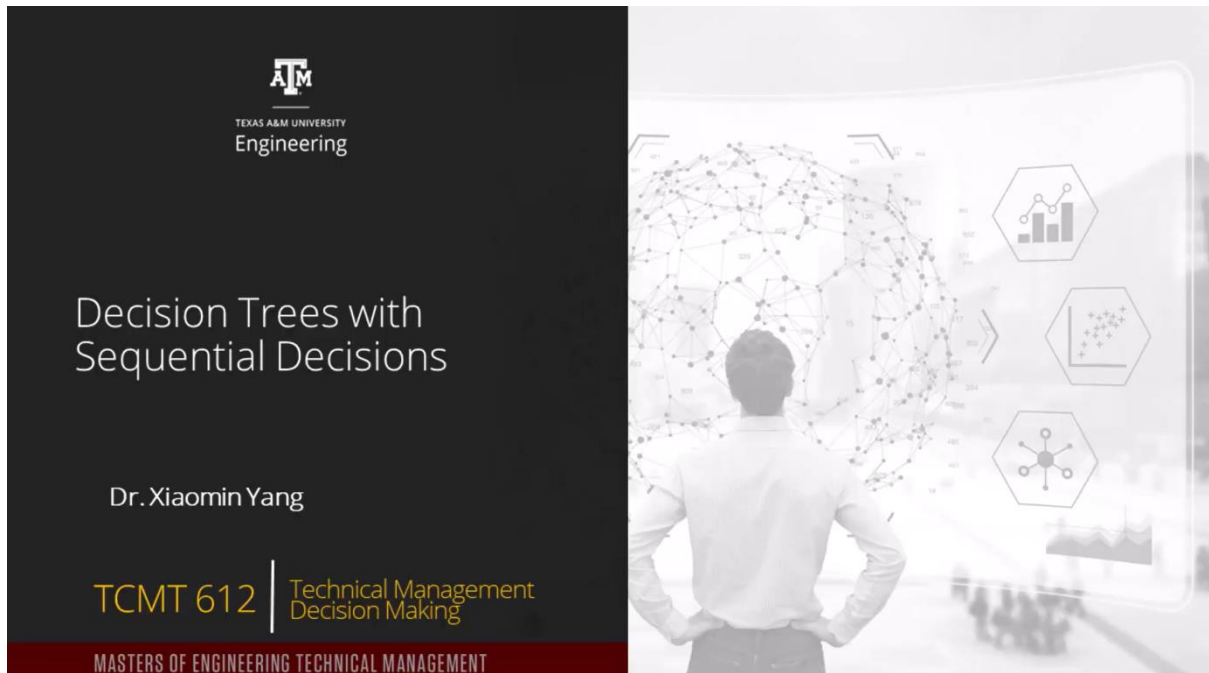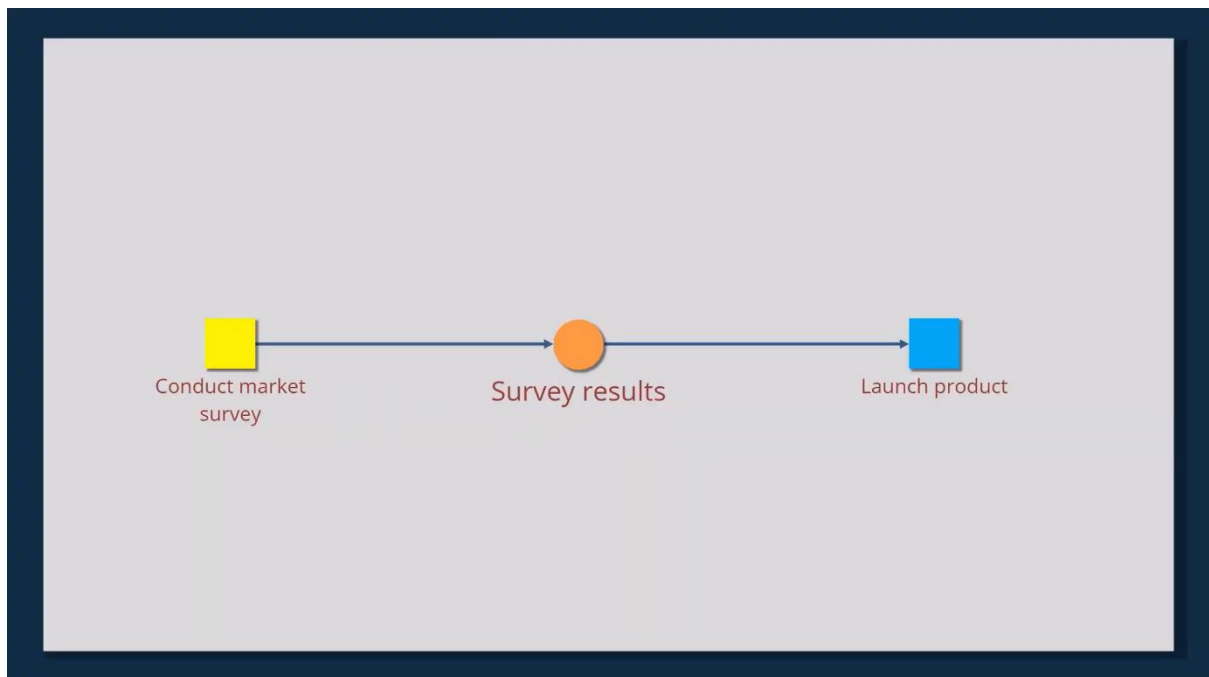# M4L11. Decision Trees with Sequential Decisions

