

AGENDA

A 5 min Plan for Class 6 and Week 6

B 70 min **Lecture 6, Part 1:** Decision Analysis and Support in Organizations

- 1** Decision making and decision analysis
- 2** Decision making under certainty and uncertainty
- 3** Decision making under risk

15 min break

C 20 min **Lecture 6, Part 2:** Decision Analysis and Support in Organizations

- 4** Decision trees analysis

D 40 min In-Class Group Exercise **GW6-1:** Preparation for Assignment 2

E 15 min Discussion Forum Week 6 and Preparation for Quiz 3: Q & A

F (During W6) **Individual Exercise IW6-2:** Working with Tutorial for AD715
'Decision Trees in Tree Plan – How to Prepare Assignment 2

Preparation for Class 6 and Week 6

FOUNDATIONS OF MANAGERIAL DECISION MAKING (MDM)	L-1: Foundations of MDM	L-3: Managing Group Decisions & Negotiations				
	L-2: Improving Individual Judgment in MDM	L-4: Strategic Decision Making in Organizations				
DECISION ANALYSIS & DECISION SUPPORT IN BUSINESS			L-5: Quantitative Analysis and DM			
			L-6: Decision Analysis & Support in Business			
APPLICATIONS OF MANAGERIAL DECISION MAKING				L-7: Marketing Management and DM	L-9: Operations Management and DM	L-11: Performance Management and DM
				L-8: Financial Management and DM	L-10: Innovation Management and DM	L-12: Managers of 21 st Century and MDM

Preparation for Class 6 and Week 6

Week Date	Modules & Topics	Readings	Discussion Topics	Individual Exercises & Assignments & Quizzes
Week 6 A1: 10/20 – 10/26 A2: 10/20 – 10/26 A7: 10/7 – 10/13 A8: 10/8 – 10/14 Class #6 A1: 10/20 (Tue) A2: 10/20 (Tue) A7: 10/7 (Wed) A8: 10/8 (Thu)	Lecture 6 Decision Analysis and Decision Support in Business Part 1: B 1 2 3 Part 2: C 4	e-Reserve Render, Ch. 3: Decision Analysis Problems with Solutions from Ch.3	A Plan for Class 6 and Week 6 Bb Discussion Forum Week 6 E	In-Class <u>Group</u> Exercise GW6-1: Preparation for Assignment 2 (Tasks 2.1 to 2.4) D Individual Exercise IW6-2: Working with Tutorial for AD715 “ <i>Decision Trees in TreePlan – How to Prepare Assignment 2</i> ” F Quiz 3: open on Monday 10/12 at 9am ET until 10/13 at 11:59pm ET E ay

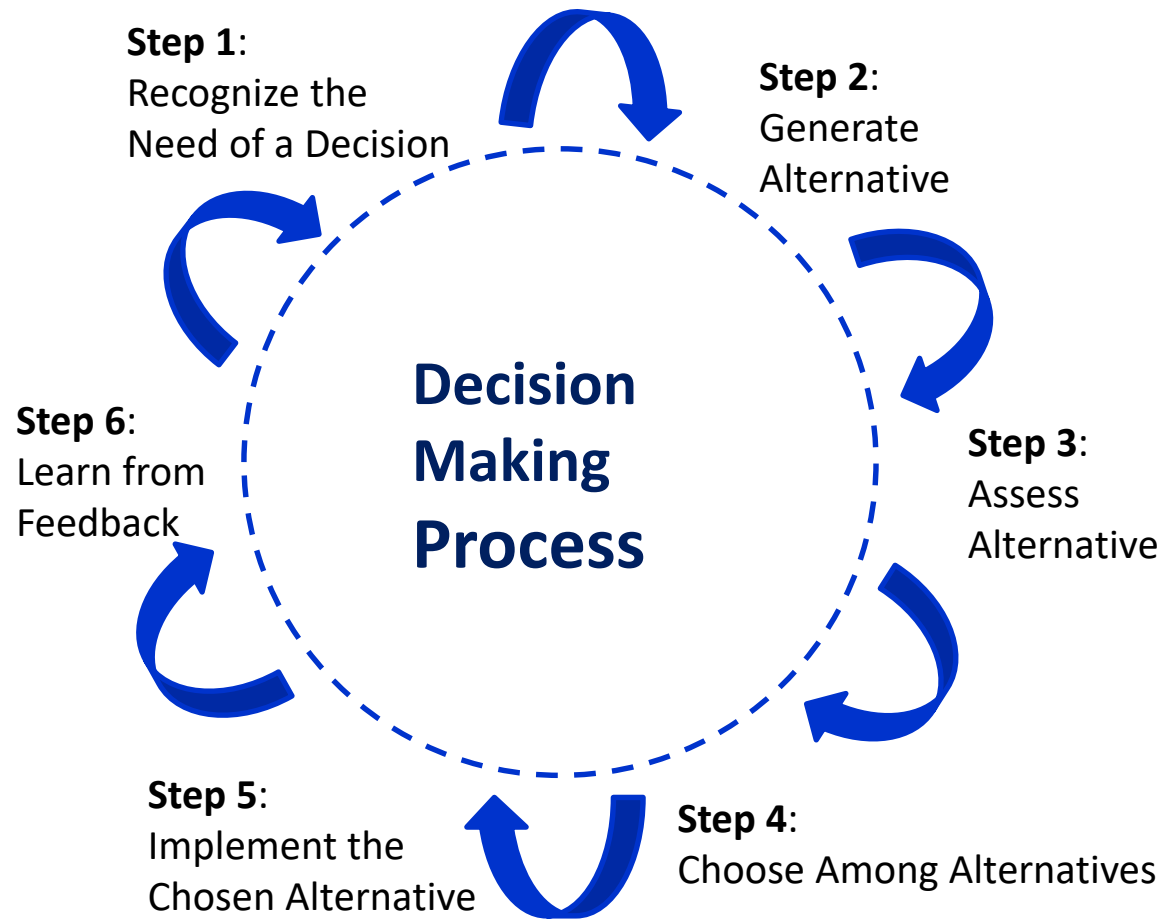
L6: LEARNING OBJECTIVES

After you complete this lecture, you will be familiar with the following concepts:

- 1** Decision making and decision analysis – an introduction
- 2** Decision making under certainty and uncertainty
- 3** Decision making under risk
- 4** Decision trees analysis & Using software for payoff table and decision tree problems

Decision Making and Decision Analysis – An Introduction

The Steps in the Managerial Decision Making Process



The Six Steps in
Decision Making: Decision
Analysis Prospective

1. Clearly define the problem at hand
2. List the possible alternatives
3. Identify the possible outcomes or states of nature
4. List the payoff (typically profit) of each combination of alternatives and outcomes
5. Select one of the mathematical decision theory models
6. Apply the model and make your decision

Decision Making and Decision Analysis – An Introduction

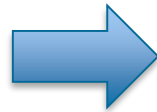
Demonstration of the Decision Making Process as a Step-By-Step Analytical Approach



Business Running Case: Thompson Lumber Company

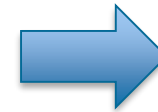
Step 1 – Define the problem

- Consider expanding by manufacturing and marketing a new product – backyard storage sheds



Step 2 – List possible alternatives

- Construct a large new plant
- Construct a small new plant
- Do not develop the new product line



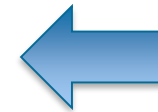
Step 3 – Identify possible outcomes or states of nature

- The market could be favorable or unfavorable



Step 4 – List the payoffs

- Identify **conditional values** for the profits for large plant, small plant, and no development for the two possible market conditions



