Decision Making with Spreadsheet
Prof. Ramesh Anbanandam
Department of Management Studies
Indian Institute of Technology-Roorkee

Lecture - 49
Decision Analysis - IV

Dear students, so far, what you have done in the decision analysis problems is that we did not consider any sample information before recommending d_3 as the best decision. How have we recommended constructing large-size complexes be the best decision? Because the probability of strong demand and the probability of weak demand is given.

Now, we are going to conduct some sample study or market research study. With the help of that sample data, we are going to revise the probability of strong demand and weak demand; then we are going to recommend the final decision. So, the agenda for this lecture is to analyze the decision with the sample information. So far, we have not considered the sample information.

Agenda

• Decision analysis with sample information

Only in this lecture onwards are we going to see the effect of sample information on our recommended decision.

Decision Analysis with Sample Information - Preliminary or Prior Probability

- In applying the expected value approach, we showed how probability information about the states of nature affects the expected value calculations and thus the decision recommendation.
- Frequently, decision makers have preliminary or prior probability assessments for the states of nature that are the best probability values available at that time.

So here we are, I am going to introduce a term called prior probability. Otherwise, in applying the expected value approach, we showed how probability information about the states of nature affects the expected value calculation and, thus, decision recommendation. So here in our problem, there was a strong demand and weak demand. It was 0.8 for the probability of strong demand, and 0.2 was the probability of weak demand.

We have seen how these probabilities affect our decision recommendation. Frequently, decision-makers have prior probability assessments for the states of nature that are the best probability values available at the time. So, 0.8 and 0.2 is the prior probability. At present, only this information they have, and they have made the decision based on this prior information.

Decision Analysis with Sample Information - Preliminary or Prior Probability

- However, to make the best possible decision, the decision maker may want to seek additional information about the states of nature.
- This new information can be used to revise or update the prior probabilities so that the final decision is based on more accurate probabilities for the states of nature.

However, to make the best possible decision, the decision maker may want to seek additional information about the states of nature. This new information can be assessed to revise or update the prior probabilities so that the final decision is based on more accurate probabilities for the states of nature. So initially, we have the probability of a strong demand at 0.8 and a weak demand at 0.2.

So, we are going to take some samples, and we are going to gain some information. Based on that, we are going to revise this probability to 0.8 for some values and 0.2 for some values. So, this probability is called posterior probability or revised probability.

Preliminary or Prior Probability

- Most often, additional information is obtained through experiments designed to provide sample information about the states of nature.
- Raw material sampling, product testing, and market research studies are examples of experiments (or studies) that may enable management to revise or update the state-of-nature probabilities.
- These revised probabilities are called posterior probabilities.

Most often, additional information is obtained through experiments designed to provide sample information about the states of nature. What kind of experiments can we think of? Raw material sampling, product testing, and market research studies are examples of experiments or studies that may enable management to revise or update the states of nature probabilities.

So, in our problem, we are going to conduct market research studies to update our prior probability. So, these revised probabilities are called posterior probabilities.

Conducting Market Research Study

- Assume that management is considering a 6-month market research study designed to learn more about potential market acceptance of the condominium project.
- Management anticipates that the market research study will provide one of the following two results:
- 1. Favorable report: A substantial number of the individuals contacted express interest in purchasing a condominium.
- 2. Unfavorable report: Very few of the individuals contacted express interest in purchasing a condominium.

Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2018) An introduction to management science: quantitative approach. Cengage learning.

So, how are we going to get the sample information with the help of a market research study? Assume that the management is considering a six-month market research study designed to learn more about potential market acceptance of the condominium project. Management anticipates that the market research study will provide one of the following two results.

One is they may provide favorable reports. What is the meaning of a favorable report? A substantial number of individuals contacted by this market research study expressed interest in purchasing the condominium. Then, the market research study may provide unfavorable reports. What is the meaning of this unfavorable report?

Very few of the individuals showed interest in purchasing the condominium. That means that is why they have provided an unfavorable report.
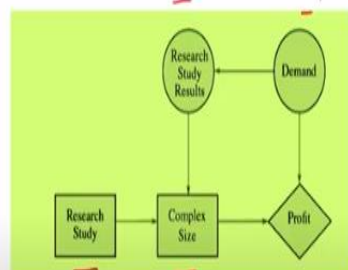
Now, the influence diagram is going to change slightly. How? By introducing the possibility of conducting a market research study, the problem in discussion becomes more complex. The influence diagram for the expanded problem is shown in the figure. Remember, previously, there was complex size was there, demand was there, and profit was there. Now, we have included this research study.