Slide #1

In this topic, we will discuss how to analyze sequential decisions with decision trees.

Slide #2

Suppose that prior to making the launch or no launch decision, the firm would commission a survey that would help the firm forecast how well the market will respond to the product launch.

The survey will generate valuable information for a company to manage the risks associated with the market uncertainty.

Based on the survey results, the company can make a decision on whether to launch the product.

Slide #3
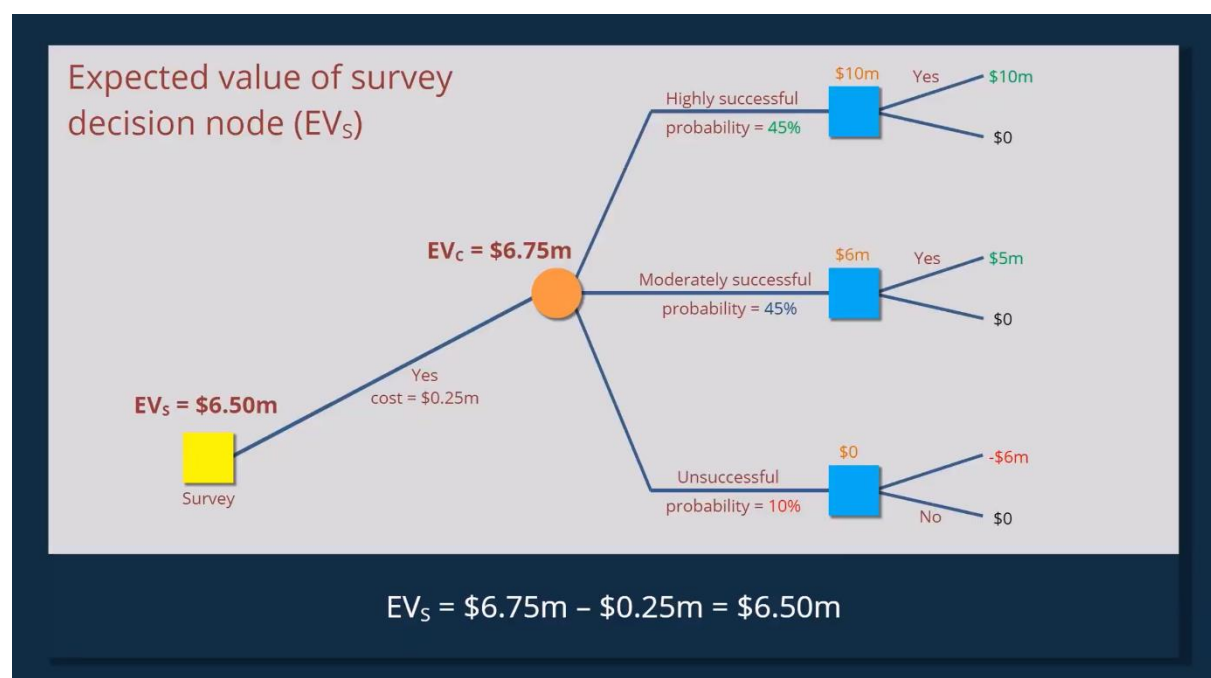
Of course, whether to conduct the survey is itself a decision.

