Supplement 1

Operational Decision-Making Tools: Decision Analysis

S1-1. a. *Minimin:*
South Korea 15.2
China 17.6
Taiwan 14.9
Poland 13.8
Mexico 12.5 ← minimum
Select Mexico

b. *Minimax:*
South Korea 21.7
China 19.0 ← minimum
Taiwan 19.2
Poland 22.5
Mexico 25.0
Select China

c. *Hurwicz* $(\alpha = 0.40)$:

South Korea: $15.2(0.40) + 21.7(0.60) = 19.10$

China: $17.6(0.40) + 19.0(0.60) = 18.44$

Taiwan: $14.9(0.40) + 19.2(0.60) = 17.48 \leftarrow \text{minimum}$

Poland: $13.8(0.40) + 22.5(0.60) = 19.02$

Mexico: $12.5(0.40) + 25.0(0.60) = 20.0$

Select Taiwan

d. *Equal likelihood:*
South Korea:
$21.7(0.33) + 19.1(0.33) + 15.2(0.33) = 18.48$

China: $19.0(0.33) + 18.5(0.33) + 17.6(0.33) = 18.18$

Taiwan: $19.2(0.33) + 17.1(0.33) + 14.9(0.33) = 16.90 \leftarrow \text{minimum}$

Poland: $22.5(0.33) + 16.8(0.33) + 13.8(0.33) = 17.52$

Mexico: $25.0(0.33) + 21.2(0.33) + 12.5(0.33) = 19.37$

Select Taiwan

S1-2. $EV(\text{South Korea}) = 21.7(.30) + 19.1(.40) + 15.2(.30) = 18.71$

$EV(\text{China}) = 19.0(.30) + 18.5(.40) + 17.6(.30) = 18.38$

$EV(\text{Taiwan}) = 19.2(.30) + 17.1(.40) + 14.9(.30) = 17.07 \leftarrow \text{minimum}$

$EV(\text{Poland}) = 22.5(.30) + 16.8(.40) + 13.8(.30) = 17.61$

$EV(\text{Mexico}) = 25.0(.30) + 21.2(.40) + 12.5(.30) = 19.73$

Select Taiwan

Expected value of perfect information $= 19(.30) + 16.8(.40) + 12.5(.30) = 16.17$

EVPI $= 16.17 - 17.07 = \$ - 0.9$ million

The EVPI is the maximum amount the *cost* of the facility could be reduced (.9 million) if perfect information can be obtained.

S1-3. a. *Maximax criteria:*
Office building 4.5 ← maximum
Parking lot 2.4
Warehouse 1.7
Shopping mall 3.6
Condominiums 3.2
Select office building

b. *Maximin criteria:*
Office building 0.5
Parking lot 1.5 ← maximum
Warehouse 1.0
Shopping mall 0.7
Condominiums 0.6
Select parking lot

c. *Equal likelihood:*
Office building: $0.5(0.33) + 1.7(0.33) + 4.5(0.33) = 2.21 \leftarrow$ maximum
Parking lot: $1.5(0.33) + 1.9(0.33) + 2.4(0.33) = 1.91$
Warehouse: $1.7(0.33) + 1.4(0.33) + 1.0(0.33) = 1.35$
Shopping mall: $0.7(0.33) + 2.4(0.33) + 3.6(0.33) = 2.21 \leftarrow$ maximum
Condominiums: $3.2(0.33) + 1.5(0.33) + 0.6(0.33) = 1.75$
Select office building or shopping mall

d. *Hurwicz criteria* $(\alpha = 0.3)$:
Office building: $4.5(0.3) + 0.5(0.7) = 1.70$
Parking lot: $2.4(0.3) + 1.5(0.7) = 1.77 \leftarrow$ maximum
Warehouse: $1.7(0.3) + 1.0(0.7) = 1.21$
Shopping mall: $3.6(0.3) + 0.7(0.7) = 1.57$
Condominiums: $3.2(0.3) + 0.6(0.7) = 1.38$
Select parking lot

