Module A. Decision Modeling.

Discussion Questions

1. The 6 steps of the decision–making process are:
1. Clearly define the problem and the factors that influence it.
2. Develop specific and measurable objectives.
3. Develop a model.
4. Evaluate each alternative solution.
5. Select the best alternative.
6. Implement the solution.

2. The purpose of this question is to make students use a personal experience to distinguish between good and bad decisions. A "good" decision is one that is based on logic and all available information.

A "bad" decision is one that is not based on logic and all available information. It is possible for an unfortunate or undesired outcome to result from a "good" decision (witness a patient expiring after open-heart surgery). It is also possible to have a favorable or desirable outcome result from a "bad" decision (you win at Blackjack, even though you drew a card when you already held an "18").

3. The **equally likely** model selects the alternative with the highest *average* value; it assumes each state of nature is equally likely to occur.

4. The basic difference between decision making under certainty, risk, or uncertainty is based on the nature and amount of chance or risk that is involved in making the decision. Decision making under **certainty** assumes that we know with complete confidence the outcomes that result from our choice of each alternative. Decision making under **risk** implies that we do not know the specific outcome that will result from our choice of a particular alternative, but that we do know the set of *possible* outcomes, and that we are able to objectively measure or estimate the probability of occurrence of each of the outcomes in the set. Decision making under **uncertainty** implies that we do not know the specific outcome that will result from our choice of a particular alternative; we know only the set of *possible* outcomes and are unable to objectively measure or estimate the probability of occurrence of any of the outcomes in the set.

5. A decision tree is a graphic display of the decision process that indicates decision alternatives, states of nature and their respective probabilities, and payoffs for each combination of alternative and states of nature.

6. Decision trees can be used to aid decision making in such areas as capacity planning (Supplement 7), new product analysis (Chapter 5), location analysis (Chapter 8), scheduling (Chapter 15), and maintenance (Chapter 17).

7. EVPI is the difference between payoff under certainty and maximum EMV under risk.

8. Expected value with perfect information is the expected return if we have perfect information about the states of nature before a decision has to be made.

9. Decision tree steps:
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 the EMV for each state of nature node.

10. Maximax considers only the best outcomes, while maximin considers only worst-case scenarios.

11. Expected values is useful for repeated decisions because it is an averaging process. However, it averages out the extreme outcomes. A rational decision maker is concerned with these extreme outcomes and will incorporate them into the decision-making process.

12. Decision trees are most useful for sequences of decisions under risk.

End-of-Module Problems

A.1 (a) EMV (assembly line) = (0.4)($10,000) + (0.6)($40,000)
= $28,000
EMV (plant) = (0.4)(– $100,000) + (0.6)($600,000) = $320,000
EMV (nothing) = 0
Select the new plant option.

(b) EVPI = $364,000 – 320,000 = $44,000

A.2 (a) EMV (Alt. 1) = (0.4)(10,000) + (0.6)(30,000)
= $22,000
EMV (Alt. 2) = (0.4)(5,000) + (0.6)(40,000) = $26,000
EMV (Alt. 3) = (0.4)(–2,000) + (0.6)(50,000)

= $29,200

So the Max EMV is Alternative 3.

(b) Expected value with perfect information = (0.4)(10,000)
+ (0.6)(50,000)
= $34,000

(c) EVPI = $34,000 – $29,200 = $4,800.

A.3

Alternatives	Very Favorable Market	Average Market	Unfavorable Market	Row Minimum	Row Maximum	Row Average
	States of Nature					
Build new plant	$350,000	$240,000	−$300,000	−300,000	350,000	96,667
Subcontract	$180,000	$90,000	−$20,000	−20,000	180,000	83,333
Overtime	$110,000	$60,000	−$10,000	−10,000	110,000	53,333
Do nothing	$0	$0	$0	0	0	0
				↑ maximin	↑ maximax	↑ equally likely

