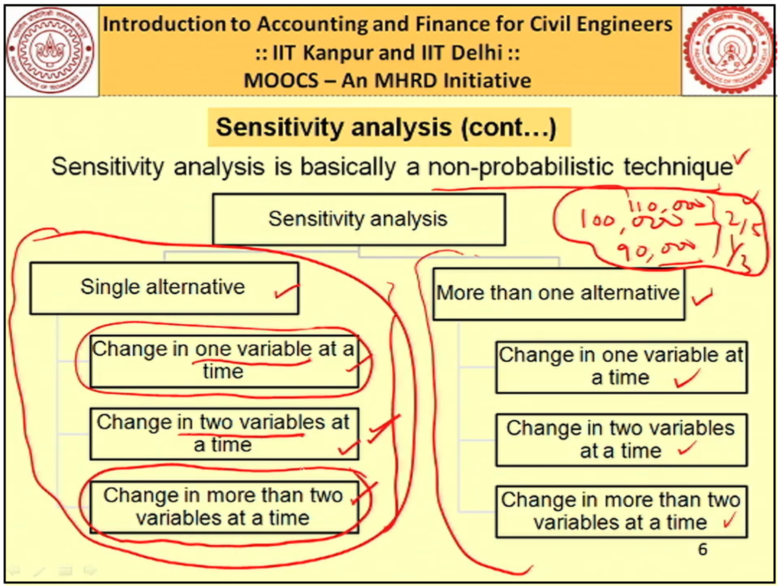

Now, as far as Sensitivity Analysis is concerned, it is basically a non-probabilistic technique. When I say non-probabilistic, we are not assigning any probability to, different variable values. Say for example, when I say, my income is 100,000. And, it may go up to 90,000, or in extreme cases, it may go up to 110,000. So, that is it. We are not assigning that, Okay, for 90,000 the probability is 1 by 3, 100,000 the probability is 2 by 5, and so on.

So, we are not at all assigning the probability, corresponding to the different possibilities, of these variable values. So, in that sense, it is a non-probabilistic technique. We will also like to do probabilistic technique, but in some other lecture, where we will assign various probability values, associated with different variable values. And then, we will see, what is the risk associated with a particular alternative.

Now, if you try to look at the different forms of Sensitivity Analysis, this figure captures, all the possible forms of Sensitivity Analysis. Now, we can carry out the Sensitivity Analysis, for one alternative. We can carry out the Sensitivity Analysis, for more than one alternative. Now, in the beginning, we will concentrate on, single alternative Sensitivity Analysis. Now, there also, you can make changes in, one variable at a time.

So here, we are changing, one variable at a time. So, either we can change income alone at a time, or expense alone at a time, or salvage value at a time, or service life at a time, and so on. In another case, we will change, two variables at a time. So, we may take two variables, any two variables, for example we can take, income versus service life, salvage value versus service life. So, we will take two variables, and we will change them, and then see, what is the impact on the original decision.

So, this comes under, change in two variables at a time. Then in one case, we will try to change, all the variables at a time. So, more than two variables, or in worst case, we will make changes in all the variables at a time. So, what you find here is, we are moving closely towards, practical situation. If you remember, our earlier assumption was, all the variable values, what we are assuming for our analysis, they are fixed, there are certain to occur, there is no change.

So, whether it was interest rate, even if it was the life for 5 years, we said okay, interest rate is not going to change. So, the salvage value also, is not going to be changed. So, everything, we assume it to be certain, and fixed. But, what we are doing now. We are taking one single alternative at a time, and we are making changes. One variable at a time. May be, two variables at a time. And, more practical, we are making changes in, different variables, at the same point of time. Likewise, the same analysis, we can carry on for, more than one alternative also.

And, there also, we can have changes in, one variable at a time, we can have changes in, two variables at a time, and we can change, more than two variables at a time. Now, in Sensitivity Analysis, we have a tradition of, representing the results of Sensitivity Analysis, in different forms. So, for example, change in one variable at a time, we show it with the help of a spider web diagram. We will show you.