Then, the research study result. So, by the introduction of this research study and its result, how it is going to affect the profit. We will see that in the next slide.

Note that two decision nodes correspond to the research study and complex size decisions. You see that there is this one, this one, and this one. Two chance nodes the

research study result and demand, and two chance nodes correspond to the research study result and demand for the condominiums.
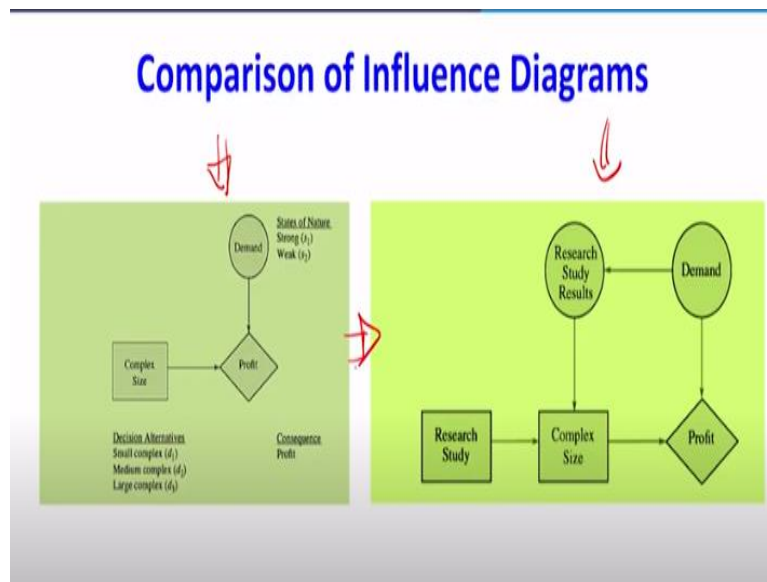
Now you see the comparison of the influence diagram without sample information. So, this one shows an influence diagram without sample information. Now, if you do a market research study, you can see how the influence diagram changes. That is for the comparison. It became more complicated after the introduction of this research study.

Finally, the consequence of the profit is the profit. From the arc of the influence diagram, we see that demand influences both research study results and profit. So, this demand affects the research study results and the profit. Although demand is currently unknown to the company, some level of demand for the condominium already exists.

Influence Diagram

- If existing demand is strong, the research study is likely to find a substantial number of individuals who express an interest in purchasing a condominium.
- However, if the existing demand is weak, the research study is more likely to find a substantial number of individuals who express little interest in purchasing a condominium.
- In this sense, existing demand for the condominiums will influence the research study results, and clearly, demand will have an influence upon the company's profit.
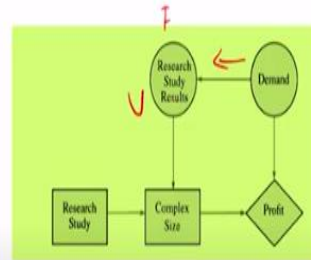
If the existing demand is strong, the research study is likely to find a substantial number of individuals who expressed an interest in purchasing a condominium. So, if the demand is strong, what will be the outcome or outcome of this research study result? They will provide a favorable report. However, if the existing demand is weak, the research study is more likely to find a substantial number of individuals who expressed little interest in purchasing condominiums.

That means they may provide unfavorable reports. In this sense, existing demand for condominiums will influence research study results, and clearly, demand will have an influence on the company's profit. So, what do we understand from the influence diagram? The demand will influence the research study result, and the demand also will affect the overall profit.

Influence Diagram

- The arc from the research study decision node to the complex-size decision node indicates that the research study decision precedes the complex-size decision.
- No arc spans from the research study decision node to the research study results node because the decision to conduct the research study does not actually influence the research study results.
- The decision to conduct the research study makes the research study results available, but it does not influence the results of the research study.
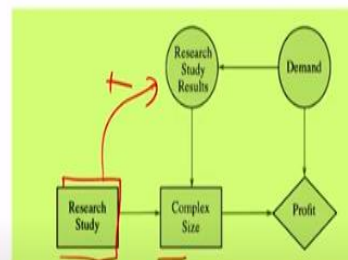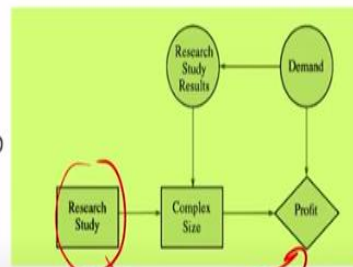
The arc from the research study decision, the arc from the research, and the arc from the research study decision node indicate that the research study decision precedes the complex size decision. So, what are we understanding here? Before deciding the size of the complex, we have to do a market research study. And no arc spans from the research study decision node to the research study result.