(a) Build new plant
(b) Do nothing
(c) Build new plant

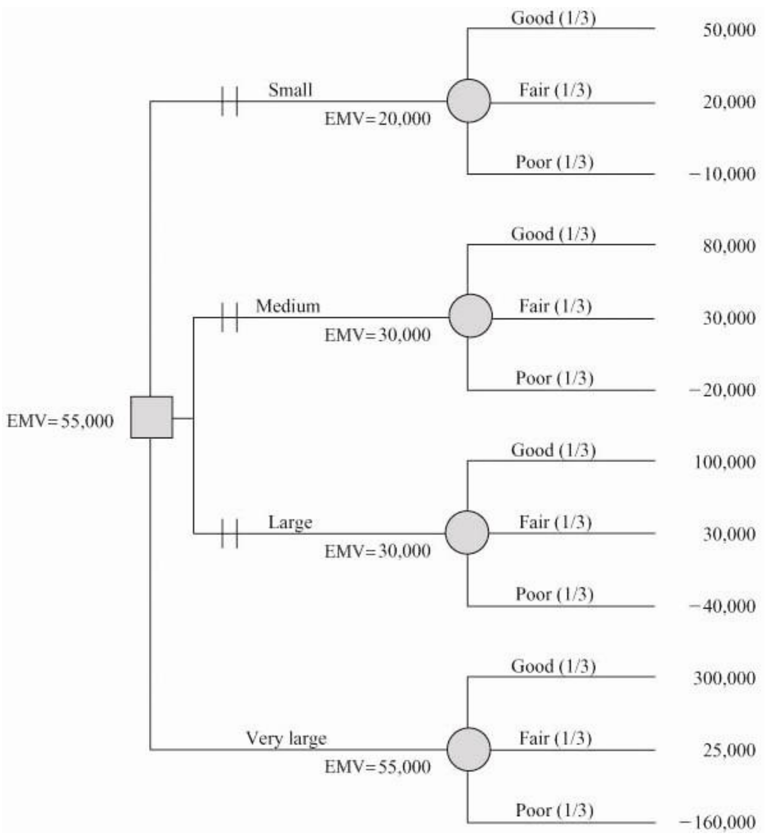
A.4

(a)

Size of First Station \ Market	Good Market	Fair Market	Poor Market	Row Minimum	Row Maximum	Row Average
Small	50,000	20,000	−10,000	−10,000	50,000	20,000
Medium	80,000	30,000	−20,000	−20,000	80,000	30,000
Large	100,000	30,000	−40,000	−40,000	100,000	30,000
Very large	300,000	25,000	−160,000	−160,000	300,000	55,000
				↑ maximin	↑ maximax	↑ equally likely

(b) Maximax decision: very large station
(c) Maximin decision: small station
(d) Equally likely decision: very large station

(e)



The first station should be very large, with EMV = $55,000

A.5 *Note:* In the text, the states of nature appeared in the left column and the decision alternative across the top row. This is to let students know that data are sometimes presented in alternative formats.

(a)

Decision Alternatives	Fixed	Slight Increase	Major Increase	Minimum
	← States of Nature →			
N (No)	$ 0	$ 2,000	$ 3,000	$ 0 ←
M (Moderate)	–4,000	8,000	9,000	–4,000
L (Large)	–10,000	6,000	20,000	–10,000
D (Double)	–50,000	4,000	40,000	–50,000

(b) using the maximin criterion; No floor space (N).

A.6

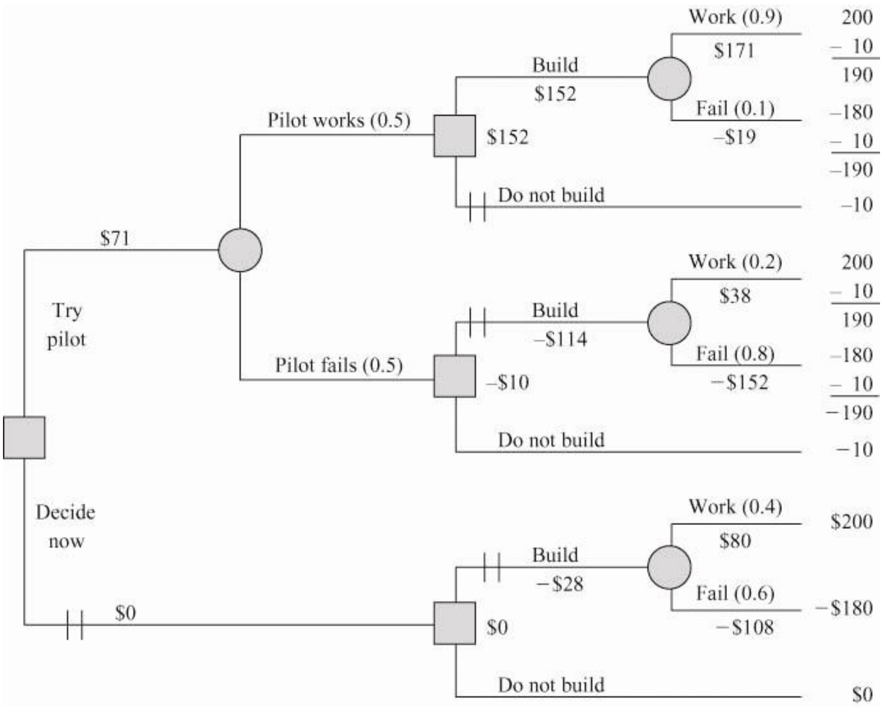
	Row Average
Increasing capacity	$700,000
Using overtime	$700,000
Buying equipment	$733,333 ←

Using equally likely, "Buying equipment" is the best option.

A.7 (a) EMV (large stock) = 0.3(22) + 0.5(12) + 0.2(–2) = 12.2
EMV (average stock) = 0.3(14) + 0.5(10) + 0.2(6) = 10.4
EMV (small stock) = 0.3(9) + 0.5(8) + 0.2(4) = 7.5
Maximum EMV is large inventory = $12,200

(b) EVPI = $13,800 – 12,200 = $1,600
where: $13,800 = 0.3(22) + 0.5(12) + 0.2(6)

A.8 *Note:* All dollar values in $1,000s.