S1-4. a) $\text{EV}(\text{Office building}) = .5(.50) + 1.7(.40) + 4.5(.10) = 1.38$
$\text{EV}(\text{Parking lot}) = 1.5(.50) + 1.9(.40) + 2.4(.10) = 1.75$
$\text{EV}(\text{Warehouse}) = 1.7(.50) + 1.4(.40) + 1.0(.10) = 1.51$
$\text{EV}(\text{Shopping mall}) = 0.7(.50) + 2.4(.40) + 3.6(.10) = 1.67$
$\text{EV}(\text{Condominiums}) = 3.2(.50) + 1.5(.40) + .06(.10) = 2.26 \leftarrow$ maximum
Select Condominium project

b) EVPI = Expected value of perfect information–expected value without perfect information
= 3.01–2.26 = $0.75 million

S1-5. a. Maximax: Risk fund, maximax payoff = $167,000
b. Maximin: Savings bond maximin payoff = $30,000
c. Equal likelihood: Bond fund, maximum payoff = $35,000

S1-6. a. Best decision, given probabilities: Bond fund, maximum payoff = $35,000
b. Expected value *given* perfect information
= (5*0.1) + (4*0.2) + (4.2*0.4) + (9.3*0.2) + (16.7*0.1) = $6.51
EVPI = $6.51- $3.50 = $3.01 or $30,100

S1-7. Since the payoff table includes "costs," the decision criteria must be reversed.
a. Minimin: Philippines, minimum cost = $170,000
b. Minimax: Brazil, minimum cost = $570,000
c. Equal likelihood: Philippines, minimum cost = $399,000
d. Minimax regret: Philippines, minimum regret = $70,000

S1- 8 a. EV (China) = 5.328
EV (India) = 5.375
EV (Philippines) = 5.218
EV (Brazil) = 5.178 *Select*
EV (Mexico) = 5.202
b. EV *given* perfect information = $(1.7)(0.09) + (3.8)(0.27) + (5.4)(0.64) = $4.635
EVPI = $5.178 – 4.365 = $0.813 or $813,000

S1– 9. Since this payoff table includes "losses," the decision criteria must be reversed.
a. Minimin: Thailand, minimum loss = $3 million
b. Minimax: India, minimum loss = $14 million
c. Equal likelihood: India, minimum loss = $8.91 million
d. Minimax regret: Philippines, minimum regret = $2 million

S1-10. EV (China) = $10.91
EV (India) = 7.21 ***Select***
EV (Thailand) = 9.77
EV (Philippines) = 7.54

S1-11. a.

Product	**Expected Value**
Widget	$160,000(0.2)+90,000(0.5)-50,000(0.3)=\$62,000$
Hummer	$70,000(0.2)+40,000(0.5)+20,000(0.3)=\$40,000$
Nimnot	$45,000(0.2)+35,000(0.5)+30,000(0.3)=\$35,500$

The best option is to introduce the widget.

b. EV given perfect information:
$160,000(0.2)+90,000(0.5)+30,000(0.3)=\$86,000.$

EV without perfect information: Widget at $62,000.
Value of perfect information: $\$86,000-\$62,000=\$24,000$

The company would consider this a maximum; since perfect information is rare, it would probably pay

less than $24,000.

c. Maximax: Introduce widget, maximax payoff $= \$160,000$

Maximin: Introduce nimnot, maximin payoff $= \$30,000.$

Minimax regret: Introduce widget, Minimax regret $= \$80,000$

Equal likelihood: Introduce widget, maximum payoff $= \$66,000$

S1-12. a. Maximax: Major physical revision, maximum payoff = $972,000
b. Maximin: Paperback, maximum payoff = $68,000
c. Equal likelihood: Major content revision, maximum payoff = $419,430
d. Hurwicz: Major content revision, maximum payoff = $273,900

S1-13.

Publication Decision	Expected Value
Paperback	$216,290
Similar revision	386,340
Major content revision	468,780
Major physical revision	405,970

Best decision = major content revision
Overall "best" decision appears to be a "major content revision"

EVPI = (.23)(68,000) + (.46)(515,000) + (.31)(972,000) − 468,780
= $85,080
This is the maximum amount Wiley would pay an "expert" for additional information about the future competitive market.

