Lesson 4. COMPLEMENT: DECISION TREES

Basic references:

- Heizer, J. & Render, B. (2014): Operations Management. New Jersey: Pearson Prentice Hall
- Slack, N; Brandon-Jones, A (2019) :Operations Management. 9^{th} ed, Pearson

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Decision Making Tools

1. Terms:

a. Alternative —A course of action or strategy that may be chosen by a decision maker (e.g., not carrying an umbrella tomorrow).

b. *State of nature* —An occurrence or a situation over which the decision maker has little or no control (e.g., tomorrow's weather).

2. Symbols used in a decision tree:

a. Decision node ■ from which one of several alternatives may be selected.

b. A state-of-nature node ● out of which one state of nature will occur.

Decision Making Tools

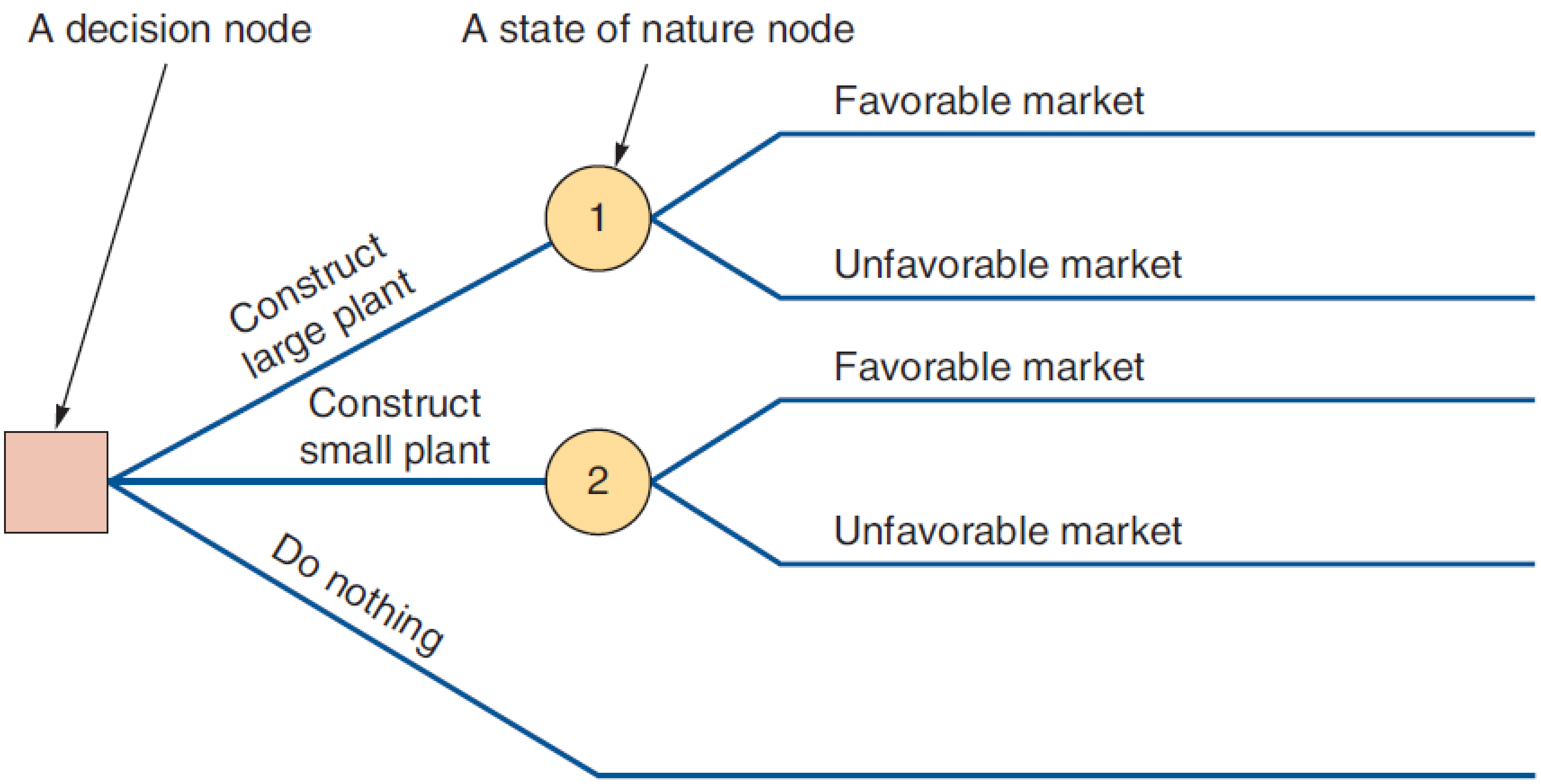
Example

Whessoe Products Company is investigating the possibility of producing and marketing backyard storage sheds. Undertaking this project would require the construction of either a large or a small manufacturing plant.