The recommended strategy (EMV = 71) is

- Try pilot
- If pilot is success: build plant
  If pilot is failure: do not build plant

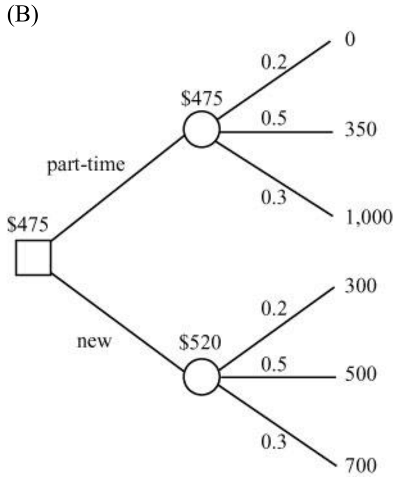
Note: All costs/revenues have been entered at the end of the branches of the tree.

A.9 (a) Expected cost of hiring full-timer = 0.2(300) + 0.5(500) + 0.3(700)
= $60 + 250 + 210
= $520

Expected cost of part-timers = 0.2(0) + 0.5(350)
+ 0.3(1,000)
= $0 + 175 + 300
= $475

Thus, use part-time nurses.

(B)



A.10 (a) The primary challenge in this problem is constructing the payoff table. Each book stocked and sold results in a $30 profit. That's $2,100 for the combination 70–70. Each book stocked but not sold results in a $46 loss. Demand that cannot be satisfied results in no loss of revenue or profit. Profit from each book sold = $112 – 82 = $30. Loss from each book bought but not sold = $82 – 36 = $45. Thus the payoff table is:

	Demand				
	70	**75**	**80**	**85**	**90**
Stock	p = 0.15	p = 0.30	p = 0.30	p = 0.20	p = 0.05
70	2,100	2,100	2,100	2,100	2,100
75	1,870	2,250	2,250	2,250	2,250
80	1,640	2,020	2,400	2,400	2,400
85	1,410	1,790	2,170	2,550	2,550
90	1,180	1,560	1,940	2,320	2,700

(b)

	EMV
Stock 70	2,100
Stock 75	2,193
Stock 80	2,172
Stock 85	2,037
Stock 90	1,826
Best EMV = 2,193	

The largest EMV is associated with the action: Stock 75 books.

A.11 (a) Under conditions of risk, the company should choose batch processing, with an expectation of $1,000,000, which is twice as high as the next best choice.

(b) EVPI is $170,000.

	Technology Choice Solution				
	Poor	**Fair**	**Good**	**Excellent**	**EMV**
Probabilities	0.1	0.4	0.3	0.2	
Batch	−200,000	1,000,000	1,200,000	1,300,000	1,000,000
Custom	100,000	300,000	700,000	800,000	500,000
Group Technology	−1,000,000	−500,000	500,000	2,000,000	250,000
Perfect Information	100,000	1,000,000	1,200,000	2,000,000	Best EMV
Perfect info × probability	10,000	400,000	360,000	400,000	1,170,000
Best Expected Value					1,000,000
Exp Value of Perfect Info					170,000

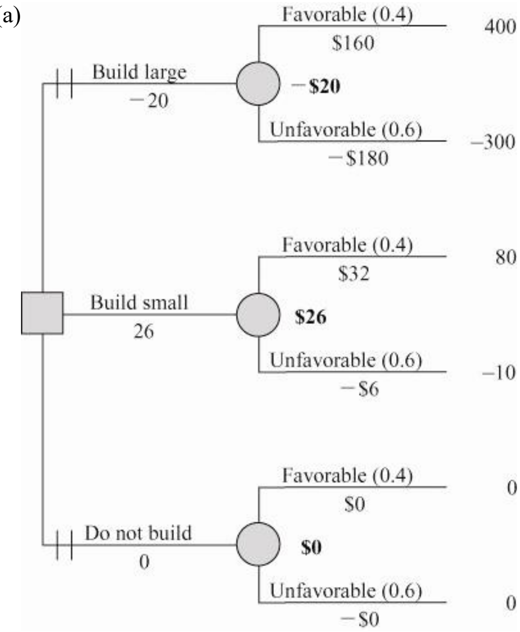
A.12 Profit from each case sold: $95 – $45 = $50. Loss from each case produced but not sold: $45.

	Demand (Cases)				
Production (Cases)	**6** p = 0.1	**7** p = 0.3	**8** p = 0.5	**9** p = 0.1	**EMV**
6	300	300	300	300	$300.00
7	300 –45 = 255	350	350	350	$340.50
8	300 –90 = 210	350 –45 = 305	400	400	$352.50
9	300 –135 = 165	350 –90 = 260	400 –45 = 355	450	$317.00

She should manufacture eight cases per month.

A.13 *Note:* All dollar values are in 1,000s.