Likewise, when you are making changes in, two variables at a time, we show the results, either using family of curves, or using isoquants. Likewise, associated with different forms of Sensitivity Analysis, we have different way of representation. So, we will see, each one of them, separately. So, in order to illustrate this, whatever we have discussed so far, we will take one small example, and then we will explain you, how to go about it.

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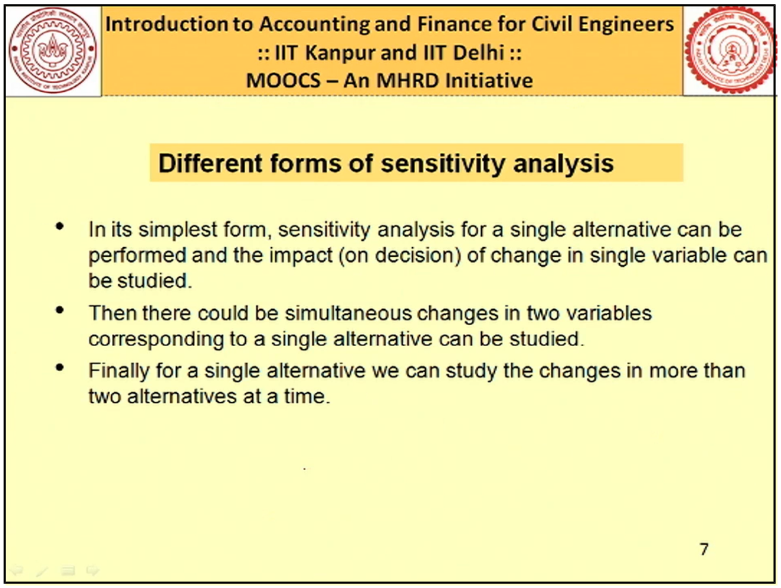

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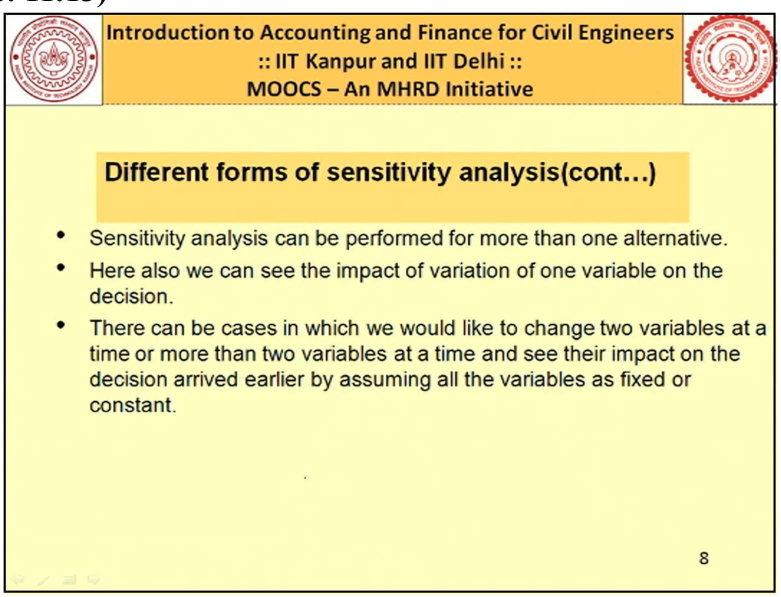

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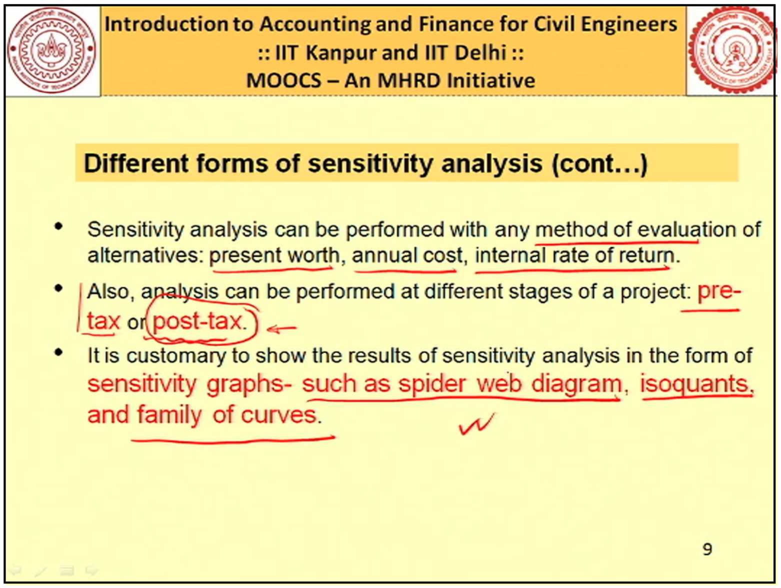