The market for the product produced—storage sheds—could be either favorable or unfavorable.

Whessoe, of course, has the option of not developing the new product line at all.

Decision Making Tools



Decision Making Tools

Whessoe Products now wishes to organize the following information into a table. With a favorable market, a large facility will give Whessoe Products a net profit of $200,000. If the market is unfavorable, a $180,000 net loss will occur. A small plant will result in a net profit of $100,000 in a favorable market, but a net loss of $20,000 will be encountered if the market is unfavorable.

	STATES OF NATURE	
ALTERNATIVES	FAVORABLE MARKET	UNFAVORABLE MARKET
Construct large plant	$200,000	−$180,000
Construct small plant	$100,000	−$ 20,000
Do nothing	$ 0	$ 0

Decision Making Under Uncertainty

When there is complete *uncertainty* as to which state of nature in a decision environment may occur (i.e., when we cannot even assess probabilities for each possible outcome), we have 3 decision methods:

MAXIMAX: This method finds an alternative that *maximizes* the *maximum* outcome for every alternative. First, we find the maximum outcome within every alternative, and then we pick the alternative with the maximum number. "Optimistic" decision criterion.

MAXIMIN: This method finds the alternative that *maximizes* the *minimum* outcome for every alternative. First, we find the minimum outcome within every alternative, and then we pick the alternative with the maximum number. "Pessimistic" decision criterion.

EQUALLY LIKELY: This method finds the alternative with the highest average outcome. First, we calculate the average outcome for every alternative, which is the sum of all outcomes divided by the number of outcomes. We then pick the alternative with the maximum number. The equally likely approach assumes that each state of nature is equally likely to occur.

Decision Making Under Uncertainty

	STATES OF NATURE				
ALTERNATIVES	FAVORABLE MARKET	UNFAVORABLE MARKET	MAXIMUM IN ROW	MINIMUM IN ROW	ROW AVERAGE
Construct large plant	$200,000	–$180,000	$200,000	–180,000	$10,000
Construct small plant	$100,000	–$ 20,000	$100,000	–$20,000	$40,000
Do nothing	$ 0	$ 0	$ 0	$ 0	$ 0
			Maximax	Maximin	Equally likely

The maximax choice is to construct a large plant. This is the maximum of the maximum number within each row, or alternative.

The maximin choice is to do nothing. This is the maximum of the minimum number within each row, or alternative.

The equally likely choice is to construct a small plant. This is the maximum of the average outcome of each alternative. This approach assumes that all outcomes for any alternative are equally likely .

Decision Making Under Risk

Decision making under risk relies on probabilities.
Several possible states of nature may occur, each with an assumed probability, which must sum to 1.

Expected monetary value (EMV) for each alternative. This figure represents the expected value or *mean* return for each alternative *if we could repeat this decision a large number of times.*

The EMV for an alternative is the sum of all possible payoffs from the alternative, each weighted by the probability of that payoff occurring:

EMV (Alternative *i*) = (Payoff of 1st state of nature) * (Probability of 1st state of nature)

+ (Payoff of 2nd state of nature)* (Probability of 2nd state of nature)

+ . . . + (Payoff of last state of nature) * (Probability of last state of nature)