So that means there is no arc here, there is no arc here. This indicates that the decision to conduct the research study does not actually influence the research study's results. The decision to conduct the research study makes the research study result available, but it does not influence the result of the research study.

Finally, the complex size and demand nodes influence the profit. Note that if the stated cost to conduct the research study were given, that means the cost of conducting the research study is given, then the decision to conduct the research study would also influence the profit. In such a case, we would need an arc from the research study decision to the profit to show the influence that research study cost would have on profit.
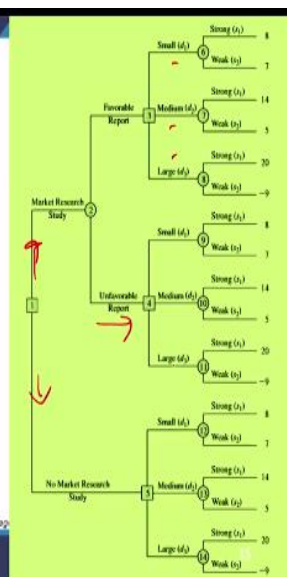
Decision Tree
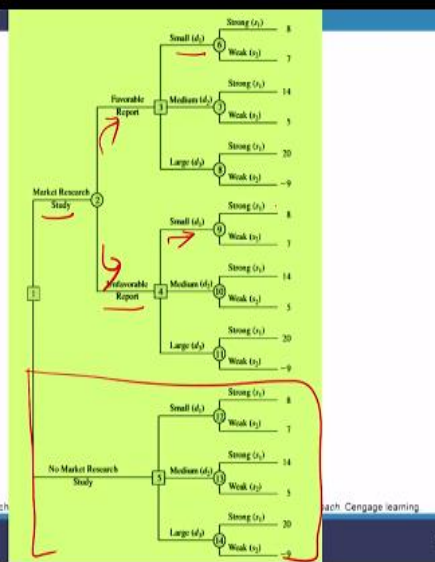
Now, this is the decision tree. Please remember that we solved only this portion of the decision tree in the previous lecture because we did not do any market research study; we did not use any sample information. Now, we are going to conduct a market research study. They may provide a favorable report or an unfavorable report.

If they provide a favorable report, we have three chances, we have three alternatives. If they provide a favorable report, we have three alternatives. One is d_1, d_2, d_3. If I go for d 1, there are two chance outcomes: strong demand and weak demand. In the same way, if the market research study provides an unfavorable report, if I go for d_1, that is the constructing a small-sized condominium, then there is a probability of strong and weak demand.

Decision Tree

- First, the company's management must decide whether the market research should be conducted.
- If it is conducted, the management must be prepared to make a decision about the size of the condominium project if the market research report is favorable and, possibly, a different decision about the size of the condominium project if the market research report is unfavorable.