Now, you will also find that, Sensitivity Analysis can be performed, with any method of evaluation, whatever we have studied so far. It could be, Present Worth Method of evaluation. Or, it could be, annual cost method of evaluation. Or, it could be, internal rate of return method of evaluation. Also, this analysis, we can carry out, at different stages. It could be, pre-tax stage. You already know, in pre-tax, we are not concerned about the taxes. We can also do this analysis, for post-tax. Post-tax analysis, you have not been exposed to this stage, so far.

We will take it up, in one lecture, subsequently. When the talk of post-tax, in this basically, we will consider depreciation, and various corporate taxes, that are prevalent. And then, we will draw the cash flow diagram. So, you can find that, all these analysis, you can carry out, both in the pre-tax stage, as well as in post-tax stage. Fine. This I have already told you that, the results of Sensitivity Analysis, you can show it either as, spider web diagram, or isoquants, or family of curves. All these, we will show you, little later.

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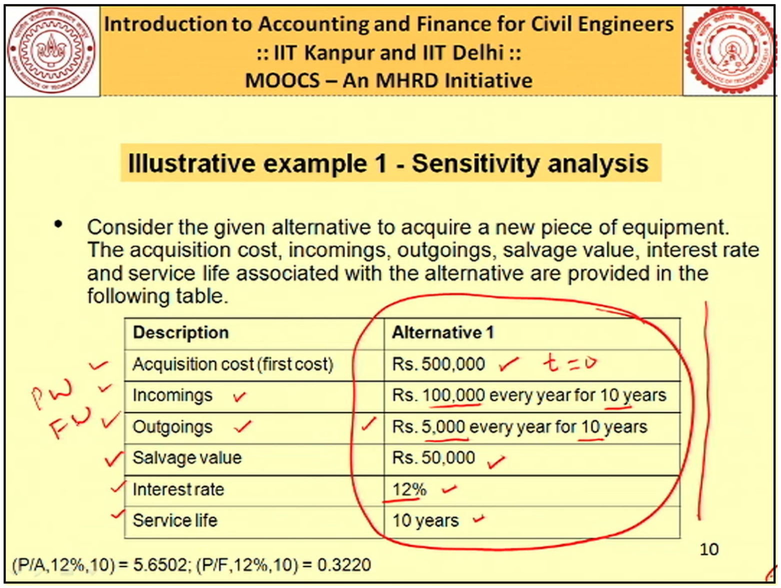

Now, to illustrate, what we learned so far, and to tell you, how exactly we carry out Sensitivity Analysis, for single alternative. Remember, right now, we are going ahead with single alternative. Subsequently, we will also go with, multiple alternative. But, to start with, we take a small example, that too with a single alternative. And, the data that is given, pertaining to this alternative, is shown here. It says that, there is an alternative, in which, you have to invest rupees 500,000, at time T is equal to 0.

We call this, either as the first cost, or the initial cost. So, cost is 500,000. First cost is the initial cost. That means, this is the investment, that you have to make, at time T is equal to 0. Incomings, out of this investment is going to be, 100,000 every year, for 10 years. Outgoings, for this plan is going to be, 5,000 every year, for next 10 years. Expected salvage value is, 50,000. The interest rate that is assumed as 12%. And, the service life is 10 years.

Now, all these values, if you remember so far, we had assumed them to be constant. Now, what exactly we are planning to do here is, to make changes, in each of these variables, one at a time. That is the simplest, to start with. So, we would like to see, what happens, if my incomings value, changes from 100,000, to some other value, will my original decision change.