So, we will start with a decision node for a survey.

The cost of the survey is $250,000.

The market may respond to the new product with three possible outcomes.

The node after the survey node is a chance event node and it has three branches.

Each represents one of the three market response possibilities.

The survey results will confirm one of the three possibilities.

After receiving the survey results, the firm will make product launch decisions.

So we need to add a product decision node after each possible survey outcome.

For instance, assuming the survey confirms that the product will be certainly highly successful, then your decision would be obvious.

You will choose to launch the product, so the value of the product decision is 10 million dollars for the highly successful scenario.

At the planning stage, you are not sure which scenario the survey will confirm, so we still need to include the launch decision node for each outcome branch.

If the survey results predicted that the product launch will be moderately successful, the firm should choose to launch the product since this decision will create a 5 million dollar profit.

So the value of the product decision is 5 million dollar for the moderately successful scenario.

However, if the survey results show that the market will reject the product, the firm should choose not to launch the product.

Otherwise, the firm will lose 6 million dollars from producing the product.

So the value of the product decision is zero for the unsuccessful scenario.

The rightmost nodes are all decision nodes.

Note that they follow the chance node because if the firm does a survey, it will know how successful its new product will be at the time it decides whether to launch the product.

At the top two decision nodes, the firm would launch the product because positive amounts of money beat nothing.

While at the bottom of the decision node, it would not launch the product because otherwise it's going to lose 6 million dollars and 0 beats, suffering a loss.

When the firm launched the survey, it did not know the outcome of this survey, so what it will learn from the survey is uncertain.

This is reflected by the chance node that precedes the decision node.

The expected value of the survey chance node is equal to 45% multiplied by 10 million dollars plus 45% multiplied by 5 million dollars, which represents the payoff of the moderately successful scenario plus 10% multiplied by 0.

Which means, if survey shows the product is not successful, the firm will decide not to launch the product.

So, the expected value is 6.75 million dollars.

Since the survey cost $250,000, the expected payoff with conducting the survey is 6.75 million dollars minus 0.25 million, which is 6.5 million dollars.

So the expected value of conducting a survey followed by a product launch decision is 6.5 million dollars.