First, I will explain how this decision tree works. First, the company's management must decide whether market research should be conducted or not. First, they have to decide from one point whether they should go in this direction or they should go in this direction. If it is the direction of the market research study, then these are the consequences.
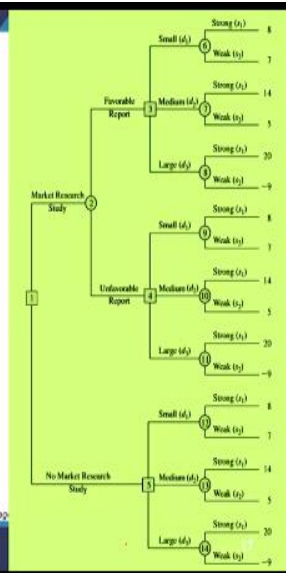
If it is conducted, the management must be prepared to make the decision about the size of the condominium project, this one d_1, d_2, d_3. Suppose the market research report is favorable, possibly a different decision about the size of the condominium project if the market research report is unfavorable. If the report is favorable, they have to decide the size. If the report is unfavorable, then they also have to decide what the size should be.
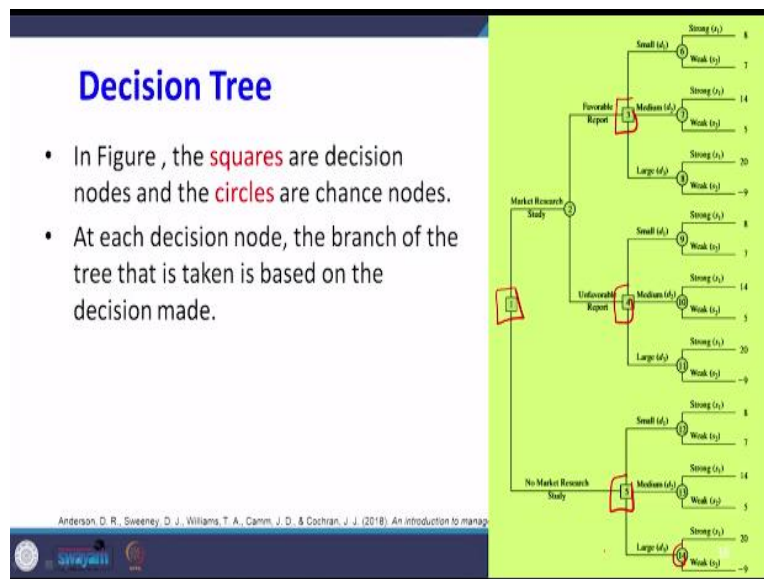
In the figure, the squares represent the decision nodes, which are squares. And the circle represents the chance nodes. You see that, wherever the circle is there, that is the chance. At each decision node, the branch of the tree that is taken is based on the decision made.

At each chance node, the branch of the tree that is taken is based on the probability of, based on probability or chance. For example, decision node one shows that the company must decide whether to conduct the market research study or not.

If the market research study is undertaken, chance node two here and chance node 2 indicate that both the favorable report branch and the unfavorable report branch are not under the company's control and will be determined by chance. Node 3 is a decision node indicating that the company must make the decision to construct small, medium, or complex large complex if the market research report is favorable.
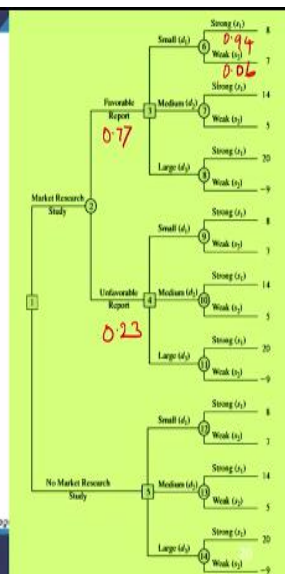
Node 4, this one, is a decision node showing that the company must decide to construct the small, medium, and large complex if the market research report is unfavorable. Node 5 is a decision node indicating that the company must decide to construct a small, medium, or large complex if market research is not undertaken. Nodes 6 to 14 here, 6 to 6, 7, 8, 9, 10, and 14 are chance nodes, indicating that the strong demand or weak demand states of nature branches will be determined by chance.
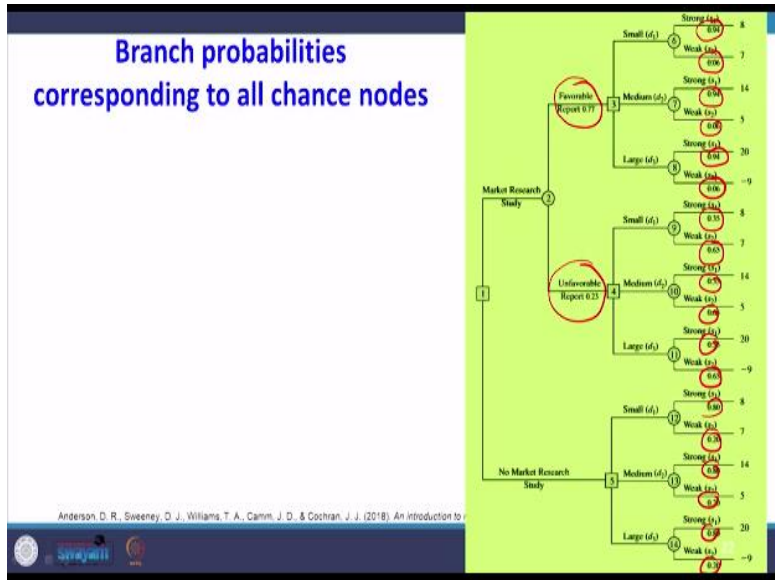