Similarly, I would like to know, what will happen, if instead of an estimated outgoing of rupees 5,000, there is some other outgoing, will it change my original decision. Or, for that matter, salvage value 50,000, it changes to some other value, what will happen out of that. Interest rate, instead of 12%, some other interest rate, what will happen to my original decision. So, before we see the impact on our original decision, first we would like to see, what is my original decision.

So, given this data, what will you do. Will you select this alternative, will you not select this alternative? First we would like to go ahead with that decision. For that, as I told you, during the lecture, we can find that answer, either using Present Worth Method, or Future Worth Method, or any other method, that we have studied so far. Now, in order to find the, let us say, we are going ahead with the Net Present Worth value.

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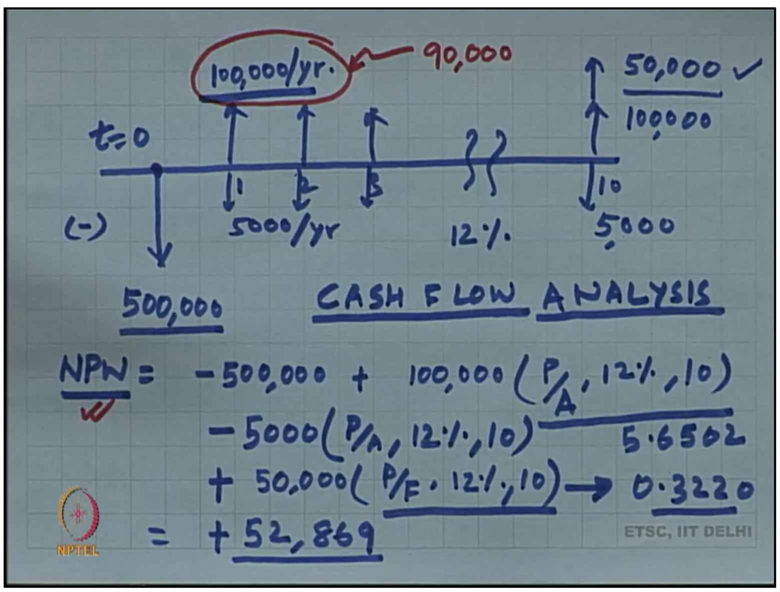

We would like to first draw the cash flow diagram, for this. So, let us try to do that. So, let us assume, this is, time T is equal to 0. Now, at this point of time, we are investing, 500,000. The incomings that are expected are, 100,000 per year, for the next 10 years. So, this is 100,000. This is year 10. Now, outgoings are also estimated. These are 5,000. Every year, 5,000. Here also, it is 5,000. And, the salvage value is given to be, 50,000.

So, this is the cash flow diagram. Remember, right now, we are carrying out the Sensitivity Analysis, only for single alternative. And, that too, if you remember, we are going ahead with changing, one variable at a time. So, right now, for these estimated values, the Net Present Worth is going to be, interest rate has given is 12%. It is going to be, - 500,000. This is all negative. Plus 100,000, we want to find its present worth.

We are given, Annuity P given A, for 12%, 10 years, - this 5,000, which is outgoing, multiplied by P given A, 12%, 10, + for this salvage value, we will calculate, which is 50,000 P given F. This is the future value. We want to find its value, at time T is equal to 0. So, we are using this factor P given F, 12%, 10. Now, as far as these factors are concerned, I will give you the value. For P given A, 12%, and the value is 5.6502. And, for P given F, 12%, for 10 years, this value is 0.3220.

So, if you put these values, you will find, we are getting a Net Present Worth in positive, which is 52,869. You can crosscheck them. So, the idea here is, we are getting NPW of positive. So, it means, we are okay with this investment plan, if we are going with the Net Present Worth criteria, we are getting positive values, so we will say that, okay, this investment of 500,000, which is giving me a return of 100,000 every year, and we need to spend 5,000 every year, for next 10 years, with a salvage value of 50,000, is worth pursuing.

So, this is my original decision, worth pursuing this investment plan. Now, what I will do is, I will make changes here. So, this is my fixed value, for the calculation of NPW now. What I am thinking of doing it now is, I want to find, what will happen to my decision, if let us say, instead of this 100,000 per year assumed value of income, if it becomes 90,000, will my decision still hold good, or will my decision change. Let us try this. So, what I do? I will make the changes here.