Slide #4
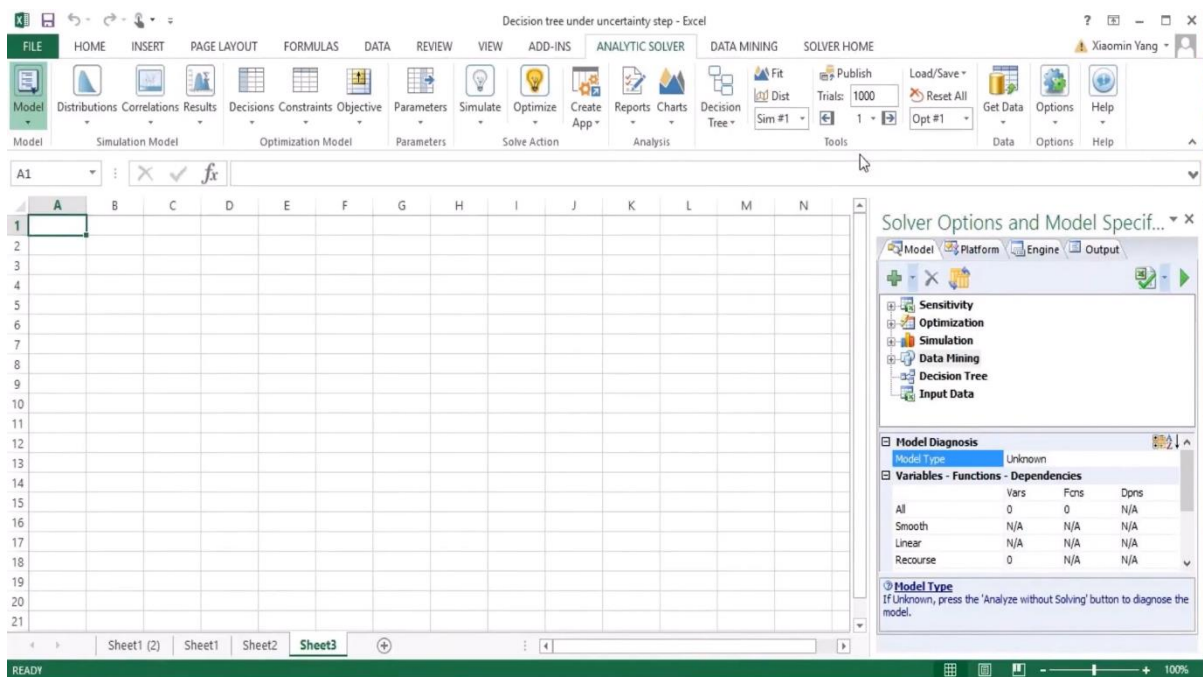
I am going to demonstrate how to build the above decision tree with analytic solver.

To build the decision tree, click decision tree, node, add node.

This is a decision node.

For market survey, we are going to have two decisions, conduct survey and no survey.

The survey itself will cost $250,000.

So, we add negative value, and this is the first decision, the survey decision.

Pick the terminal on conduct survey, add node, and this is the event node.

There are three possible outcomes from the survey.

Market response.

The first possibility is highly successful. This is the best case scenario. The chance of this scenario is 45%.

Because the product launch is after the survey, so the value of the scenario is zero.

We are just doing a survey. We are not launching any product yet.

So the value of each scenario is zero.

The third scenario is unsuccessful.

There is a 10% chance.

Again, the value of each scenario is zero because we have not made the product launch decision yet.

This is the event node of survey.

Three possibilities.

Now we are going to add a decision node.

The product decision node, launch product.

One decision is to launch the product.

Since in this case, this is the best case scenario, we know the return is 10 million dollars.

The second decision is cancel the product launch.

And we are not going to lose anything.

So it is a zero.

We do not earn any money.

For the second market response scenario, we add another node by copy and paste and we need to change the node to give it a different number because in this case the payoff is 5 million dollars.

So, I change it to 5 million dollars.

We go to the terminal node of the third scenario, unsuccessful, replace the node, and then we are going to change the node.

Another way to change the node is go to the model window and take the node, select the node.

In this case, because the market response is not favorable.