(a)



(b) Based on the expected monetary value criterion, Dwayne should elect to build a small plant.

(c) We can find the EVPI from the following:

- Expected value under certainty = (0.4)(400,000) + 0.6(0) = $160,000
- Maximum EMV = $26,000
- EVPI = $160,000 – $26,000 = $134,000

A.14

E(A) = 0.4(40) + 0.2(100) + 0.4(60) = $60

E(B) = 0.4(85) + 0.2(60) + 0.4(70) = $74 ←

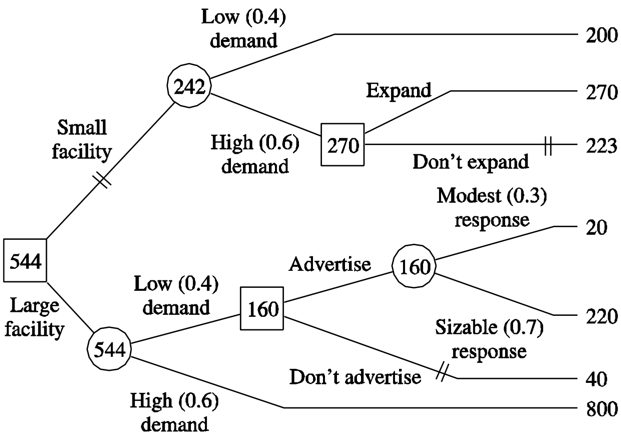
E(C) = 0.4(60) + 0.2(70) + 0.4(70) = $66

E(D) = 0.4(65) + 0.2(75) + 0.4(70) = $69

E(E) = 0.4(70) + 0.2(65) + 0.4(80) = $73

Choose Alternative B.

A.15 More than one decision is involved, and the problem is under risk, so use a decision tree approach:

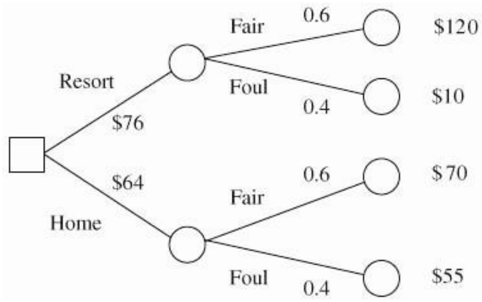


Note: Payoffs and expected payoffs are in $1,000s.

(a) Build the large facility. If demand proves to be low, then advertise to stimulate demand. If demand proves to be high, no advertising is needed (so don't advertise).

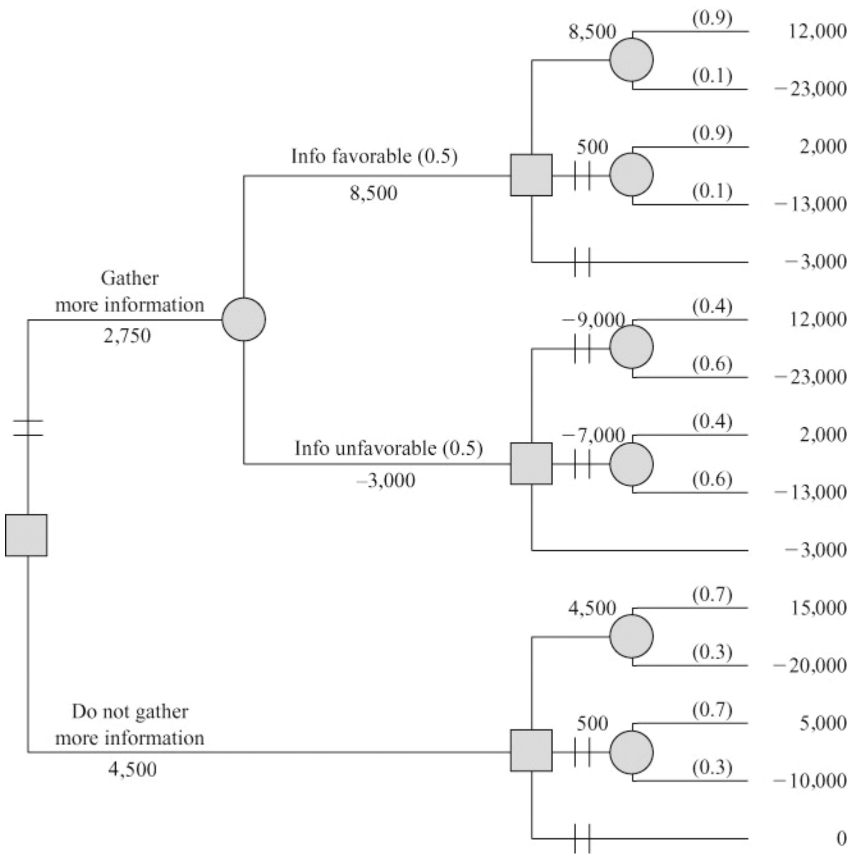
(b) *Expected payoff*: $544,000.