Step 5 – Select the decision model

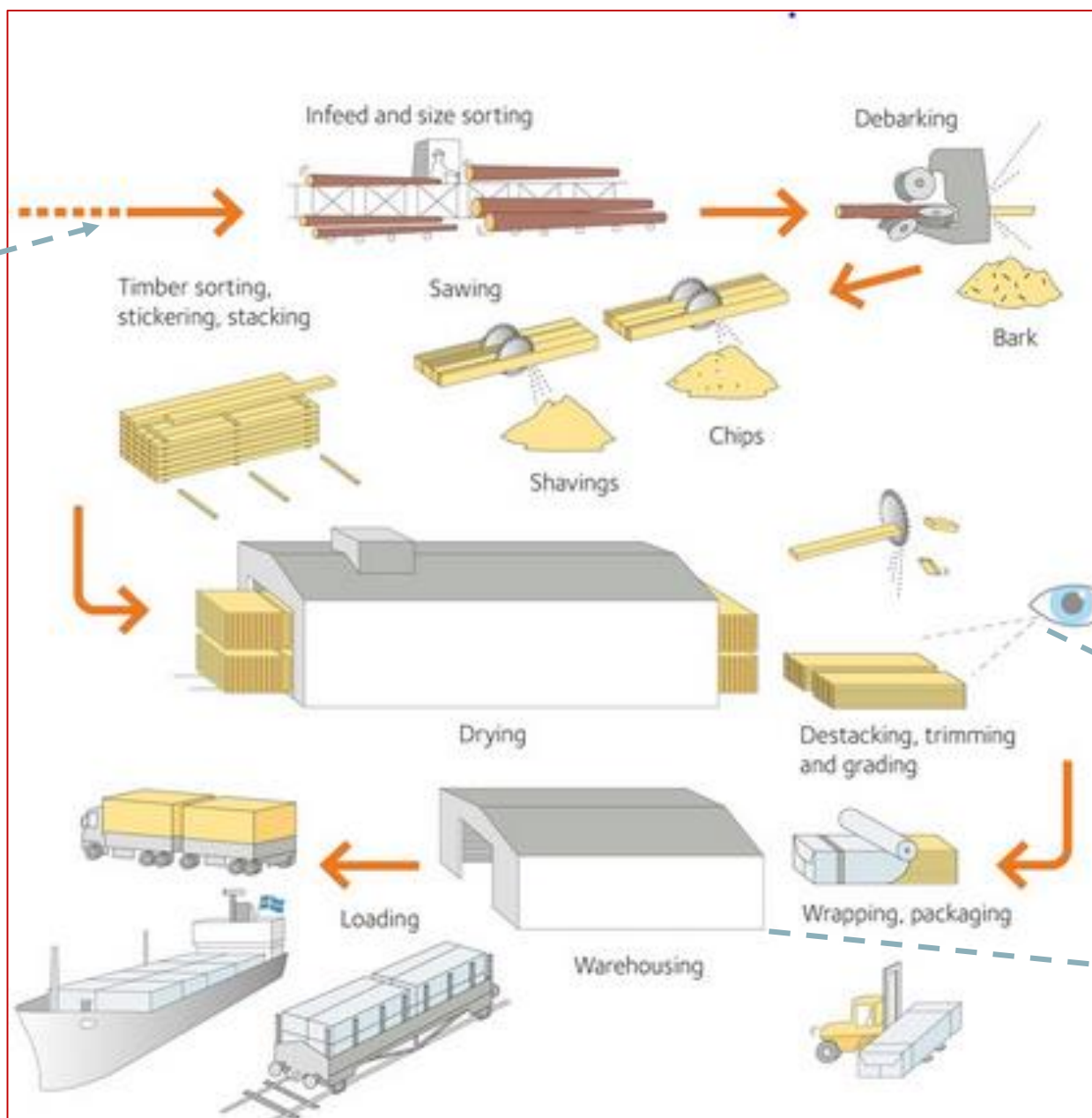
- Depends on the environment and amount of risk and uncertainty



Step 6 – Apply the model to the data



Decision Making and Decision Analysis – An Introduction



Images of
a Lumber
Company



Dimension Lumber Sizes			
Surfaced Dry(S-Dry), Size, mm	Surfaced Dry (S-Dry), Size, in. (actual)	Rough Sawn Size, in. (nom.)	Surfaced Green (S-Grn) Size, in. (actual)
38 x 38	1-1/2 x 1-1/2	2 x 2	1-9/16 x 1-9/16
38 x 64	1-1/2 x 2-1/2	2 x 3	1-9/16 x 2-9/16
38 x 89	1-1/2 x 3-1/2	2 x 4	1-9/16 x 3-9/16
38 x 140	1-1/2 x 5-1/2	2 x 6	1-9/16 x 5-5/8
38 x 184	1-1/2 x 7-1/4	2 x 8	1-9/16 x 7-1/2
38 x 235	1-1/2 x 9-1/4	2 x 10	1-9/16 x 9-1/2
38 x 286	1-1/2 x 11-1/4	2 x 12	1-9/16 x 11-1/2
64 x 64	2-1/2 x 2-1/2	3 x 3	2-9/16 x 2-9/16
64 x 89	2-1/2 x 3-1/2	3 x 4	2-9/16 x 3-9/16
64 x 140	2-1/2 x 5-1/2	3 x 6	2-9/16 x 5-5/8
64 x 184	2-1/2 x 7-1/4	3 x 8	2-9/16 x 7-1/2
64 x 235	2-1/2 x 9-1/4	3 x 10	2-9/16 x 9-1/2
64 x 286	2-1/2 x 11-1/4	3 x 12	2-9/16 x 11-1/2
89 x 89	3-1/2 x 3-1/2	4 x 4	3-9/16 x 3-9/16
89 x 140	3-1/2 x 5-1/2	4 x 6	3-9/16 x 5-5/8
89 x 184	3-1/2 x 7-1/4	4 x 8	3-9/16 x 7-1/2
89 x 235	3-1/2 x 9-1/4	4 x 10	3-9/16 x 9-1/2
89 x 286	3-1/2 x 11-1/4	4 x 12	3-9/16 x 11-1/2

Decision Making and Decision Analysis – An Introduction

Business Running Case: Thompson Lumber Company

Step 2 – List possible alternatives

- Construct a large new plant
- Construct a small new plant
- Do not develop the new product line

The easiest way to present the combination of decision alternatives, possible states of nature, and conditional values for each one of the possible decision alternatives and states of nature is called **decision table** or **payoff table**.

Decision Table (Payoff Table)
with Conditional Values

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	200,000	−180,000
Construct a small plant	100,000	−20,000
Do nothing	0	0

Step 3 – Identify possible outcomes or states of nature

- The market could be favorable or unfavorable

States of Nature:
Outcomes over which the decision makers has little or no control

Decision Making and Decision Analysis – An Introduction

Business Running Case: Thompson Lumber Company

Step 4 – List the payoffs

- Identify **conditional values** for the profits for large plant, small plant, and no development for the two possible market conditions

Conditional Values:

Possible combination of alternatives and outcomes, also called payoffs.

Payoffs can be based on money or any appropriate means of measuring benefits.

Decision Table (Payoff Table) with Conditional Values

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	200,000	-180,000
Construct a small plant	100,000	-20,000
Do nothing	0	0

Net profit of \$200,000 is a **conditional value** because receiving the money is conditional upon both building a large factory and having a good (favorable) market

Net loss of \$180,000 is a **conditional value** because receiving the money is conditional upon both building a large factory and having an unfavorable market

Types of Decision-Making Environments

- **Decision making under certainty**
 - The decision maker knows with certainty the consequences of every alternative or decision choice
- **Decision making under uncertainty**
 - The decision maker does not know the probabilities of the various outcomes
- **Decision making under risk**
 - The decision maker knows the probabilities of the various outcomes

Decision Making Under Certainty

The decision makers know with certainty the consequence of every alternative or decision choice

Example:

You have \$10,000 to invest for a one year period

Existing alternatives to invest in two equally secure and guaranteed investments:

	Consequences (Return after 1 year in interest)
• Alternative #1 is to open a saving account paying 4% interest	\$400
• Alternative #2 is to invest in a government Treasury bond paying 6% interest	\$600

Decision Choice: Select **Alternative #2** (\$600 > \$400)

Decision Making Under Uncertainty

Criteria for making decisions under uncertainty

1. Maximax (optimistic)
2. Maximin (pessimistic)
3. Criterion of realism (Hurwicz)
4. Equally likely (Laplace)
5. Minimax regret

Decision Making Under Uncertainty

→ Maximax Decision

→ Maximin Decision

Optimistic

Used to find the alternative that maximizes the maximum payoff – **maximax** criterion