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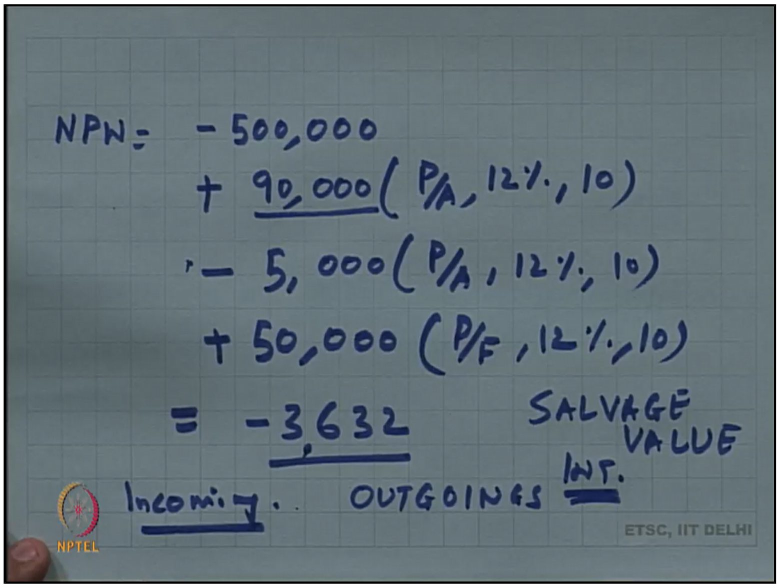

I calculate Net Present Worth, like this now. It is - 500,000, no change here. Now, instead of 100,000, now I am writing 90,000. Here again, it is P given A, 12%, 10 - 5,000, this is outgoing, P given A, 12%, 10 + 50,000, which is salvage value, P given F, 12%, 10. So, we will find that, we are getting a minus value, - 3,632. So, what you find here is that, with 100,000 incomings, we were getting a positive value. Whereas, with 90,000, just 10,000 drop in income, and you find, you are landing in a negative value.

So now, with this value, your decision would be, not to pursue this investment plan. So, what you find? You found that, even if there is a 10% reduction in my income, from the projected income, my decision changes, from acceptance to rejection. So, we can say that, this is a very sensitive variable. Because, it cannot sustain even, 10% change in its value. So, this is a highly sensitive variable. So, this is your incoming.

Now, in the same manner, I can do this exercise for outgoings, I can do this exercise for salvage value, I can do this exercise for interest rate. So, I can take each of these variables, one at a time, and make changes there. Now, if you do this exercise, you will find that, some of the variables are sensitive, some of the variables are not. Now, this is very important conclusion. Because, the moment you understand that, ok, this variable is very sensitive, you are going to be very careful about, the estimate of that particular value.

Sometimes, if you find, some variable is highly sensitive, you may even think of, hiring a consultant, to give you those values. Because, those values are very important. Slight change in the value, here and there, and your decision is going to change. So, you need to spend time, and money, effort, to forecast those values, very accurately.

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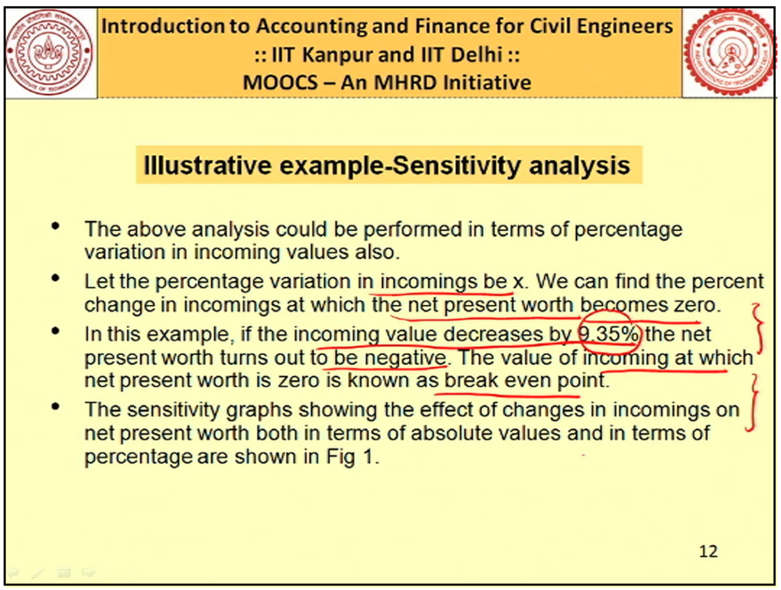