S1-14. a. Maximax: Singapore, maximum payoff = $71 million
b. Maximin: Kaohsiung, maximum payoff = -$15 million
c. Equal likelihood: Kaohsiung, maximum payoff = $28.05 million
d. Hurwicz: Singapore, maximum payoff = $37.8 million
e. Minimax regret: Singapore, minimum regret = $9 million

S1-15. Expected value

Port	Expected Value
Hong Kong	$22.99
Singapore	34.52
Shanghai	24.54
Busan	28.30
Kaohsiung	33.66

a. Best decision = Singapore
b. Singapore appears to be the best "overall" decision.

S1-16. Expected value

Lease Decision	Expected Value
1 – year	$65,980
2 – year	103,010
3 – year	133,810

4 – year	154,300
5 – year	114,210

S1-17. EVPI = (.17)(1,228,000) + (.34)(516,000) + (.49)(−551,000) − 154,300
= $237,740

This is the maximum amount the restaurant owner would pay an energy "expert" for additional information about future energy prices.

S1-18. a. Maximax: Food court, maximum payoff = $87,000
b. Maximin: Child care center, maximum payoff = $17,000
c. Hurwicz: Lockers and showers, maximum payoff = $32,250
d. Equal likelihood: Lockers and showers, maximum payoff = $34,980

S1-19.

Service Facility	Expected Value
Child care center	$30,560
Swimming pool	7,610
Lockers and showers	44,150
Food court	15,440
Spa	20,580

Best decision = Lockers and showers

S1-16. a. Payoff table:

	Demand				
	20	**21**	**22**	**23**	**24**
Stock (lb)	**0.10**	**0.20**	**0.30**	**0.30**	**0.10**
20	20.00	20.00	20.00	20.00	20.00
21	18.50	21.00	21.00	21.00	21.00
22	17.00	19.50	22.00	22.00	22.00
23	15.50	18.00	20.50	23.00	23.00
24	14.00	16.50	19.00	21.50	24.00

$$\text{EV}(20) = \$20$$
$$\text{EV}(21) = 18.50(0.1) + 21(0.2) + 21(0.3) + 21(0.3) + 21(0.1) = \$20.75$$
$$\text{EV}(22) = 17(0.1) + 19.50(0.2) + 22(0.3) + 22(0.3) + 22(0.1) = \$21.00$$
$$\text{EV}(23) = 15.50(0.1) + 18(0.2) + 20.50(0.3) + 23(0.3) + 23(0.1)$$
$$= \$20.50$$
$$\text{EV}(24) = 14(0.1) + 16.50(0.2) + 19(0.3) + 21.50(0.3) + 24(0.1)$$
$$= \$19.25$$

Order 22 lb of apples for a profit of $21.00.

b. Maximax: Stock 24 lb for a maximax profit of $24.00.
Maximin: Stock 20 lb for a maximin profit of $20.00.

S1-21. a. Payoff table:

	Demand					
Stock (lb) (boxes)	**25 0.10**	**26 0.15**	**27 0.30**	**28 0.20**	**29 0.15**	**30 0.10**
25	50	50	50	50	50	50
26	49	52	52	52	52	52
27	48	51	54	54	54	54
28	47	50	53	56	56	56
29	46	49	52	55	58	58
30	45	48	51	54	57	60

$$\text{EV}(25) = 50(0.1)+50(0.15)+50(0.3)+50(0.2)+50(0.15)+50(0.1) = \$50.00$$
$$\text{EV}(26) = 49(0.1)+52(0.15)+52(0.3)+52(0.2)+52(0.15)+52(0.1) = \$51.70$$
$$\text{EV}(27) = 48(0.1)+51(0.15)+54(0.3)+54(0.2)+54(0.15)+54(0.1) = \$52.95$$
$$\text{EV}(28) = 47(0.1)+50(0.15)+53(0.3)+56(0.2)+56(0.15)+56(0.1) = \$53.30$$
$$\text{EV}(29) = 46(0.1)+49(0.15)+52(0.3)+55(0.2)+58(0.15)+58(0.1) = \$53.05$$
$$\text{EV}(30) = 45(0.1)+48(0.15)+51(0.3)+54(0.2)+57(0.15)+60(0.1) = \$52.35$$