- Locate the maximum payoff for each alternative
- Select the alternative with the maximum number

Pessimistic

Used to find the alternative that maximizes the minimum payoff – **maximin** criterion

- Locate the minimum payoff for each alternative
- Select the alternative with the maximum number

Business Running Case: Thompson Lumber Company

Maximax Decision

ALTERNATIVE	STATE OF NATURE		MAXIMUM IN A ROW (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	200,000
Construct a small plant	100,000	-20,000	100,000
Do nothing	0	0	0

Maximax

Maximin Decision

ALTERNATIVE	STATE OF NATURE		MINIMUM IN A ROW (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	-180,000
Construct a small plant	100,000	-20,000	-20,000
Do nothing	0	0	0

Maximin

Criterion of Realism (Hurwicz)

Often called **weighted average**

- Compromise between optimism and pessimism
- Select a coefficient of realism α , with $0 \leq \alpha \leq 1$
 - $\alpha = 1$ is perfectly optimistic
 - $\alpha = 0$ is perfectly pessimistic
- Compute the weighted averages for each alternative
- Select the alternative with the highest value

Weighted average = $\alpha(\text{best in row}) + (1 - \alpha)(\text{worst in row})$

Business Running Case: Thompson Lumber Company

→ For the large plant alternative using $\alpha = 0.8$

$$(0.8)(200,000) + (1 - 0.8)(-180,000) = 124,000$$

→ For the small plant alternative using $\alpha = 0.8$

$$(0.8)(100,000) + (1 - 0.8)(-20,000) = 76,000$$

Criterion of Realism Decision

ALTERNATIVE	STATE OF NATURE		CRITERION OF REALISM ($\alpha = 0.8$) \$
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	124,000 Realism
Construct a small plant	100,000	-20,000	76,000
Do nothing	0	0	0

Equally Likely (Laplace)

Considers all the payoffs for each alternative

- Find the average payoff for each alternative
- Select the alternative with the highest average

Equally Likely Decision

Business Running Case: Thompson Lumber Company

ALTERNATIVE	STATE OF NATURE		ROW AVERAGE (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	10,000
Construct a small plant	100,000	-20,000	40,000
Do nothing	0	0	0

Equally likely

Minimax Regret

Based on **opportunity loss** or **regret** → The difference between the optimal profit and actual payoff for a decision

1. Create an opportunity loss table by determining the opportunity loss from not choosing the best alternative
2. Calculate opportunity loss by subtracting each payoff in the column from the best payoff in the column
3. Find the maximum opportunity loss for each alternative and pick the alternative with the minimum number

Business Running Case: Thompson Lumber Company

Determining Opportunity Losses

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	$200,000 - 200,000$	$0 - (-180,000)$
Construct a small plant	$200,000 - 100,000$	$0 - (-20,000)$
Do nothing	$200,000 - 0$	$0 - 0$

Minimax Decision Using Opportunity Loss

ALTERNATIVE	STATE OF NATURE		MAXIMUM IN A ROW (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	0	180,000	180,000
Construct a small plant	100,000	20,000	100,000
Do nothing	200,000	0	200,000

Minimax

Opportunity Loss Table

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	0	180,000
Construct a small plant	100,000	20,000
Do nothing	200,000	0

Expected Monetary Value (EMV)

When there are several possible states of nature and the probabilities associated with each possible state are known

- Most popular method – choose the alternative with the highest expected monetary value (EMV)

$$\text{EMV}(\text{alternative}) = \sum X_i P(X_i)$$

where

X_i = payoff for the alternative in state of nature i

$P(X_i)$ = probability of achieving payoff X_i
(i.e., probability of state of nature i)

$\sum$ = summation symbol

**Expanding the equation**

EMV (alternative i) = (payoff of first state of nature)
x (probability of first state of nature)
+ (payoff of second state of nature)
x (probability of second state of nature)
+ ... + (payoff of last state of nature)
x (probability of last state of nature)

Business Running Case: Thompson Lumber Company (EMV)

- Each market outcome has a probability of occurrence of 0.50
- Which alternative would give the highest EMV?

$$\begin{aligned}\text{EMV (large plant)} &= (\$200,000)(0.5) + (-\$180,000)(0.5) \\ &= \$10,000 \\ \text{EMV (small plant)} &= (\$100,000)(0.5) + (-\$20,000)(0.5) \\ &= \$40,000 \\ \text{EMV (do nothing)} &= (\$0)(0.5) + (\$0)(0.5) \\ &= \$0\end{aligned}$$

Decision Table with Probabilities and EMVs

ALTERNATIVE	STATE OF NATURE		EMV (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	10,000
Construct a small plant	100,000	-20,000	40,000
Do nothing	0	0	0
Probabilities	0.5	0.5	

Best EMV

Expected Value of Perfect Information (EVPI)

EVPI places an upper bound on what you should pay for additional information

EVwPI is the long run average return if we have perfect information before a decision is made

$$\text{EVwPI} = \sum (\text{best payoff in state of nature } i) (\text{probability of state of nature } i)$$

Expanded EVwPI becomes

$$\begin{aligned} \text{EVwPI} = & (\text{best payoff for first state of nature}) \\ & \times (\text{probability of first state of nature}) \\ & + (\text{best payoff for second state of nature}) \\ & \times (\text{probability of second state of nature}) \\ & + \dots + (\text{best payoff for last state of nature}) \\ & \times (\text{probability of last state of nature}) \end{aligned}$$

and

$$\text{EVPI} = \text{EVwPI} - \text{Best EMV}$$

Business Running Case: Thompson Lumber Company (EVPI)

- Scientific Marketing, Inc. offers analysis that will provide certainty about market conditions (favorable)
- Additional information will cost \$65,000

Should Thompson Lumber purchase the information?

Decision Table with Perfect Information

ALTERNATIVE	STATE OF NATURE		EMV (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	200,000	-180,000	10,000
Construct a small plant	100,000	-20,000	40,000
Do nothing	0	0	0
Probabilities	0.5	0.5	
With Perfect Information	200,000	0	100,000

Best EVwPI

$$\text{EVPI} = \text{EVwPI} - \text{Best EMV} = \$100,000 - \$40,000 = \$60,000$$

Therefore, the maximum Thompson should pay for the additional information is \$60,000

SOLUTION: Thompson should not pay \$65,000 for this information

Best EMV The maximum EMV without additional information is \$40,000

$$\text{EVwPI} = \$200,000 \times 0.5 + \$0 \times 0.5 = \$100,000$$

where \$200,000 is best payoff for first state of nature

\$0 is the best payoff for second state of nature

Expected Opportunity Loss

Expected opportunity loss (EOL) is the cost of not picking the best solution

- Construct an opportunity loss table
- For each alternative, multiply the opportunity loss by the probability of that loss for each possible outcome and add these together
- Minimum EOL will always result in the same decision as maximum EMV
- Minimum EOL will always equal EVPI

EOL Table

Business Running Case: Thompson Lumber Company

$$\text{EOL (large plant)} = (0.50)(\$0) + (0.50)(\$180,000) = \$90,000$$

$$\text{EOL (small plant)} = (0.50)(\$100,000) + (0.50)(\$20,000) = \$60,000$$

$$\text{EOL (do nothing)} = (0.50)(\$200,000) + (0.50)(\$0) = \$100,000$$

Opportunity
Loss Table

ALTERNATIVE	STATE OF NATURE		EOL (\$)
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)	
Construct a large plant	0	180,000	90,000
Construct a small plant	100,000	20,000	60,000
Do nothing	200,000	0	100,000
Probabilities			0.5 0.5

Best EOL

Decision Making Under Risk

→ EMV & Sensitivity Analysis

EMV & Sensitivity Analysis

Business Running Case: Thompson Lumber Company

$$\begin{aligned}\text{EMV}(\text{large plant}) &= \$200,000P - \$180,000(1 - P) \\ &= \$200,000P - \$180,000 + \$180,000P \\ &= \$380,000P - \$180,000\end{aligned}$$

$$\text{If } P = 1 \text{ then EMV} = \$380,000 \times 1 - \$180,000 = \$200,000$$

$$\text{If } P = 0 \text{ then EMV} = \$380,000 \times 0 - \$180,000 = -\$180,000$$