Now we are going to introduce the branch probabilities corresponding to all chance nodes. If the market research study is undertaken, the probability of providing a favorable report is 0.77 here. The probability of providing an unfavorable report is 0.23. If the market research report is favorable, then the probability of strong demand is 0.94. The probability of weak demand is 0.06.

Now I have shown branch probabilities corresponding to all chance nodes. What are they? The probability of providing a favorable report is 0.77; the unfavorable report is 0.23. If it is a favorable report probability of strong demand is 0.94, weak demand is 0.06 everywhere; 0.94, 0.06. If it is an unfavorable report, if you go for strong demand, it is 0.35, and weak demand is 0.65.

If you are not going for any market research study, the probability of strong demand is 0.8, 0.2. Strong, weak, strong, weak. Now, the value of 0.94, 0.06, is directly given to you. In the next lecture, I will explain how we have a value of 0.94 for strong demand and 0.06 for weak demand. We will discuss the in the next lecture. But at present, assume that you have received 0.94, 0.06. At the same time, 0.35 and 0.65 are given to you.
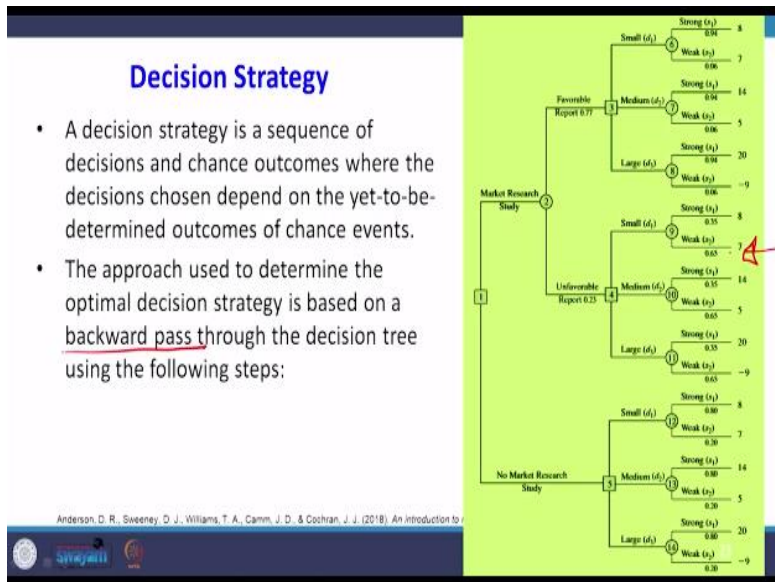
Now we have to suggest a decision strategy to the management. A decision strategy is a sequence of decisions and chance outcomes where the decision chosen depends on yet-to-be-determined outcomes of chance events. So, we have to suggest what path we have to follow. That suggests that the path is nothing but our decision strategy.

The approach used to determine the optimal decision strategy is based on the backward pass through the decision tree using the following steps. Actually, we have to provide the decision strategy. That means what path it has to be followed. But we are going to suggest that path by doing calculations from the backward onwards. That I will explain in the next slide.
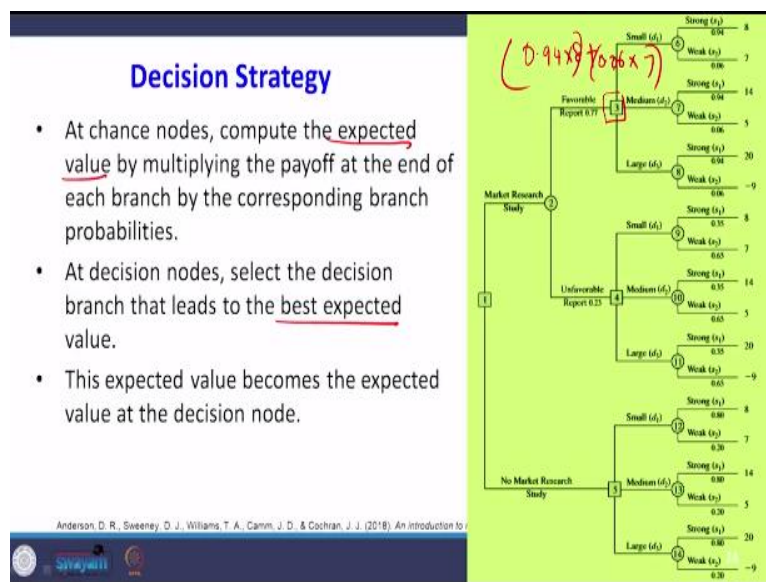
At chance nodes, compute the expected value by multiplying the payoff at the end of each branch by the corresponding branch probability. So first, we have to find out the expected value for each chance node. For example, 6 is there, and we have to find out the expected value. 7. How we will find out 0.94. Plus 7. We have to do this for all the chance nodes.