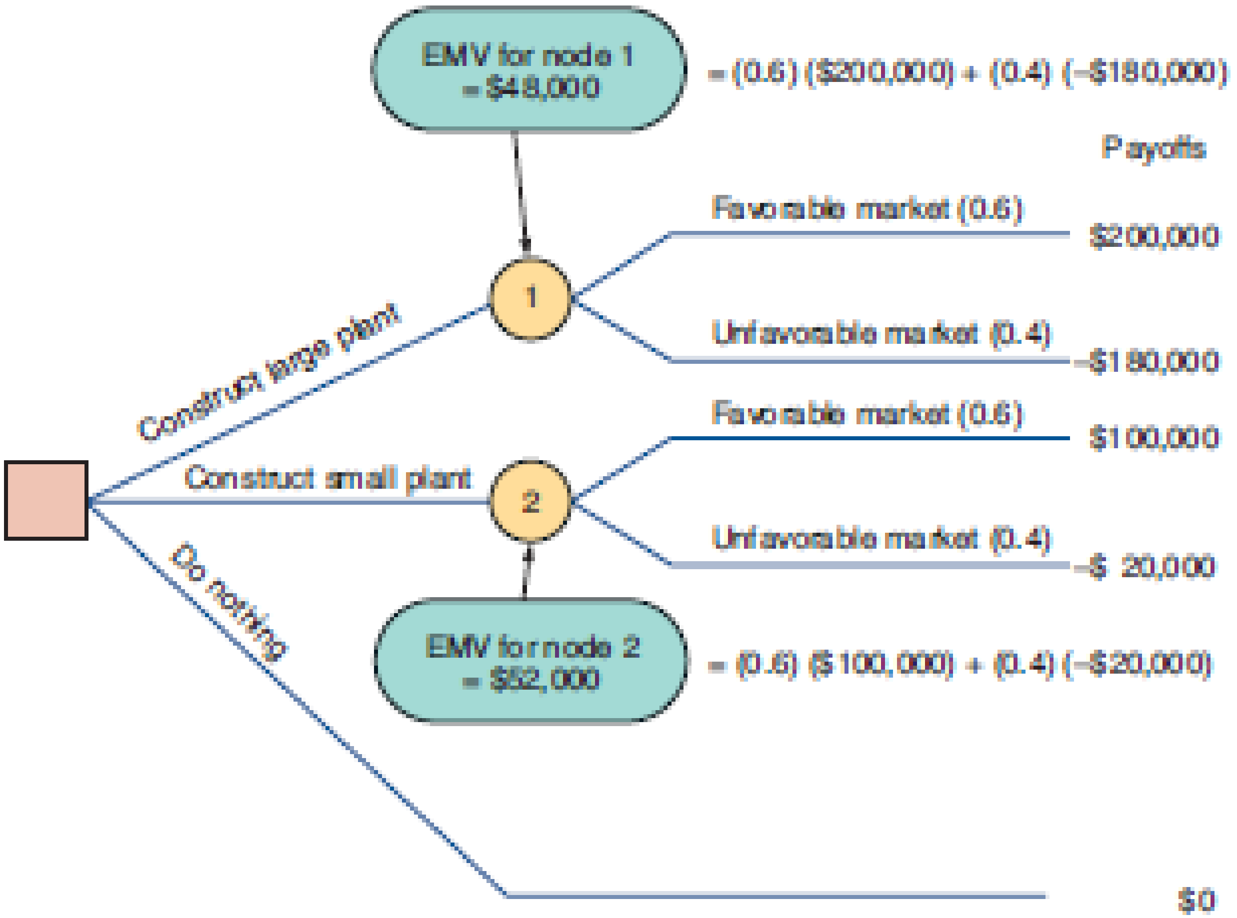
Decision Making Under Risk

	STATES OF NATURE	
ALTERNATIVES	FAVORABLE MARKET	UNFAVORABLE MARKET
Construct large plant (A_1)	$200,000	–$180,000
Construct small plant (A_2)	$100,000	–$ 20,000
Do nothing (A_3)	$ 0	$ 0
Probabilities	0.6	0.4

1. EMV (*A*1) = (0.6) (+200,000) + (0.4) (-180,000) = 48,000
2. EMV (*A*2) = (0.6) (+100,000) + (0.4) (-20,000) = 52,000
3. EMV (*A*3) = (0.6) (+0) + (0.4) (+0) = +0

The maximum EMV is seen in alternative *A* 2 . Thus, according to the EMV decision criterion, Whessoe would build the small facility.

Decision Making Under Risk



Decision Making Under Risk

When a sequence of decisions must be made, decision trees are much more powerful tools than are decision tables.

Imagine that Whessoe Products has two decisions to make, with the second decision dependent on the outcome of the first.

Before deciding about building a new plant, Whessoe has the option of conducting its own marketing research survey, at a cost of $10,000. The information from this survey could help it decide whether to build a large plant, to build a small plant, or not to build at all. Whessoe recognizes that although such a survey will not provide it with perfect information, it may be extremely helpful.

Whessoe's new decision tree is represented in next slide. Take a careful look at this more complex tree. Note that all possible outcomes and alternatives are included in their logical sequence. This procedure is one of the strengths of using decision trees. The manager is forced to examine all possible outcomes, including unfavorable ones. He or she is also forced to make decisions in a logical, sequential manner.