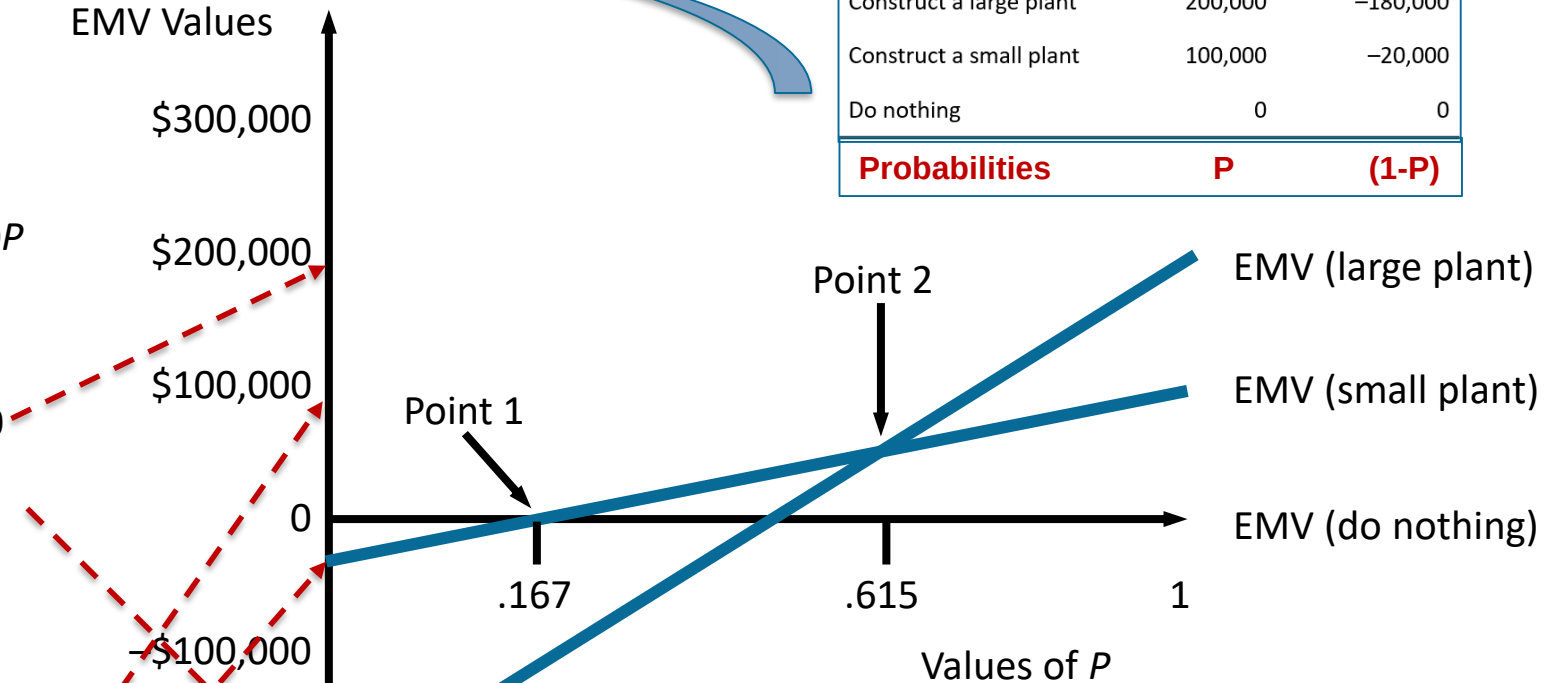
$$\begin{aligned}\text{EMV}(\text{small plant}) &= \$100,000P - \$20,000(1 - P) \\ &= \$100,000P - \$20,000 + \$20,000P \\ &= \$120,000P - \$20,000\end{aligned}$$

$$\text{If } P = 1 \text{ then EMV} = \$120,000 \times 1 - \$20,000 = \$100,000$$

$$\text{If } P = 0 \text{ then EMV} = \$120,000 \times 0 - \$20,000 = -\$20,000$$

$$\begin{aligned}\text{EMV}(\text{do nothing}) &= \$0P + 0(1 - P) \\ &= \$0\end{aligned}$$

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	200,000	-180,000
Construct a small plant	100,000	-20,000
Do nothing	0	0
Probabilities	P	(1-P)



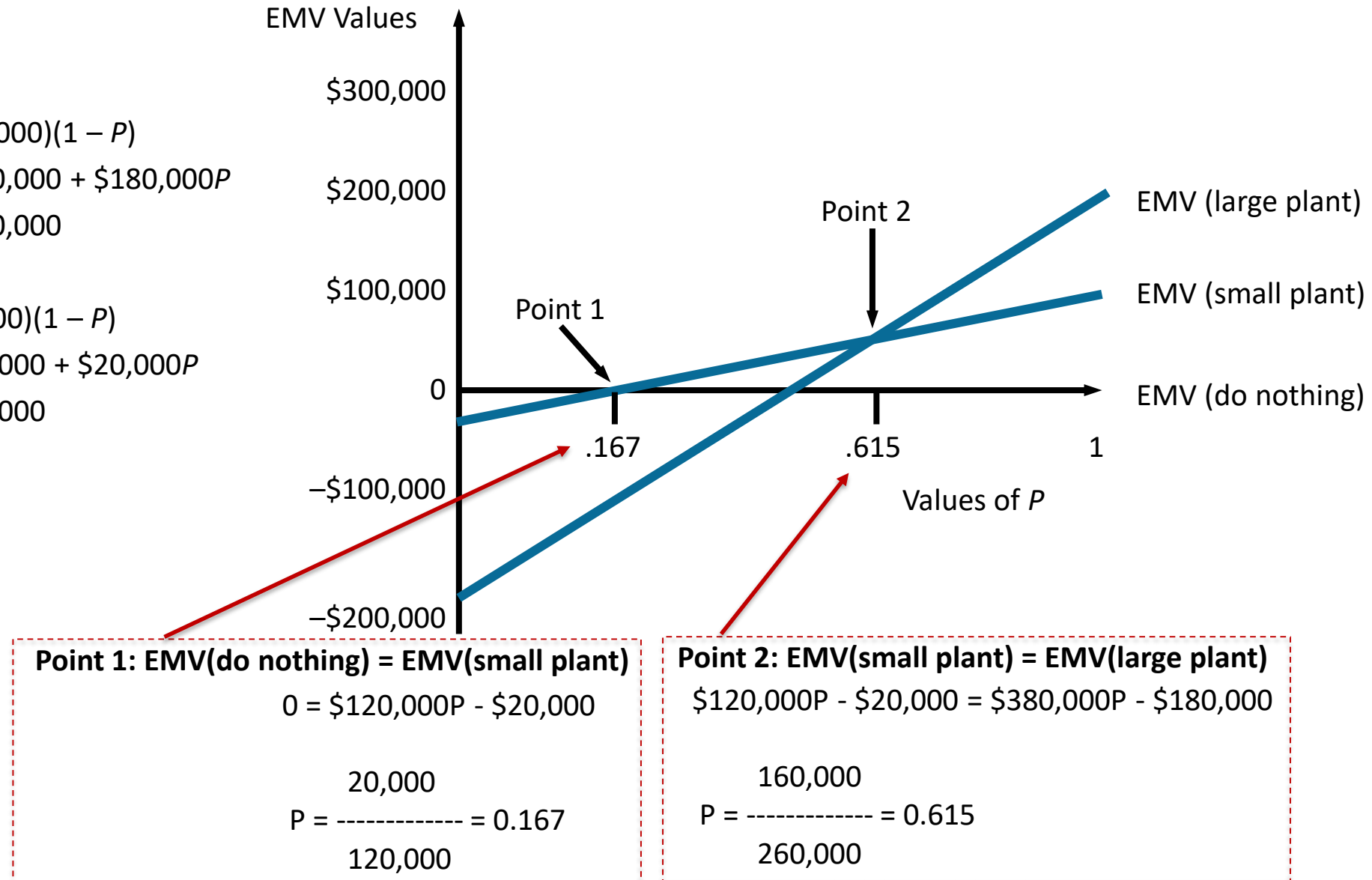
EMV & Sensitivity Analysis

**Business Running Case:
Thompson Lumber Company**

$$\begin{aligned}
 \text{EMV}(\text{large plant}) &= \$200,000P - \$180,000(1 - P) \\
 &= \$200,000P - \$180,000 + \$180,000P \\
 &= \$380,000P - \$180,000
 \end{aligned}$$

$$\begin{aligned}
 \text{EMV}(\text{small plant}) &= \$100,000P - \$20,000(1 - P) \\
 &= \$100,000P - \$20,000 + \$20,000P \\
 &= \$120,000P - \$20,000
 \end{aligned}$$

$$\begin{aligned}
 \text{EMV}(\text{do nothing}) &= \$0P + 0(1 - P) \\
 &= \$0
 \end{aligned}$$