Now, this exercise, instead of doing it in absolute terms, we can also do it, in terms of percentage. So, what you can see here is that, I can assume that, let us say, the variation in incomings is X. So, instead of changing the value from 100,000 to 90,000, I might do this, in form of percentage. So, I will say, let us change this variable, by X%. And, what happens, to the Net Present Worth, corresponding to that percentage change? I would like to find. For what percentage change in incoming, my Net Present Worth become zero.

Because, that point zero, will be the point at which, the Net Present Worth changes from, plus value to minus value. So, it is very important for me to understand, where does the zero lie. In fact, the importance of zero is realised. And, we call that value, where you are getting zero, as Breakeven Point. We will have a detailed discussion, on Breakeven Analysis, where our main focus would be to find that Breakeven Point, where your decision reversal takes place. Your Net Present Worth changes from, plus value, to a minus value. Right.

Instead of finding the changes, in terms of absolute value, you can also find the changes, in terms of percentage. So, for example, you can very well find it out that, if the incoming value decreases by 9.35%. So, 100,000, if it decreases by 9.35%, you will find the Net Present Worth turns out to be negative. So, this 9.35% change itself, is causing the change of decision. Likewise, we can find similar percentage, for other variables also.

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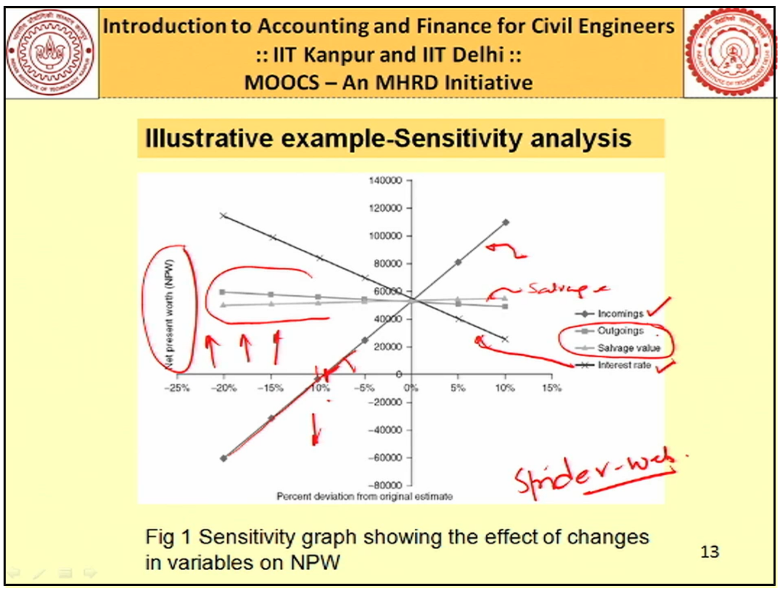

And, you can plot them, in the form of a spider web diagram. So, this is what is known as, spider web diagram. Right. And, the results of single variable change, for a single alternative, we are showing it like this. Now, you can see, this particular value here, is corresponding to change in the incomings value. You can see, this line is very steep. You can see, this slope is very steep. Now, this represents that, this variable is very, very sensitive, as we have found it out. You conceive that, even if there is a drop by 9.35%, you can see, this is 0%, - 5%, and - 10 is here.

So, even if there is a drop of - 9.35%, your decision changes. So, till here, your Net Present Worth is positive. So, Net Present Worth, is on this scale. So, all these values are positive here. And, below this, they are negative. So, the moment, there is a drop in excess of 9.35%, in the incoming value, from your estimated value, you find your Net Present Worth changes its sign, from positive to negative. This exercise, you can carry out for, individual variables. For example, this one is for the interest rate. You can see, here also, interest rate slope is very steep.