A.16 (a) Analysis of the decision tree finds that Resort has a higher EMV ($76) than Home:



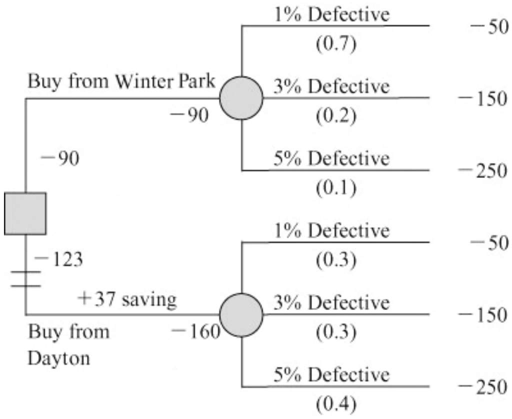
(b) EMV (Resort) = 0.6(120) + 0.4(10) = $76
EMV (Home) = 0.6(70) + 0.4(55) = $64
Choose Resort.

A.17



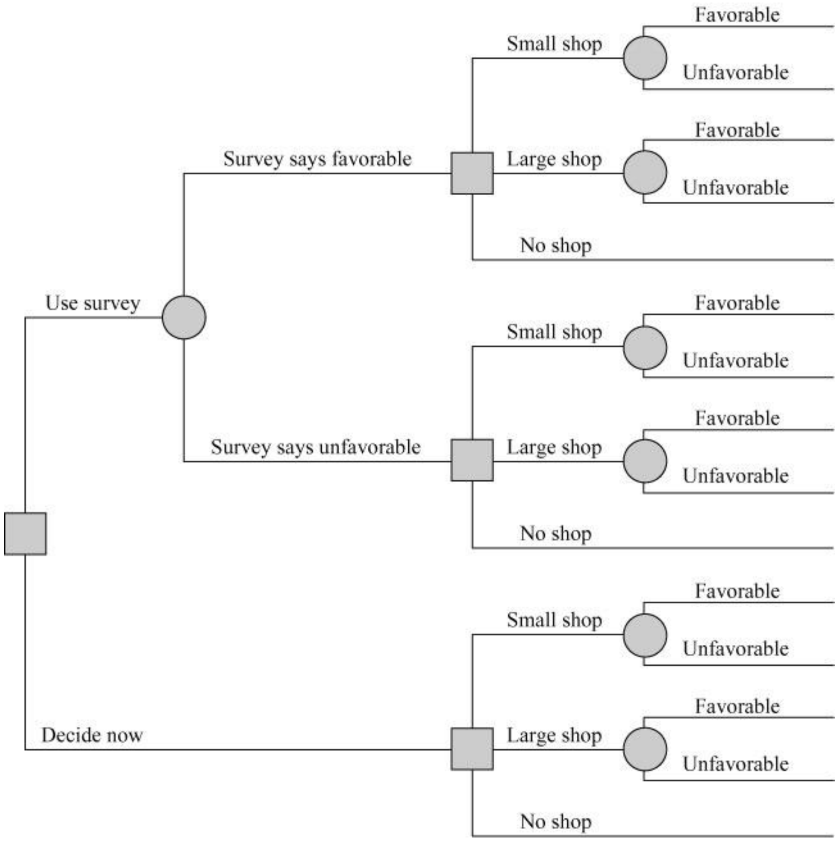
Your advice should be to not gather additional information and to build a large video section.

A.18 (a)



(b) Tests should be purchased from Winter Park Technologies.

A.19



A.20 (a)

Decision	At X	At Y	At X	At Y
X	45–27	9–27	18	–18
Y	6–15	30–15	–9	15
X&Y	(45 + 6)–(27 + 15)	(30 + 9)–(27 + 15)	9	–3
Nothing	0	0	0	0
Probability	.45	.55	.45	.55