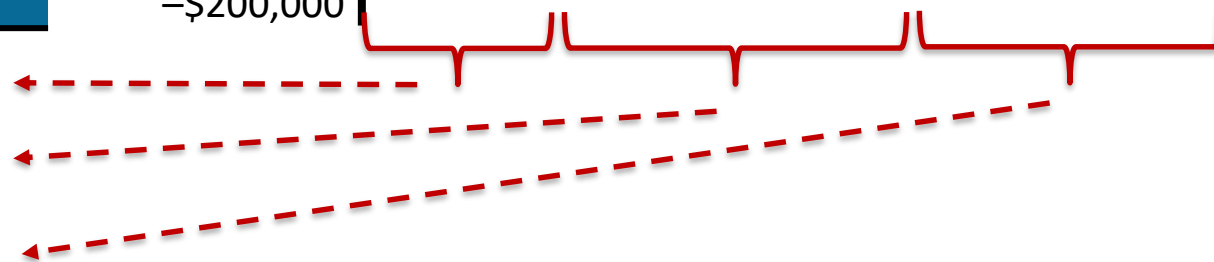
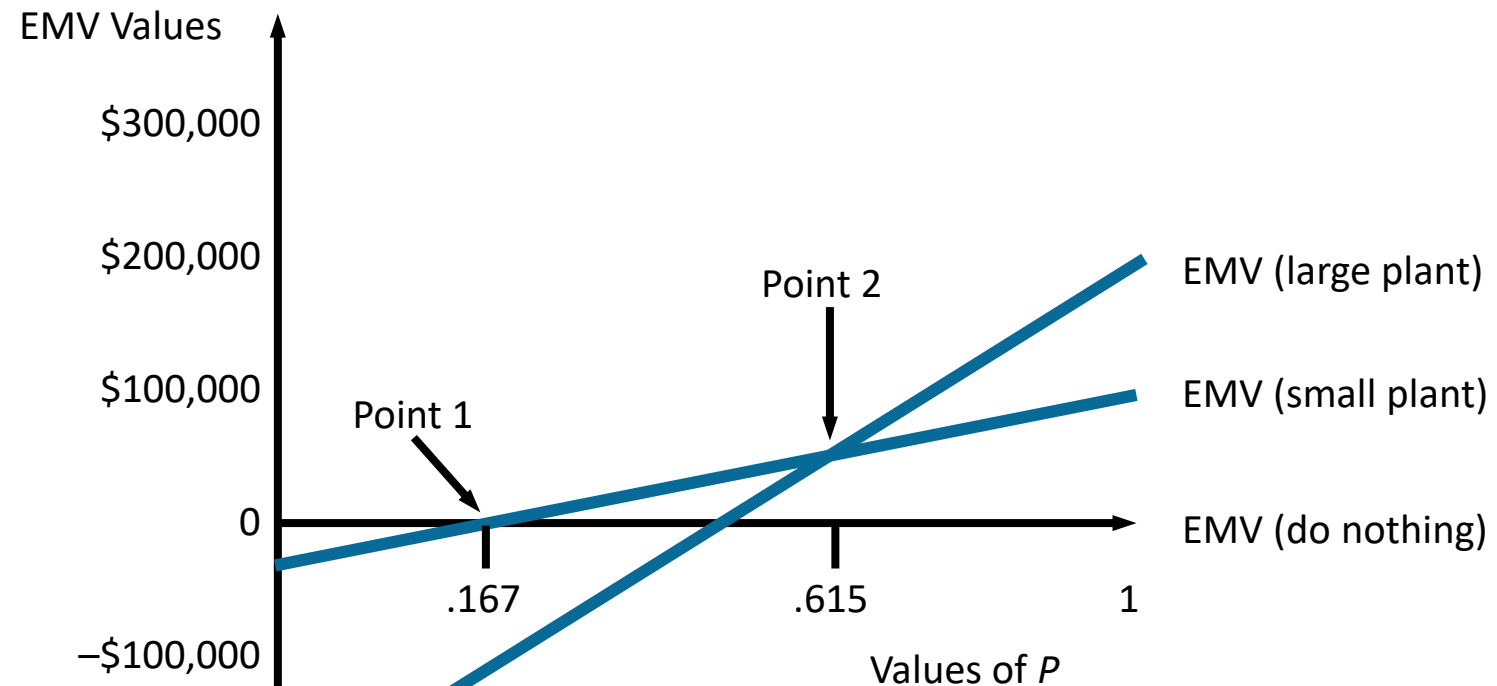


EMV & Sensitivity Analysis

**Business Running Case:
Thompson Lumber Company**

CONCLUSIONS:

BEST ALTERNATIVE	RANGE OF P VALUES
Do nothing	Less than 0.167
Construct a small plant	0.167 – 0.615
Construct a large plant	Greater than 0.615



Problem (Text, p.p.75 - 77):

A department will be signing three year lease for a new copy machine and three different machines are being considered

- For each of the machines, there is a monthly fee (incl. monthly fee & charge per each copy)
- The department has estimated that the number of copies/Mo could be 10,000 or 20,000 or 30,000
- The monthly cost for each machine based on the offers and the three levels of activities is shown in the table below

Which machine should be selected?

TABLE 3.12 – Payoff Table

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH
Machine A	950	1,050	1,150
Machine B	850	1,100	1,350
Machine C	700	1,000	1,300

Using Best Payoff (Minimum) vs Worst Payoff (Maximum)

TABLE 3.13 – Best and Worst Payoffs

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH	BEST PAYOFF (MINIMUM)	WORST PAYOFF (MAXIMUM)
Machine A	950	1,050	1,150	950	1,150
Machine B	850	1,100	1,350	850	1,350
Machine C	700	1,000	1,300	700	1,300

Using Hurwicz criteria with 70% coefficient

Decision: to select machine C based on this criterion
(it has the lowest weighted average costs)

$$\text{Weighted average} = 0.7(\text{best payoff}) + (1 - 0.7)(\text{worst payoff})$$

For each machine

$$\text{Machine A: } 0.7(950) + 0.3(1,150) = 1,010$$

$$\text{Machine B: } 0.7(850) + 0.3(1,350) = 1,000$$

$$\text{Machine C: } 0.7(700) + 0.3(1,300) = 880$$

Using equally likely criteria

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH
Machine A	950	1,050	1,150
Machine B	850	1,100	1,350
Machine C	700	1,000	1,300

For each machine

$$\text{Machine A: } (950 + 1,050 + 1,150)/3 = 1,050$$

$$\text{Machine B: } (850 + 1,100 + 1,350)/3 = 1,100$$

$$\text{Machine C: } (700 + 1,000 + 1,300)/3 = 1,000$$

Decision: to select machine C based on this criterion (it has the lowest average costs)

Using EMV Criterion

Assumptions for probability
for the three states of nature
(based on past records)

USAGE	PROBABILITY
10,000	0.40
20,000	0.30
30,000	0.30

TABLE 3.14

Expected Monetary Values and Expected Value with Perfect Information

Decision: to select machine C based on this criterion (it has the lowest EMV)

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH	EMV
Machine A	950	1,050	1,150	1,040
Machine B	850	1,100	1,350	1,075
Machine C	700	1,000	1,300	970
With perfect information	700	1,000	1,150	925
Probability	0.4	0.3	0.3	