Decision Making Under Risk

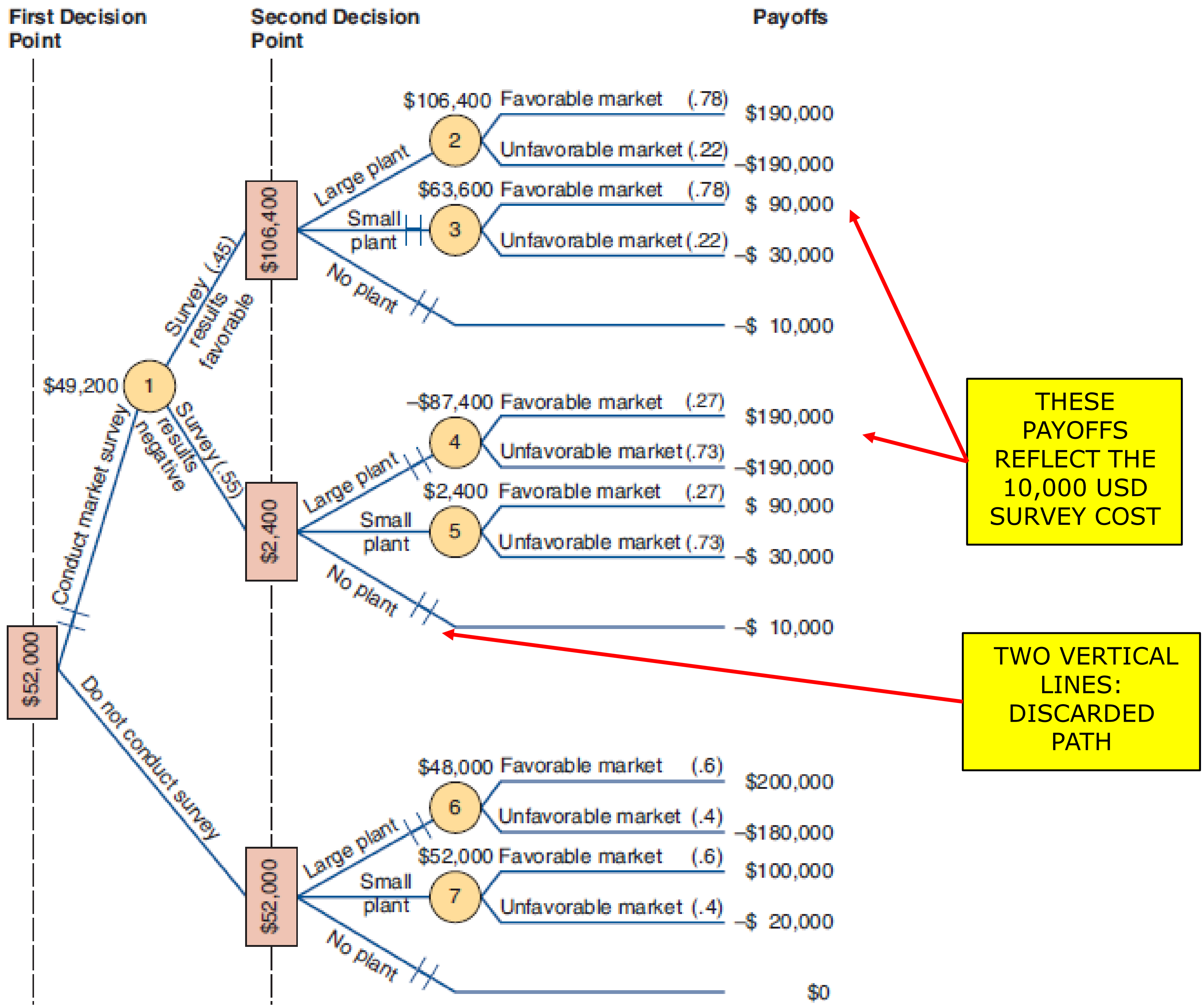
Whessoe's first decision point is whether to conduct the $10,000 market survey. If it chooses not to do the study (the lower part of the tree), it is the decision explained earlier.

If they decide to conduct the market survey. State-of-nature node number 1 has 2 branches coming out of it. Let us say there is a 45% chance that the survey results will indicate a favorable market for the storage sheds. We also note that the probability is 0.55 that the survey results will be negative.