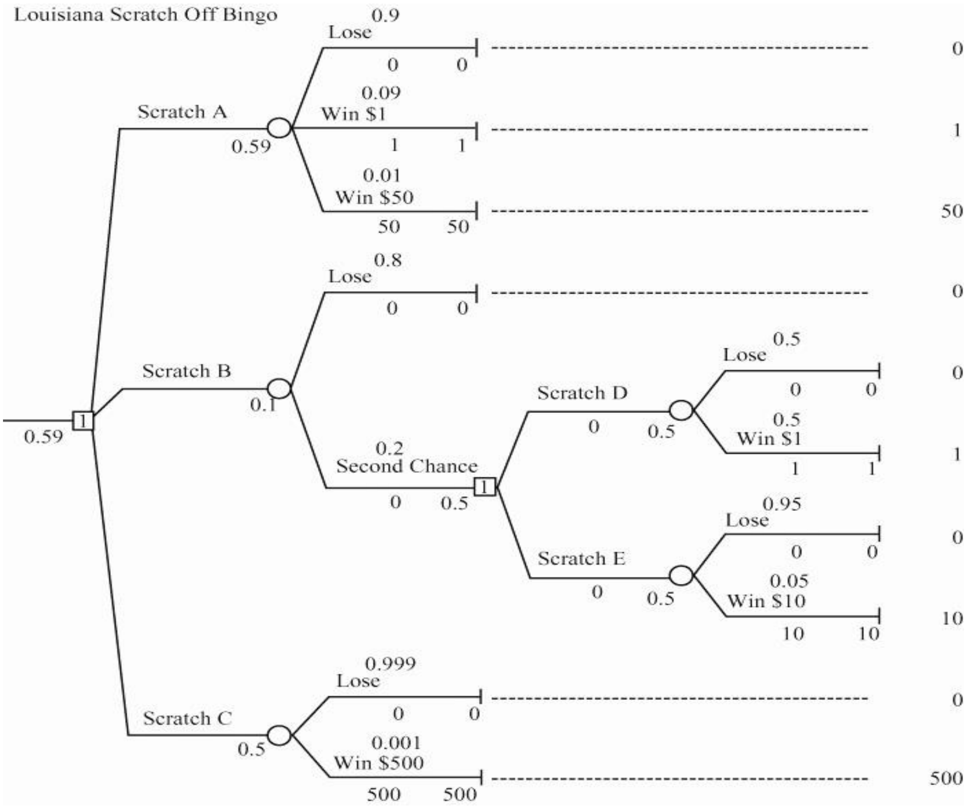
(b) EMV (X) = .45(18) + .55(–18) = –1.8
EMV (Y) = .45(–9) + .55(15) = 4.2 ← Best
EMV (X&Y) = .45(9) + .55(–3) = 2.4
EMV (Nothing) = 0

Y is best choice

A.21

(a) Maximum EMV = $11,700 [= .3(15) + .5(12) + .2(6)]
(b) EV with PI = .3(20) + .5(12) + .2(6) = 13,200
EVPI = 13,200 – 11,700 = 1,500

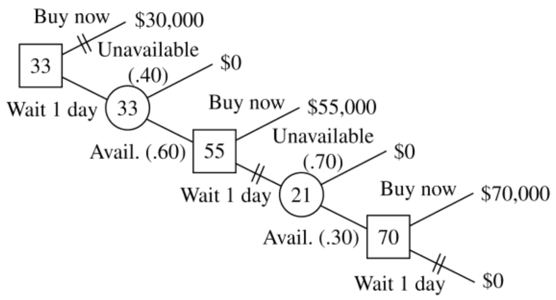
A.22



The EMV of this game is $0.59, as illustrated in the diagram below:

A.23

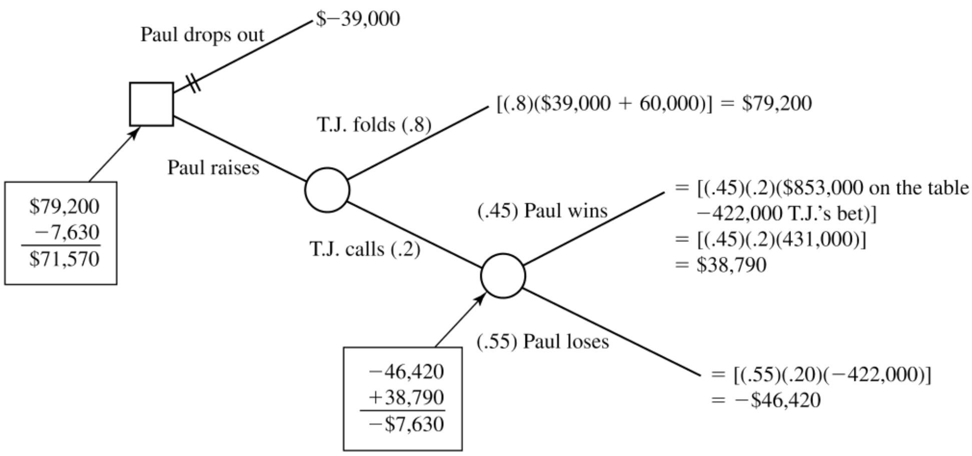
Solution approach: Decision tree, since problem is under risk and has more than one decision:



(Numbers in nodes are in $1,000s.)

Maximum expected profit: $33,000. Michael should wait 1 day. Then, if an R386 is available, he should buy it. Otherwise, he should stop pursuing an R386 on the wholesale market.

A.24



ADDITIONAL HOMEWORK PROBLEMS

Here are solutions to the additional homework problems that appear on **www.myomlab.com** and **www.pearsonglobaleditions.com/heizer**.