Using EVPI & Expected Opportunity Loss Criterion

$$EV_{wPI} = \$925$$

Best EMV without perfect information = \$970

$$EVPI = 970 - 925 = \$45$$

Decision: to select machine C based on the EOL criterion (it has the lowest expected opportunity loss)

Decision: to select machine C based on the minimax regret criterion (it has the minimum of the maximum)

TABLE 3.14

Expected Monetary Values and Expected Value with Perfect Information

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH	EMV
Machine A	950	1,050	1,150	1,040
Machine B	850	1,100	1,350	1,075
Machine C	700	1,000	1,300	970
With perfect information	700	1,000	1,150	925
Probability	0.4	0.3	0.3	

TABLE 3.15 – Opportunity Loss Table

	10,000 COPIES PER MONTH	20,000 COPIES PER MONTH	30,000 COPIES PER MONTH	MAXIMUM	EOL
Machine A	250	50	0	250	115
Machine B	150	100	200	200	150
Machine C	0	0	150	150	45
Probability	0.4	0.3	0.3		

Decision Trees

Any problem that can be presented in a decision table can be graphically represented in a **decision tree**

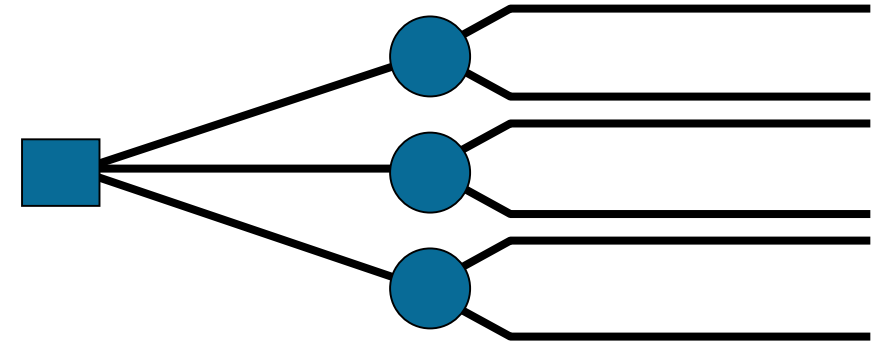
- Most beneficial when a sequence of decisions must be made
- All decision trees contain **decision points/nodes** and **state-of-nature points/nodes**
- At decision nodes one of several alternatives may be chosen
- At state-of-nature nodes one state of nature will occur

Five Steps of Decision Tree Analysis

1. Define the problem
2. Structure or draw the decision tree
3. Assign probabilities to the states of nature
4. Estimate payoffs for each possible combination of alternatives and states of nature
5. Solve the problem by computing expected monetary values (EMVs) for each state of nature node

Structure of Decision Trees

- Trees start from left to right
- Trees represent decisions and outcomes in sequential order
- Squares represent decision nodes
- Circles represent states of nature nodes
- Lines or branches connect the decisions nodes and the states of nature