So, at the decision nodes like that, once we know 6, 7, and 8, then the decision nodes will be. At the decision nodes select the decision that leads to the best expected value. Here, the best-expected value is whichever provides the highest expected value. This expected value becomes the expected value at the decision node. So out of the 6, 7, and 8, we have to see which has the highest expected value. That value should be written in the decision node.

For example, for chance node 6, what is the expected value? 0.94 into 8 0.06 multiplied by 7. We got 7.94. For the 7th node, we got 13.46. For 8th, we got 18.26. For 9th, we got 7.35.

Calculations of each node are given below:

$$EV(\text{Node 6}) = 0.94(8) + 0.06(7) = 7.94$$

$$EV(\text{Node 7}) = 0.94(14) + 0.06(5) = 13.46$$

$$EV(\text{Node 8}) = 0.94(20) + 0.06(29) = 18.26$$

$$EV(\text{Node 9}) = 0.35(8) + 0.65(7) = 7.35$$

For 10th, we got 8.15. For 11th 1.15. 12th 7.80. 13th 12.20. 14th 14.20. So we have found the expected value for all the chance nodes which are in the extreme right.
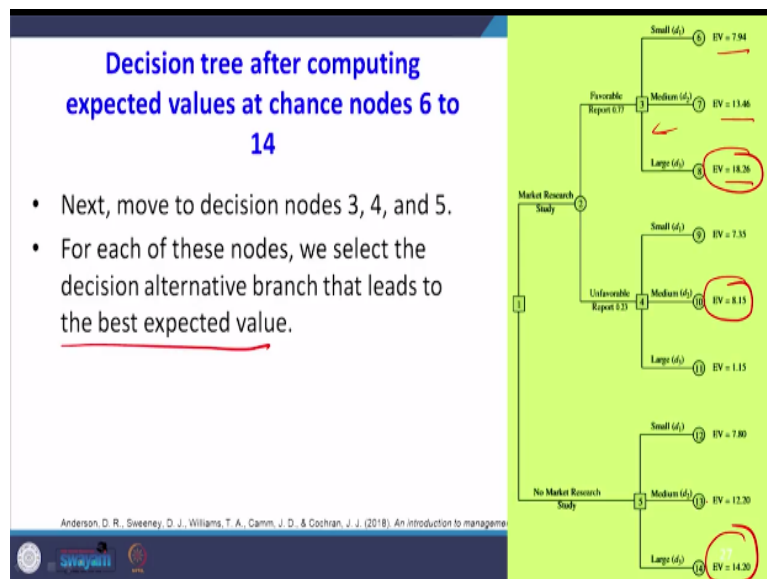
Calculations of each node are given below:

EV(Node 10) = 0.35(14) + 0.65(5) = 8.15

EV(Node 11) = 0.35(20) + 0.65(29) = 1.15

EV(Node 12) =0.80(8) + 0.20(7) = 7.80

EV(Node 13) = 0.80(14) + 0.20(5) = 12.20
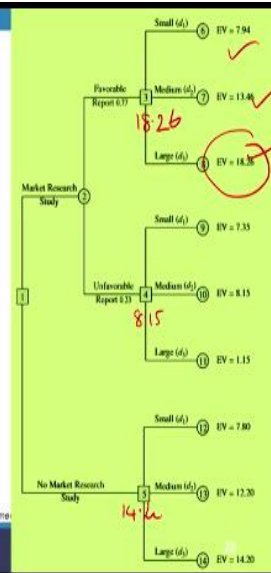
EV(Node 14) = 0.80(20) + 0.20(29) = 14.20

See that I have shown this in the pictures 7.94, 13.46, 18.26, and so on. Now, next, move to the decision nodes 3, 4, and 5. Now we have to move the left side 3, 4, 5. For each of these nodes, we select the decision alternative branch that leads to the best-expected value. So out of these 6, 7, 8 which is best? 18.46 is the best. Out of 9, 10, 11 which is best?