Best decision: Stock 28 boxes, for a profit of \$53.30.

b. Expected value under uncertainty:

$$\text{EV} = 500(0.10)+52(0.15)+54(0.30)+56(0.20)+58(0.15)+60(0.10) = \$54.90$$
$$\text{EVPI} = \$54.90 - \$53.30 = \$1.60$$

S1-22. a) Stock 25, maximum of minimum payoffs = \$50

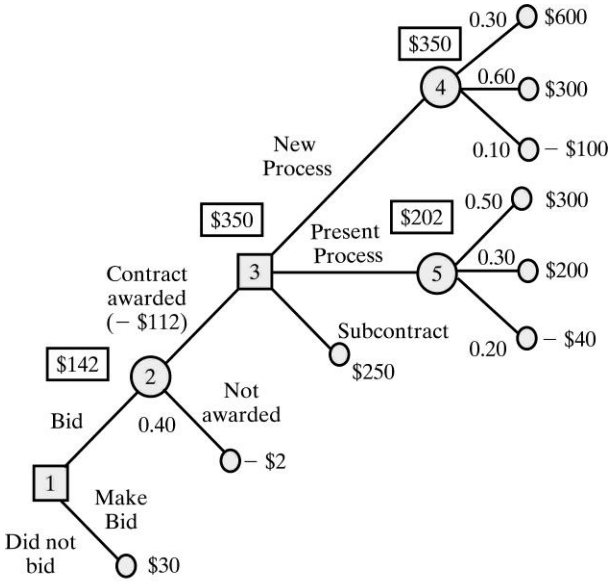
b) Stock 30, maximum of maximum payoffs = \$60

c) $25 : 50(.4)+50(.6) = 50$; $26 : 52(.4)+49(.6) = 50.2$; $27 : 54(.4)+48(.6) = 50.4$;
$28 : 56(.4)+47(.6) = 50.6$; $29 : 58(.4)+46(.6) = 50.8$; $30 : 60(.4)+45(.6) = 51$; stock 30 boxes.

d) Stock 28 or 29 boxes; minimum regret = \$4.

S1-23. $\text{EV}(\text{press}) = 40,000(.4)-8,000(.6) = \$11,200$;
$\text{EV}(\text{lathe}) = 20,000(.4)+4,000(.6) = \$10,400$;
$\text{EV}(\text{grinder}) = 12,000(.4)+10,000(.6) = \$10,800$; Purchase press.

S1-24.



make bid, $ 142 mil.

S1-25. a. Maximax = Gordon

b. Maximin = Jackson

c. Hurwicz $(\alpha = 0.25)$

$\text{Morris} = 4.4(0.25) + (-3.2)(0.75) = -\$1.3\text{M}$

$\text{O'Neil} = 6.3(0.25) + (-5.1)(0.75) = -\$2.3\text{M}$

$\text{Jackson} = 5.8(0.25) + (-2.7)(0.75) = -\$0.58\text{M}$

$\text{Gordon} = 9.6(0.25) + (-6.3)(0.75) = -\$2.33\text{M}$

Select Jackson

d. Equal likelihood

$\text{Morris} = 4.4(0.33) + (1.3)(0.33) + (-3.2)(0.33) = \$.83\text{M}$

$\text{O'Neil} = 6.3(0.33) + (1.8)(0.33) + (-5.1)(0.33) = +\$.99\text{M}$

$\text{Jackson} = 5.8(0.33) + (0.7)(0.33) + (-2.7)(0.33) = +\$1.254\text{M}$

$\text{Gordon} = 9.6(0.33) + (-1.6)(0.33) + (-6.3)(0.33) = \$.561\text{M}$

Select Jackson

e. $\text{EV}(\text{Morris}) = (-3.2)(0.15) + (1.3)(0.55) + (4.4)(0.30) = \$1.56\text{M}$

$\text{EV(O'Neil)} = (-5.1)(0.18) + (1.8)(0.26) + (6.3)(0.56) = \$3.08\text{M}$

$\text{EV}(\text{Jackson}) = (-2.7)(0.21) + (0.7)(0.32) + (5.8)(0.47) = \$2.38\text{M}$

$\text{EV}(\text{Gordon}) = (-6.3)(0.30) + (-1.6)(0.25) + (9.6)(0.45) = \$2.03\text{M}$

Select O'Neil.