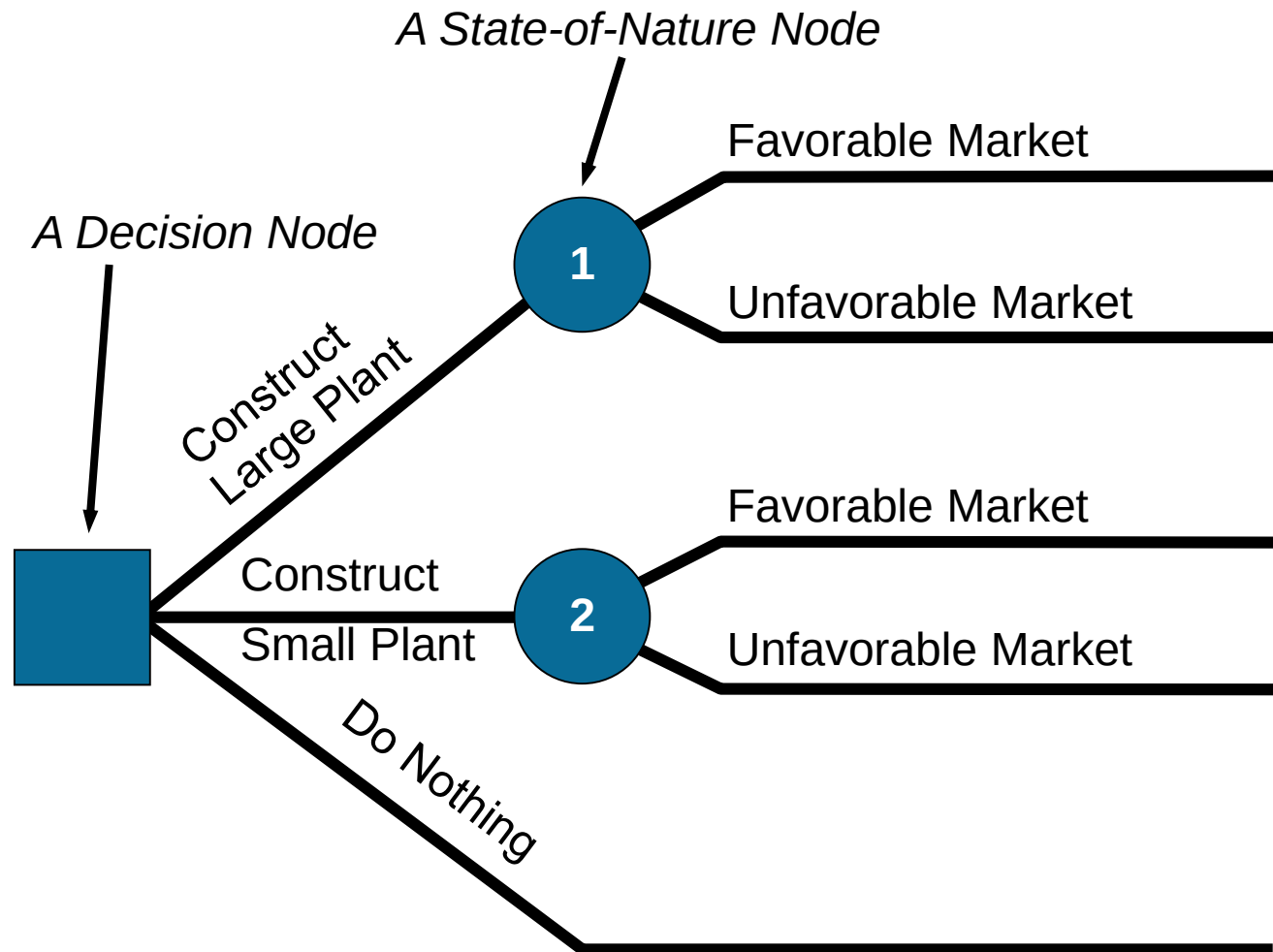
Decision Trees

Business Running Case: Thompson Lumber Company

FIGURE 3.2 Thompson's Decision Tree

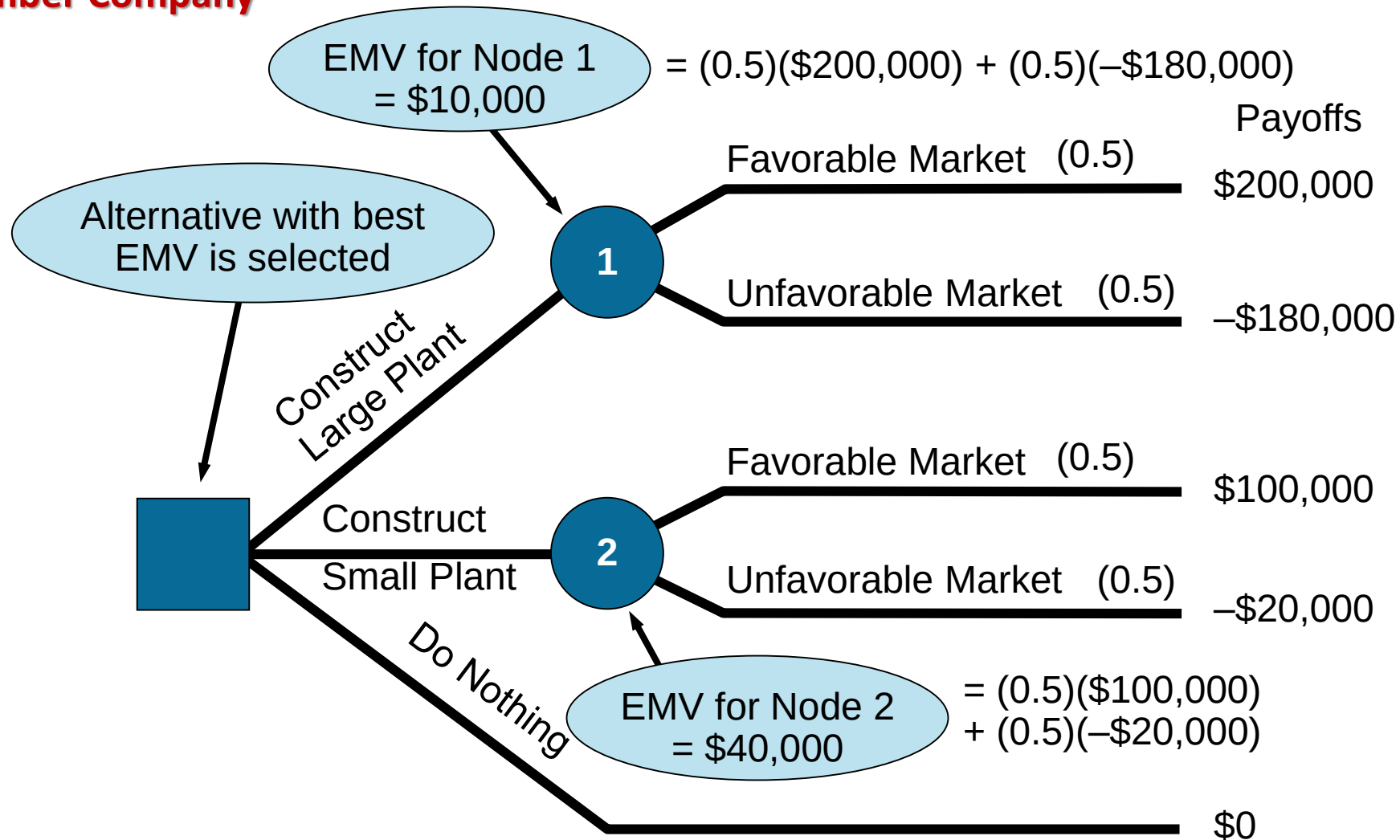
Decision Table (Payoff Table) with Conditional Values

ALTERNATIVE	STATE OF NATURE	
	FAVORABLE MARKET (\$)	UNFAVORABLE MARKET (\$)
Construct a large plant	200,000	-180,000
Construct a small plant	100,000	-20,000
Do nothing	0	0



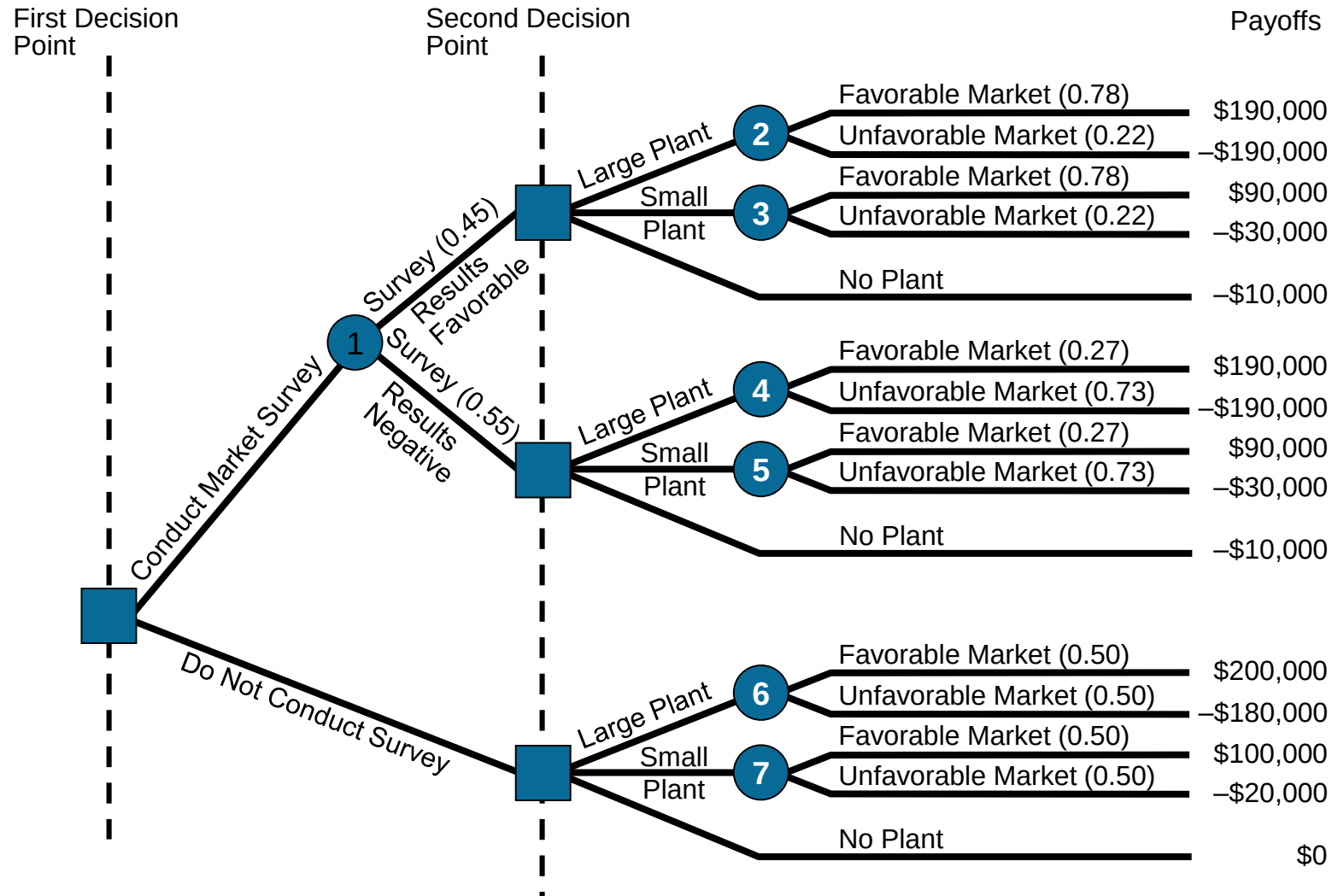
Decision Trees

Business Running Case: Thompson Lumber Company

FIGURE 3.3**Thompson's Decision Tree**

Business Running Case: Thompson Lumber Company

FIGURE 3.4 Thompson's Complex Decision Tree



Business Running Case: Thompson Lumber Company

1. Given favorable survey results

$$\text{EMV}(\text{node 2}) = \text{EMV}(\text{large plant} \mid \text{positive survey})$$

$$= (0.78)(\$190,000) + (0.22)(-\$190,000) = \$106,400$$

$$\text{EMV}(\text{node 3}) = \text{EMV}(\text{small plant} \mid \text{positive survey})$$

$$= (0.78)(\$90,000) + (0.22)(-\$30,000) = \$63,600$$

$$\text{EMV for no plant} = -\$10,000$$

2. Given negative survey results

$$\text{EMV}(\text{node 4}) = \text{EMV}(\text{large plant} \mid \text{negative survey})$$

$$= (0.27)(\$190,000) + (0.73)(-\$190,000) = -\$87,400$$

$$\text{EMV}(\text{node 5}) = \text{EMV}(\text{small plant} \mid \text{negative survey})$$

$$= (0.27)(\$90,000) + (0.73)(-\$30,000) = \$2,400$$

$$\text{EMV for no plant} = -\$10,000$$

Business Running Case: Thompson Lumber Company**3. Expected value of the market survey**

$$\begin{aligned}\text{EMV}(\text{node 1}) &= \text{EMV}(\text{conduct survey}) \\ &= (0.45)(\$106,400) + (0.55)(\$2,400) \\ &= \$47,880 + \$1,320 = \$49,200\end{aligned}$$