So, this is also, very sensitive variable. You find that, even a slight change in the interest rate, right now it is 12%, you may do this exercise for 10%, or for that matter 14%, and then see, what is happening. So, you will find that, even if there is slight change in the interest value, you will find that, your decision changes. But, when it comes to these two variables, if you see here, outgoings and salvage value. So, these two lines are corresponding to outgoings and salvage value. So, this one is for, salvage value. The triangular one, salvage. And, the other one is for outgoings.

So, you can see, the slope for them is very flat. The flatter slope represents that, they are not very sensitive, almost insensitive. So, there is no point putting, too much attention, too much focus, in estimating these variable values. Even if you are approximate, it should be alright. Because, they are not having a great impact, on your overall decision. But, when it comes to incomings, and interest rate, you find, even a slight change there, may change your decision. So, this is what, you have to understand it, very carefully.

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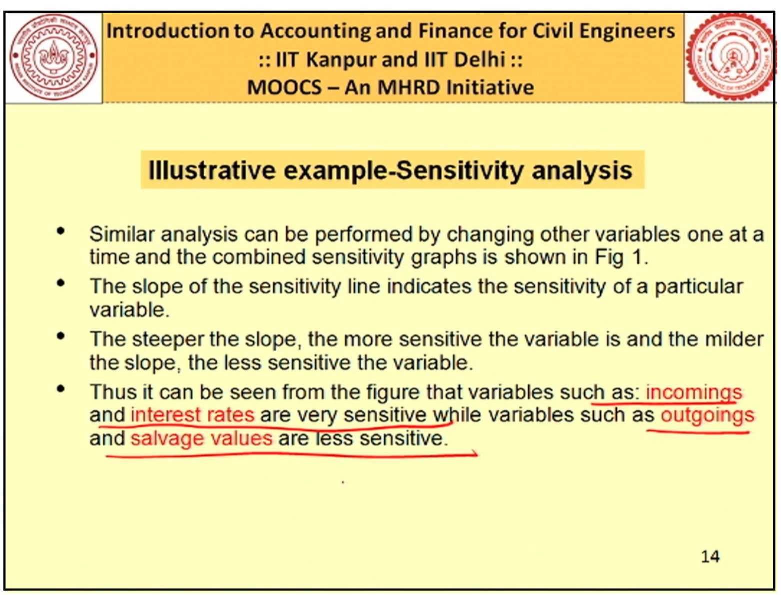

So, this is what, it says. The variables, incomings and interest rate, are very sensitive. While, variables such as, outgoings and salvage values, are less sensitive. How do we do this. The same problem, what you can do is, instead of now 5,000 outgoing, we can take it as 10,000. So, we are just saying, ok, this 500,000, we are not changing this. 100,000 remains, 100,000 itself. But, this 5,000, we are assuming, let us say, it becomes double. Expense becomes double. And, there is no change in salvage value, there is no change in the incoming values. So, this 10,000, still remains 10,000.

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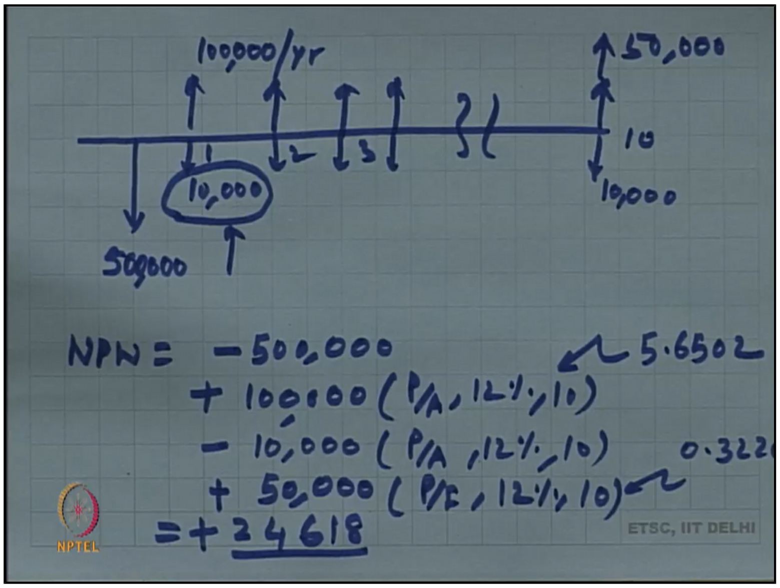