This is best. Out of 12, 13, 14, which is the best? This is the best. So this value we are going to enter into the decision nodes 3, 4, 5.

For example, at node 3, we have the choice of the small complex branch with EV (node 6) 7.94. For EV(node 7) = 13.46. And EV(node 8) = 18.26. So here we select the large complex decision alterna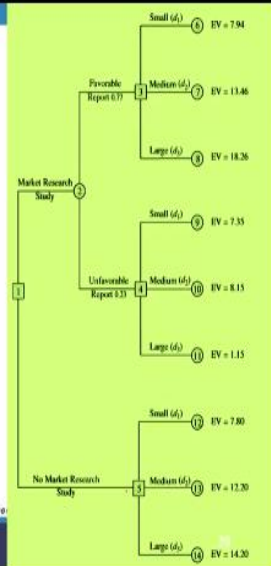tive branch, and the expected value at node 3 becomes 18.26. Because out of these, out of these three, which is the highest? 18.26 is the highest. So, the value we are going to enter here is 18.26. Similarly, here we are going to enter at 8.15. Here it is 14.20.
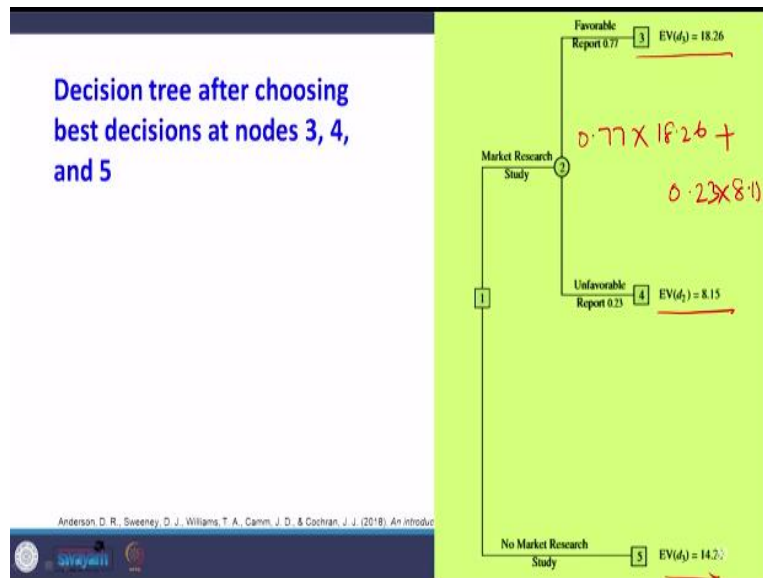

I have already explained this.

Decision tree after choosing best decisions at nodes 3, 4, and 5

Now see that we have got 18.26, 8.15 and 14.20. Now, again, we have to find out the expected value for the chance node 2. So how will you find the expected value? 0.77 multiplied by 18.26 plus 0.23 multiplied by 8.15.

Decision tree after choosing best decisions at nodes 3, 4, and 5

- The expected value at chance node 2 can now be computed as follows:
- EV(Node 2) = 0.77EV(Node 3) + 0.23EV(Node 4)
- = 0.77(18.26) + 0.23(8.15) = 15.93
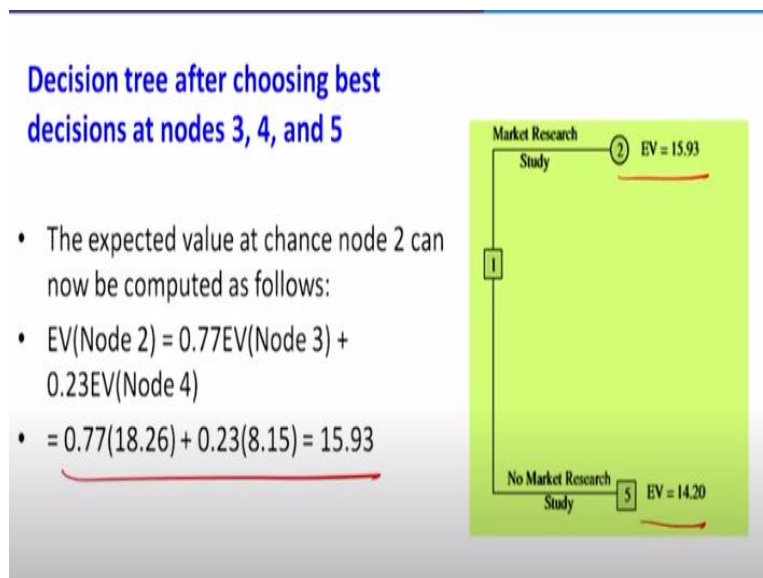
We are getting it on 15.93. So here we have entered 15.93, here we are having 14.20. The expected value at chance node 2 can now be computed as follows:

EV(Node 2) = 0.77EV(Node 3) + 0.23EV(Node 4)
= 0.77(18.26) + 0.23(8.15) = 15.93

Decision tree after choosing best decisions at nodes 3, 4, and 5

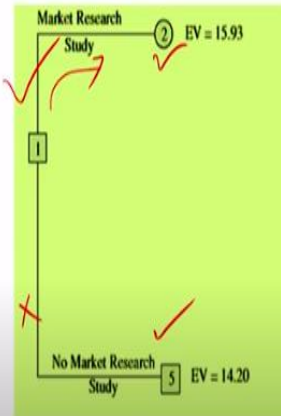- Finally, the decision can be made at decision node 1 by selecting the best expected values from nodes 2 and 5.
- This action leads to the decision alternative to conduct the market research study, which provides an overall expected value of 15.93.

Finally, the decision can be made at decision node 1 by selecting the best expected value between 2 and 5. This action leads to the decision to be an alternative to conduct a market research study because this is the highest value. So instead of going there, we should go there, because that overall expected value is 15.93.

Optimal decision for the company

- The optimal decision for the company is to conduct the market research study and then carry out the following decision strategy:
- If the market research is favorable, construct the large condominium complex.
- If the market research is unfavorable, construct the medium condominium complex.
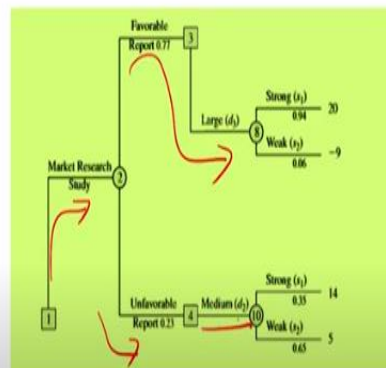
Now it is an optimal decision for the company. The optimal decision for the company is to conduct a market research study. First, you conduct the market research study and then carry out the following decision strategy. If the market research is favorable, we should go for a large condominium complex. If the market research is unfavorable, we should go for a medium complex size. So, this is our final decision for the company.

Steps in decision tree

- The analysis of the company's decision tree describes the methods that can be used to analyze more complex sequential decision problems.
- First, draw a decision tree consisting of decision and chance nodes and branches that describe the sequential nature of the problem.
- Determine the probabilities for all chance outcomes.

So, if I summarize, what are the steps in the decision tree? The analysis of the company's decision tree describes the method that can be used to analyze more complex sequential decision problems. So first draw a decision tree consisting of decision and chance nodes and branches that describe the sequential nature of the problem. Then determine the probability for all the chance outcomes.

Here the probability is already given to you. In the next lecture, I will explain how to determine the probabilities, but at present, assume that the probabilities are given to you.

Steps in decision tree

- Then, by working backward through the tree, compute expected values at all chance nodes and select the best decision branch at all decision nodes.
- The sequence of optimal decision branches determines the optimal decision strategy for the problem.

Then, by working backward through the tree, compute the expected value at all chance nodes and select the best decision branch at all decision nodes. The sequence of optimal decision branches determines the optimal digital strategy for the problem.

Dear students, in this lecture, I have discussed decision analysis with the sample information. I have explained the concept of prior and posterior probability.

Then I have explained how to construct a decision tree. Then, by working backward through the decision tree, I have explained how to propose the decision strategy. In the next lecture, I will explain how to calculate the branch probabilities using Bayes' Theorem. Thank you very much.