A.25

	States of Nature					
Alternatives	**Very Favorable Market**	**Average Market**	**Unfavorable Market**	**Row Minimum**	**Row Maximum**	**Row Average**
Large plant	$275,000	$100,000	−$150,000	−150,000	275,000	75,000
Small plant	$200,000	$60,000	−$10,000	−10,000	200,000	83,333
Overtime	$100,000	$40,000	−$1,000	−1,000	100,000	46,333
Do nothing	$0	$0	$0	0	0	0
				↑ maximin	↑ maximax	↑ equally likely

(a) Large plant
(b) Do nothing
(c) Small plant

A.26

(a) EMV (Alt. 1) = (0.4)(80) + 0.3(120) + 0.3(140)
= 32 + 36 + 42 = 110 = max. EMV

EMV (Alt. 2) = (0.4)(90) + 0.3(90) + 0.3(90)
= 36 + 27 + 27 = 90

EMV (Alt. 3) = (0.4)(50) + 0.3(70) + 0.3(150)
= 20 + 21 + 45 = 86

(b) EVPI = 117 − 110 = 7

A.27

Large has EMV = $75,000; small has EMV = $83,333; overtime EMV = $46,333; and do nothing = $0.

A.28

(a)

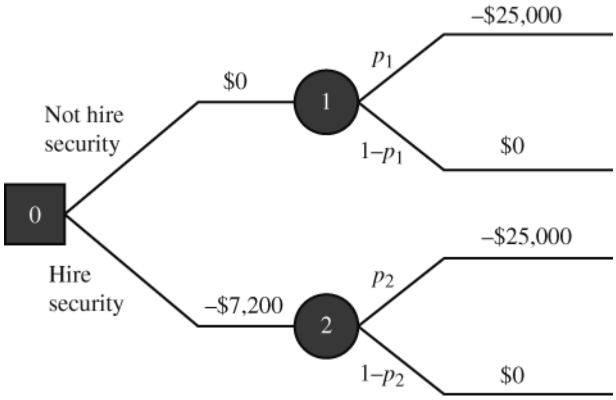
	Demand 11 Cases P = 0.45	**Demand 12 Cases P = 0.35**	**Demand 13 Cases P = 0.20**	**EMV**
Stock 11 cases	385	385	385	$385.00
Stock 12 cases	385 −56 329	420	420	$379.05
Stock 13 cases	385 −112 273	420 −56 364	455	$341.25

The recommended course of action, based on the expected monetary value criterion, is to stock 11 cases.

CASE STUDY

WAREHOUSE TENTING AT THE PORT OF MIAMI*

1. According to the timeline of events for this problem, the first thing that happens is the decision of whether to hire ProGuard, followed by the possibility of being burglarized. Because of the assumptions stated in the problem, if the warehouse is burglarized, CCI will have to pay \$25,000, and it costs \$150 × 48 = \$7,200 to hire security. These events and expenses can be depicted in a decision tree as follows:



In node 0, we make one of two decisions: choose not to hire security (payoff of \$0) or choose to hire security (payoff = –\$7,200, i.e., a cost). For each of those decisions (braches of the tree), we create event nodes (1 and 2) to take into account the possibility of being burglarized. At the top branch of the tree (node 1), the warehouse will be burglarized with probability p_1, in which case an additional expense of \$25,000 is incurred, or it will be safe with probability $(1 - p_1)$, in which case no extra cost is incurred. Therefore, the expected monetary value of not hiring security, which we will call EMV_1, is to spend \$25,000 with probability p_1 and spend nothing with probability $(1 - p_1)$. In our case, p_1 = 30%, which yields EMV_1 = –\$0 – \$25,000 (0.30) – \$0(0.70) = – \$7,500. Through a similar analysis of the bottom branch of the tree (node 2), and using the fact that the probability of begin burglarized while under surveillance is p_2 = 3%, we calculate that the expected monetary value of hiring security is EMV_2 = – \$7,200 – \$25,000(0.03) – \$0(0.97) = –\$7,950. The EMV rule says that the best course of action is the one with the greatest EMV. Because $EMV_1 > EMV_2$, it is better *not* to hire ProGuard.

2. If we look at the calculations in Question 1 and replace d for \$25,000, c for \$7,200, p_1 for 30%, and p_2 for 3%, we conclude that EMV_2 will be greater than EMV_1 when the following expression holds: $-c - dp_2 > -dp_1$, which, after some algebraic manipulations, becomes $p_1 - p_2 > c/d$. Therefore, unless the difference between burglary probabilities is greater than the cost of security divided by the deductible, you should *not* hire security. In our numerical example, $p_1 - p_2$ = 27%, which is smaller than 7,200/25,000 ≈ 28.8%. Interestingly, if p_1 were already below 28.8% to begin with, even if the security company were perfect (i.e., p_2 = 0%), it would still be better not to hire them given the projected expenses.

3. As usual, good decisions do not guarantee good outcomes. It may still be the case that CCI's warehouse will get burglarized, requiring CCI to spend \$25,000. However, given the circumstances and risks CCI is facing, not hiring security is still the best decision to make.

*Case author is Professor Tallys Yunes, University of Miami.

ADDITIONAL CASE STUDIES*

1 ARCTIC, INC.

No probabilities have been included in this case study. As an initial analysis, we expect students to input the data and run Excel OM or POM for Windows.