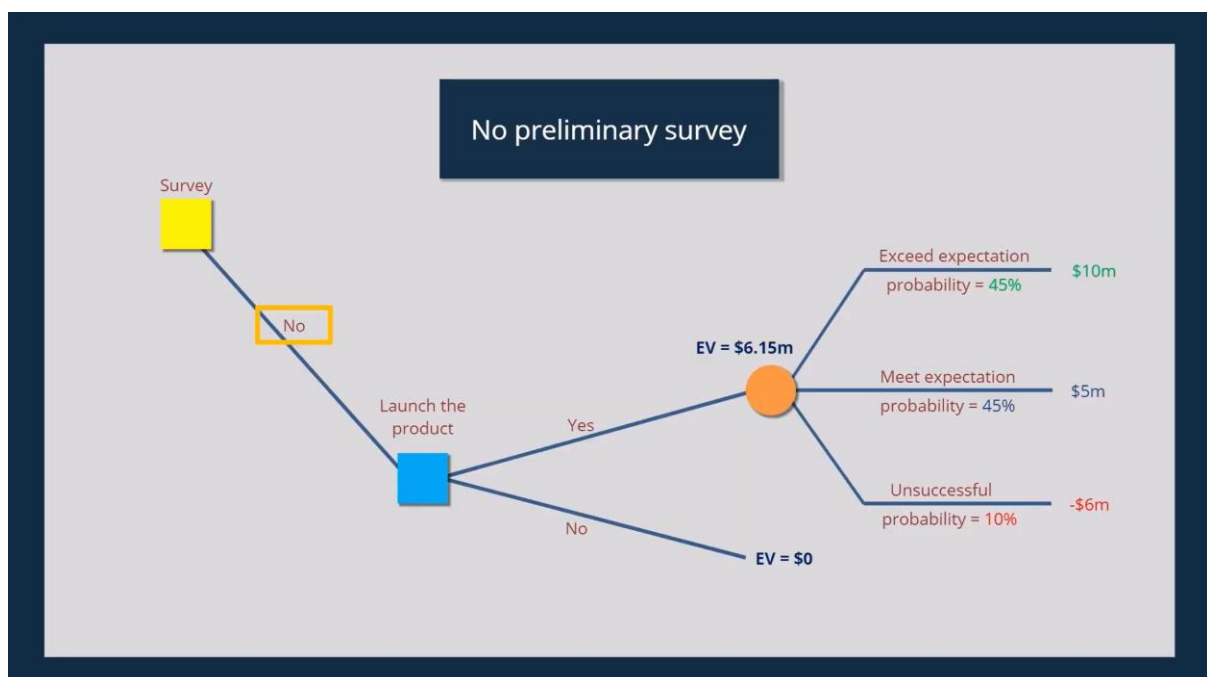So if we launch the product, we are going to lose 6 million dollars.

So if survey shows that the market does not respond, we would not launch the product.

Our decision will be cancel the product.

Finally, review the full tree and adjust the width of the cells if necessary.

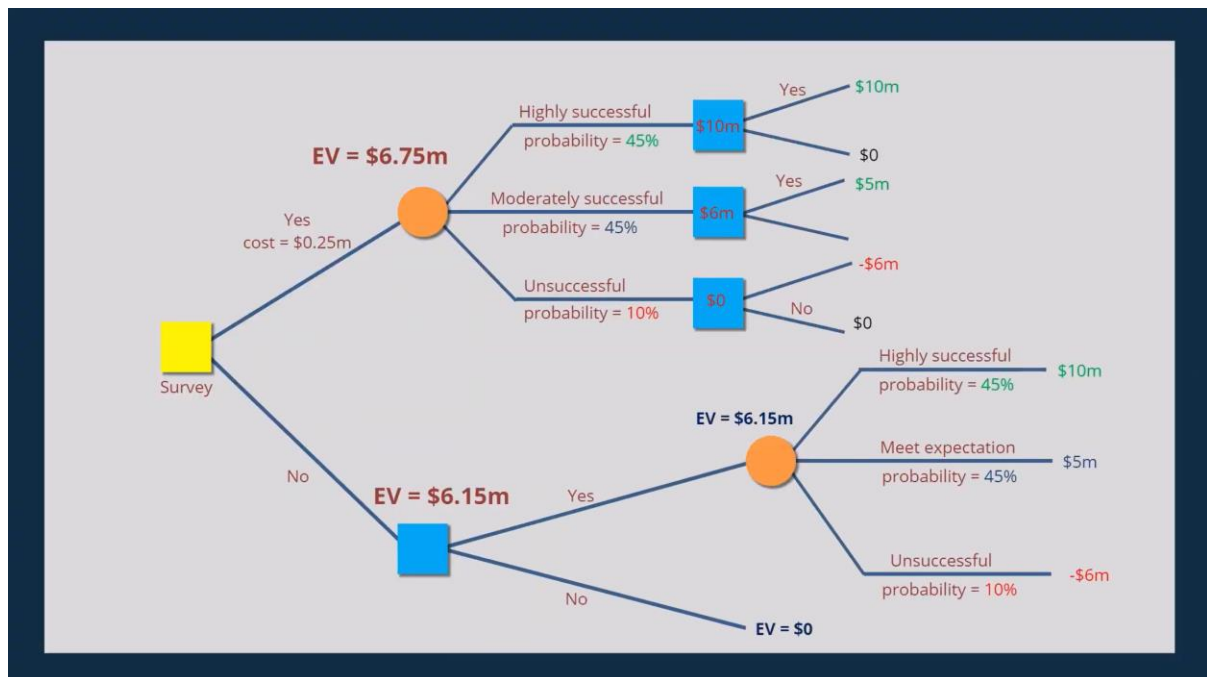Clean up the tree and double check the information to make sure every number is correct.