If the survey results are positive, the probability of a favorable market is 0.78, and that of an unfavourable one is 0.22

If the survey results are negative, the probability of a favorable market is 0.27, and that of an unfavourable one is 0.73

(Yoy'll always expect to find a high probability of a favorable market given that the research indicated that the market was good, but there is a chance that the report is not 1004 reliable: hence the probabilities)


First Decision Point
Second Decision Point
Payoffs
$52,000
Conduct market survey
Do not conduct survey
$49,200
1
Survey results favorable
Survey (.45)
Survey results negative
Survey (.55)
$106,400
Large plant
Small plant
No plant
$106,400 Favorable market (.78)
2
Unfavorable market (.22)
$63,600 Favorable market (.78)
3
Unfavorable market (.22)
$190,000
–$190,000
$ 90,000
–$ 30,000
–$ 10,000
$2,400
Large plant
Small plant
No plant
–$87,400 Favorable market (.27)
4
Unfavorable market (.73)
$2,400 Favorable market (.27)
5
Unfavorable market (.73)
$190,000
–$190,000
$ 90,000
–$ 30,000
–$ 10,000
$52,000
Large plant
Small plant
No plant
$48,000 Favorable market (.6)
6
Unfavorable market (.4)
$52,000 Favorable market (.6)
7
Unfavorable market (.4)
$200,000
–$180,000
$100,000
–$ 20,000
$0
THESE PAYOFFS REFLECT THE 10,000 USD SURVEY COST
TWO VERTICAL LINES: DISCARDED PATH

Decision Making Under Risk

A) Given favorable survey reports:

EMV (node 2, large plant) = (.78) (190,000) + (.22) (- 190,000) = $ 106,400
EMV (node 3, small plant) = (.78) (90,000) + (.22) (- 30,000) = $ 63,600
EMV No plant= -10,000

B) Given unfavorable survey reports:

EMV (node 4, large plant) = (.27) (190,000) + (.73) (-190,000) = - $ 87,400
EMV (node 5, small plant) = (.27) (90,000) + (.73) (-30,000) = + $ 2,400
EMV No plant= -10,000

BEST CHOICE

C) EMV when conducting survey :

EMV (node 1) = (.45) (106,400) + (.55) (2400) = $ 49,200

D) EMV without conducting survey :

EMV (node 6, large plant) = (.6) (200,000) + (.4) (-180,000) = $ 48,000
EMV (node 7, small plant) = (.6) (100,000) + (.4) (-20,000) = $ 52,000
EMV (No Plant) = 0

Decision Making Under Certainty

Now suppose that the Whessoe operations manager has been approached by a marketing research firm that proposes to help him make the decision about whether to build the plant to produce storage sheds.

The marketing researchers claim that their technical analysis will tell Whessoe with certainty whether the market is favorable for the proposed product. In other words, it will change Whessoe's environment from one of decision making under risk to one of decision making under certainty .

This information could prevent Whessoe from making a very expensive mistake. The cost of this information is $65,000.

What would you recommend? Should the operations manager hire the firm to make the study? Even if the information from the study is perfectly accurate, is it worth $65,000? What might it be worth? Although some of these questions are difficult to answer

Determining the value of such perfect information can be very useful. It is an upper bound on what you would be willing to spend on information, such as that being sold by a marketing consultant. This is the concept of the expected value of perfect information (EVPI).

Decision Making Under Certainty

If a manager were able to determine which state of nature would occur, then he or she would know which decision to make.

Once a manager knows which decision to make, the payoff increases because the payoff is now a certainty, not a probability.

Because the payoff will increase with knowledge of which state of nature will occur, this knowledge has value.

We now look at how to determine the value of this information. We call this difference between the payoff under perfect information and the payoff under risk the expected value of perfect information (EVPI) .

EVPI = Expected value with perfect information - Maximum EMV

To find the EVPI, we must first compute the expected value with perfect information (EVwPI) , which is the expected (average) return if we have perfect information before a decision is made.

Decision Making Under Certainty

The best outcome for the state of nature "favorable market" is "build a large facility" with a payoff of $200,000. Probability 0.6

The best outcome for the state of nature "unfavorable market" is "do nothing" with a pay-off of $0. probability 0.4

Expected value with perfect information = (+200,000)(0.6) + (+0)(0.4) = $ 120,000.

Thus, if we had perfect information, we would expect (on the average) $ 120,000 if the decision could be repeated many times.

The maximum EMV is $ 52,000 for A 2 , which is the expected outcome without perfect information. Thus:

EVPI = Expected value with perfect information - Maximum EMV= 120,000-52,000= $ 68,000 is the maximum Whessoe would pay for this perfect information.

Will you spend $ 65,000 for it?