4. Expected value no market survey

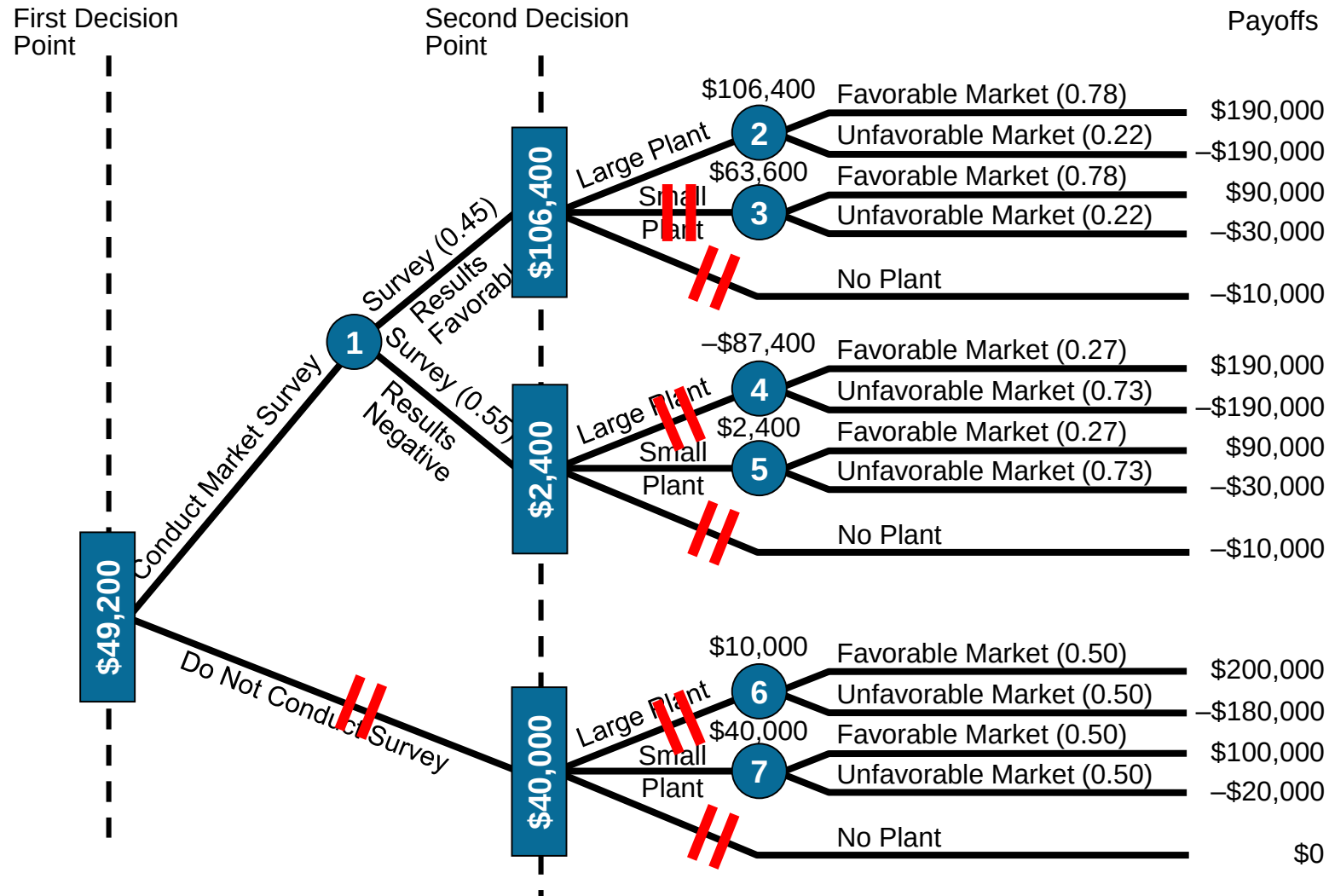
$$\begin{aligned}\text{EMV}(\text{node 6}) &= \text{EMV}(\text{large plant}) \\ &= (0.50)(\$200,000) + (0.50)(-\$180,000) = \$10,000\end{aligned}$$

$$\begin{aligned}\text{EMV}(\text{node 7}) &= \text{EMV}(\text{small plant}) \\ &= (0.50)(\$100,000) + (0.50)(-\$20,000) = \$40,000\end{aligned}$$

$$\text{EMV for no plant} = \$0$$

The best choice is to seek marketing information

FIGURE 3.5



Business Running Case: Thompson Lumber Company

Expected Value of Sample Information

Thompson wants to know the actual value of doing the survey

$$\begin{aligned} \text{EVSI} &= \left(\begin{array}{c} \text{Expected value} \\ \text{with sample} \\ \text{information} \end{array} \right) - \left(\begin{array}{c} \text{Expected value of best} \\ \text{decision without sample} \\ \text{information} \end{array} \right) \\ &= (\text{EV with SI} + \text{cost}) - (\text{EV without SI}) \end{aligned}$$

$$\text{EVSI} = (\$49,200 + \$10,000) - \$40,000 = \$19,200$$

Business Running Case: Thompson Lumber Company

Efficiency of Sample Information

- Possibly many types of sample information available
- Different sources can be evaluated

$$\text{Efficiency of sample information} = \frac{\text{EVSI}}{\text{EVPI}} 100\%$$

$$\text{Efficiency of sample information} = \frac{19,200}{60,000} 100\% = 32\%$$

Market survey is only 32% as efficient as perfect information

Decision Trees

Business Running Case: Thompson Lumber Company

Sensitivity Analysis

- How sensitive are the decisions to changes in the probabilities?
- How sensitive is our decision to the probability of a favorable survey result?
- If the probability of a favorable result ($p = .45$) were to change, would we make the same decision?
- How much could it change before we would make a different decision?

p = probability of a favorable survey result

$(1 - p)$ = probability of a negative survey result

$$\begin{aligned}\text{EMV}(\text{node 1}) &= (\$106,400)p + (\$2,400)(1 - p) \\ &= \$104,000p + \$2,400\end{aligned}$$

We are indifferent when the EMV of node 1 is the same as the EMV of not conducting the survey

$$\$104,000p + \$2,400 = \$40,000$$

$$\$104,000p = \$37,600$$

$$p = \$37,600 / \$104,000 = 0.36$$

DECISION:

If $p < 0.36$, do not conduct the survey

If $p > 0.36$, conduct the survey

ASSIGNMENT 2

Task 2-4: Apply TreePlan

Tutorial 'Decision Trees in TreePlan'
>>> v-labs (Excel 2016 Add-In 'TreePlan')

Other Decision Tree Software (A Short List):

1. Excel Decision Tree Add-Ins

- Risk Solver Pro & Analytic Solver Pro v2016 by FrontlineSolvers, www.solver.com
- Monte Carlo Risk Simulation, Decision Tree and Statistical Excel Analysis Add-In by Lumenaut, www.lumenaut.com
- Decision Tree Suite by Palisade, www.palisade.com
- TreePlan by TreePlan Software, www.treeplan.com

2. Top Decision Tree Analysis Software Products 2016

(ranked by Capterra, www.capterra.com ; Filter Results: 1000+ number of users):

- pcFinancials by Performance Canvas Financials, <http://www.performancecanvas.com>
- Analytica by Lumina Decision Systems, <http://www.lumina.com/>
- 1000Minds (Multi-Criteria Decision-Making) by 1000minds: www.1000minds.com
- Blaze Advisor by Fico, www.fico.com
- D-Sight Collaborative Decision-Making platform by D-Sight, <http://www.d-sight.com>
- Decision Lens by Decision Lens, www.decisionlens.com
- Decision Support Software by Logicnets, www.logicnets.com
- DPL 8 Direct by Syncopation, www.syncopation.com
- Spotfire by Tibco, www.tibco.com
- VisiRule by Logic Programming Associates, www.lpa.co.uk

In-Class Group Exercise GW6-1: How to Prepare Assignment 2



Live Demonstration

Q & A