Student analysis would be to determine something about maximax, maximin, equally likely, and the expected values. Because the probabilities are not known, a first try might be to assign equal probabilities—say, 0.1666. The best expected value is given by "building new," with a value of nearly 2. However, note that this value is not that much greater than the value for "expanding" the plant. "Purchasing" has a terrible expected value of (0.35) and can be eliminated. “Sole sourcing” also has a low expected value and can possibly be eliminated from consideration. The question that remains is this: How sensitive are the results to the scenario probabilities? This is where the power of a computer comes in handy. Students can try many different probability combinations and look at the expected values. We are primarily concerned with expanding, building new, subcontracting, and expanding and subcontracting.

As “drop” is the worst scenario, try probabilities of 0.125, 0.125, and 0.25 for grow, stable, and drop, respectively. In this case, “expand” or “expand and subcontract” are better options. To determine the effects of growth, reverse the probabilities. This brings “building new” to the forefront. *It is impossible to give an exact answer on what option to choose*. The analysis shows that building a new plant can be very profitable, but this strategy can also be very risky. It might be more prudent to focus on the two expansion strategies.

2 SKI RIGHT CORP.

1. Bob can solve this case using decision analysis. As you can see, the best decision is to have Leadville Barts make the helmets and have Progressive Products do the rest with an expected value of $2,600 per month. The final option of not using Progressive, however, was very close with an expected value of $2,500 per month

	Poor ($)	Average ($)	Good ($)	Excellent ($)	Expected Value	Row Minimum	Row Maximum
Probabilities	**0.1**	**0.3**	**0.4**	**0.2**			
Option 1—PP	–5,000	–2,000	2,000	5,000	700	–5,000	5,000
Option 2—LB and PP	–10,000	–4,000	6,000	12,000	2,600	–10,000	12,000
Option 3—TR and PP	–15,000	–10,000	7,000	13,000	900	–15,000	13,000
Option 4—CC and PP	–30,000	–20,000	10,000	30,000	1,000	–30,000	30,000
Option 5—LB, CC, and TR	–60,000	–35,000	20,000	55,000	2,500	–60,000	55,000
Column Best					2,600	–5,000	55,000

The maximum expected monetary value is $2,600 per month
given by Option 2—LB and PP.

2. The expected value of perfect information is presented below.
The EVPI is $15,300.

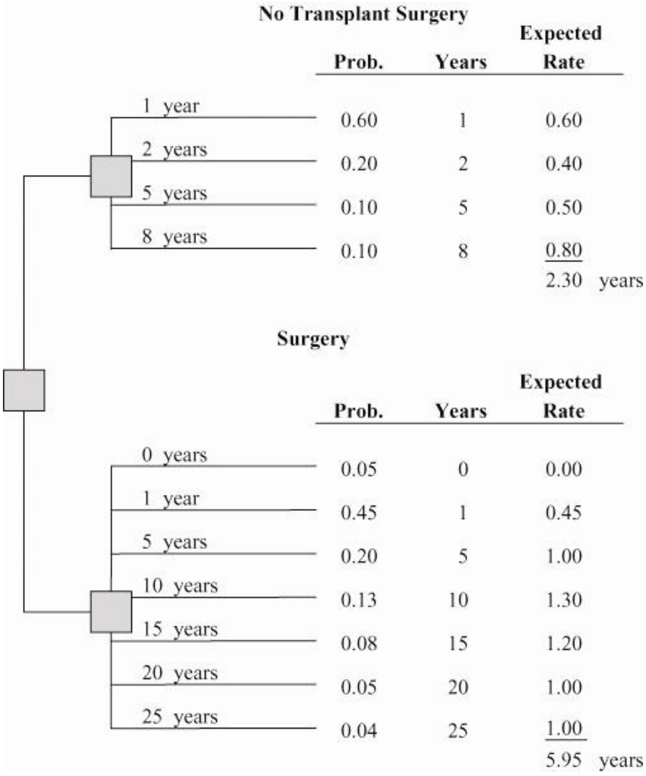
Perfect Information

	Poor Market	Average	Good	Excellent
Probabilities	**0.1**	**0.3**	**0.4**	**0.2**
Option 1—PP	–5,000	–2,000	2,000	5,000
Option 2—LB and PP	–10,000	–4,000	6,000	12,000
Option 3—TR and PP	–15,000	–10,000	7,000	13,000
Option 4—CC and PP	–30,000	–20,000	10,000	30,000
Option 5—LB, CC, and TR	–60,000	–35,000	20,000	55,000
Perfect Information	–5,000	–2,000	20,000	55,000
Perfect info × Probability	–500	–600	8,000	11,000

The expected value with certainty = 17,900
The expected value = 2,600
The expected value of perfect information = 15,300

3. There are a number of options that Bob did not consider. See if students can list one or more of these options.

3 TOM TUCKER’S LIVER TRANSPLANT



Expected survival rate with surgery (5.95 years) exceeds the nonsurgical survival rate of 2.30 years. Surgery is favorable.

Other factors might include the particular doctor and hospital used and care received.