Slide #5

If we do not conduct the market survey and launch the product, the decision tree structure of this action is the same as what we discussed.

The product will be launched without knowing how the market will respond. The expected payoff without a survey is $6,150,000.
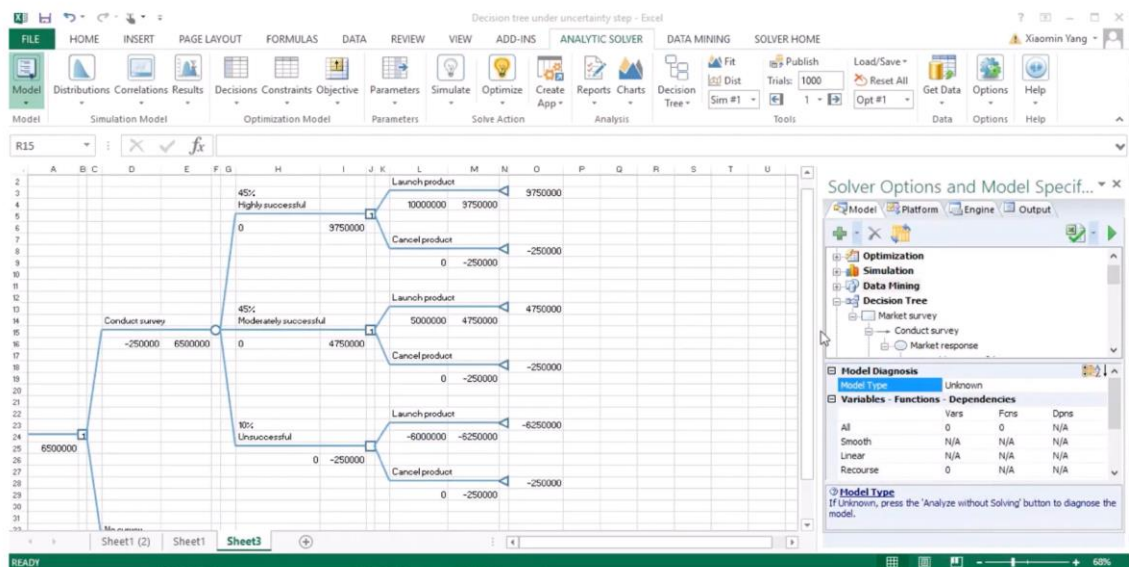
Slide #6

We can combine the decision trees with and without a survey to create the final version of the decision tree.

Slide #7

With Analytics Solver, it will be quite easy to combine the two decision trees together to make the final tree.

Let me show you how you can do that with node copy and paste functions.

We can add the product launch without survey decision tree.

By copying the tree we built already into this new one.

Click on decision tree, node, copy node.

Go to the new tree, select the terminal, then node and paste node.

Now we can see the product launch without a survey decision node is added to this tree.

Now we have conduct the survey and product launch decision all together on this tree.

Zoom out to see the entire tree.

When we go to the model window, we can see the decision node and event node in this window.

We go to the tree, select highlight best to solve the tree.

The green part represent the decisions that give us the best expected value.

For example, should we decide to do the survey and the survey result shows the market response is excellent.
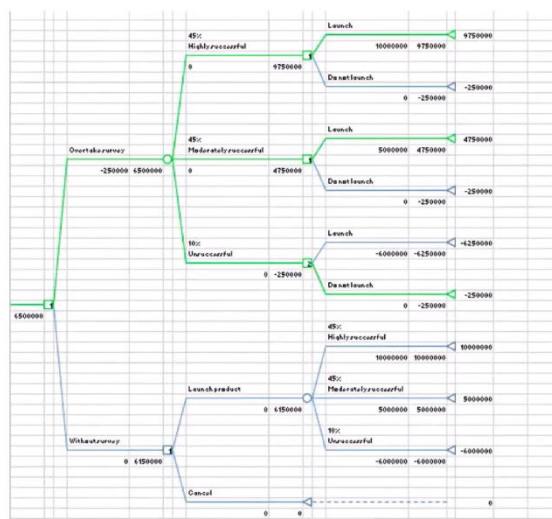
We launched the product.