Now, this is year 1, 2, 3, year 10. What you find is that, instead of 5,000, now I am making it 10,000. So, if you calculate the Net Present Worth for this situation, my Net Present Worth is going to be - 500,000, no change here, + 100,000, P given A, 12%, 10 - 10,000, P given A, 12%, 10 + this is still 50,000, no change here, + 50,000, P given F, 12%, 10. Let us try to do this. How much this comes out to be.

So, this is - 500,000. Now, I multiply 100,000. These values are, 5.6502. This is 5.6502. And, this value is 0.3220. So, I can calculate this, - 500,000. Okay. We do this, like this. 100,000 multiplied by 5.6502, + 50,000 multiplied by 0.3220, - 10,000 multiplied by 5.6502, and - 500,000 is coming out to be positive, it is 24,618. You can cross check this. So, the idea is that, we are still getting a positive value.

So, you find that, even if I am changing the expense by 2 times, 5,000 I made it 10,000, still I am getting a Net Present Worth of positive. So, that means, even if I am changing this variable value, to double of its current value, my decision still remains same. So, we say that, this is not so sensitive. In fact, this is an insensitive variable. Right. So, this is how, you have to carry out the Sensitivity Analysis. If you remember, we have carried out the Sensitivity Analysis, only for single variable, and that too for a single alternative.

In the subsequent lectures, we will discuss, single alternative, more than one variable at a time. Then, we will also discuss, more than one alternative, there also we will see, single variable at a time, more than one variable at a time. So, just to summarise, in this lecture, we discuss Sensitivity Analysis, which is basically aims at, finding the impact of my original decision, for a change in my original variable values.

So, I would like to see, what happens to my original decision, if my income changes from original X to X - Delta X, if outgoing changes from Y to Y + Delta Y. Likewise, I am going to change these variables, and I am trying to find its impact, on my original decision. The significance of this analysis, is in understanding, which variable is sensitive, which variable is insensitive.

Why I am trying to do this, is because, for the sensitive variable, I will put more focus, I will put more energy, so that I do not make mistakes, and I do not land up in change of decision, or change of plan. So, this is one very important exercise, we must carry out in, most of the situation.

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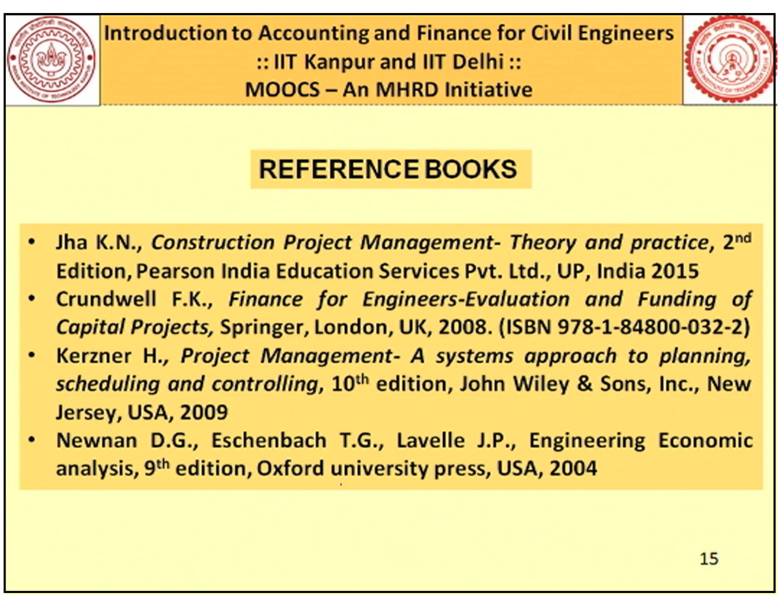

In the subsequent lectures, as I told you, we will discuss, more details on Sensitivity Analysis. But, till then, we stop at this point, and see you some other time. Thank you, very much.