If the product doesn't work, we shouldn't launch the product.

This combination of decisions will give us an expected value of $6,750,000.

This is the final version of the decision tree.

The highlighted decision and branches represent the course of action that generated the highest expected value or payoff.

If we choose to conduct the survey and make product decisions based on the survey results, the combination of decisions will generate 6.5 million dollars expected value after spending $250,000 on the survey.

Without the survey, the product launch will generate $6,150,000 expected value as shown in the blue part of the decision tree.

We can do other analyses with the decision tree.

Slide #9
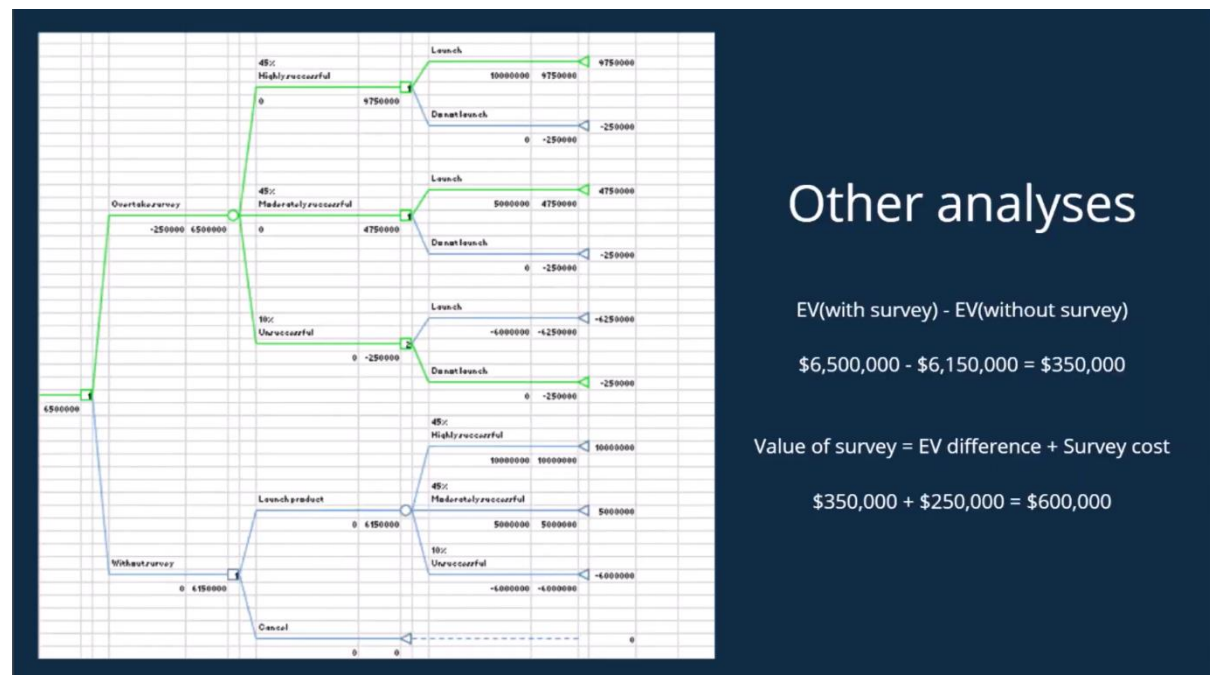
For instance, the difference in the expected payoff with the survey and the expected value without the survey was $350,000.

The survey is the only difference between the two decisions.

So, the value of the survey is $600,000, which is also on top of the $250,000 survey cost already.

So, the firm would pay up to $850,000 to have this survey conducted.

The value of the market information is $850,000.