S1-26. a. Maximax = Real Estate

b. Maximin = Nursing

c. Equal Likelihood: **select Real Estate**

Graphic design = $170,000
Nursing = $187,500
Real Estate = $202,500
Medical Technology = $195,000
Culinary technology = $170,000
Computer information technology = $186,250

d. Hurwicz (alpha = 0.25): **select Nursing**

Graphic design = $141,250
Nursing = $161,250
Real Estate = $158,750
Medical Technology = $157,500
Culinary technology = $136,250
Computer information technology = $158,750

S1-27. EV(Graphic design) = $164,250
EV(Nursing) = $183,500
EV(Real Estate) = $174,400
EV(Medical Technology) = $187,500
EV(Culinary technology) = $149,250
EV(Computer information technology) = $174,750

S1-28. a. Maximax = Juan Ramon
b. Maximin = Alan Rodriguez
c. Equal likelihood:
Garcia = 106.92
Ramon = 119.46 SELECT
Terry = 103.29
Rodriguez = 96.03
Washburn = 92.73
d. Hurwicz:
Garcia = 91.95
Ramon = 95.10 SELECT
Terry = 94.55
Rodriguez = 95.75
Washburn = 84.35

S1-29. a. EV(Garcia) = 100.3
EV(Ramon) = 112.4 SELECT
EV(Terry)= 98.2
EV(Rodriguez) = 91.6
EV(Washburn) = 85.2

b. Probably Terry; he seems to have the best tradeoff between low cost and wins. However, this is an objective opinion depending on the degree of risk the decision maker is willing to take on.

c. EV(Garcia) = 109.71
EV(Ramon) = 109.74 SELECT
EV(Terry)= 106.81
EV(Rodriguez) = 100.00
EV(Washburn) = 93.48

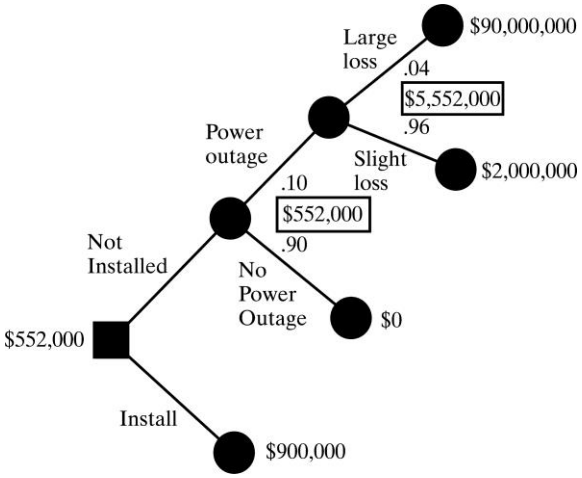
S1-30. a. Maximax = Hong Kong
b. Maximin = Pusan
c. Equal likelihood:
Shanghai = $0.44 billion
Singapore = $0.37 billion
Pusan = $0.43 billion
Kaoshiung = $0.41 billion
Hong Kong = $0.47 billion
d. Hurwicz (alpha = .55):
Shanghai = $0.47 billion
Singapore = $0.41 billion
Pusan = $0.46 billion
Kaoshiung = $0.54 billion
Hong Kong = $0.77 billion

S1-31. EV(Shanghai) = $0.608 billion
EV(Singapore) = $0.606 billion
EV(Pusan) = $0.502 billion
EV(Kaoshiung) = $0.487 billion
EV(Hong Kong) = $0.724 billion

S1-32. $\text{EV}\left(\text{snow shoveler}\right) = \$30\left(.12\right) + 60\left(.19\right) + 90\left(.24\right) + 120\left(.22\right) + 150\left(.13\right) + 180\left(.08\right) + 210\left(.02\right) = \$101.10$

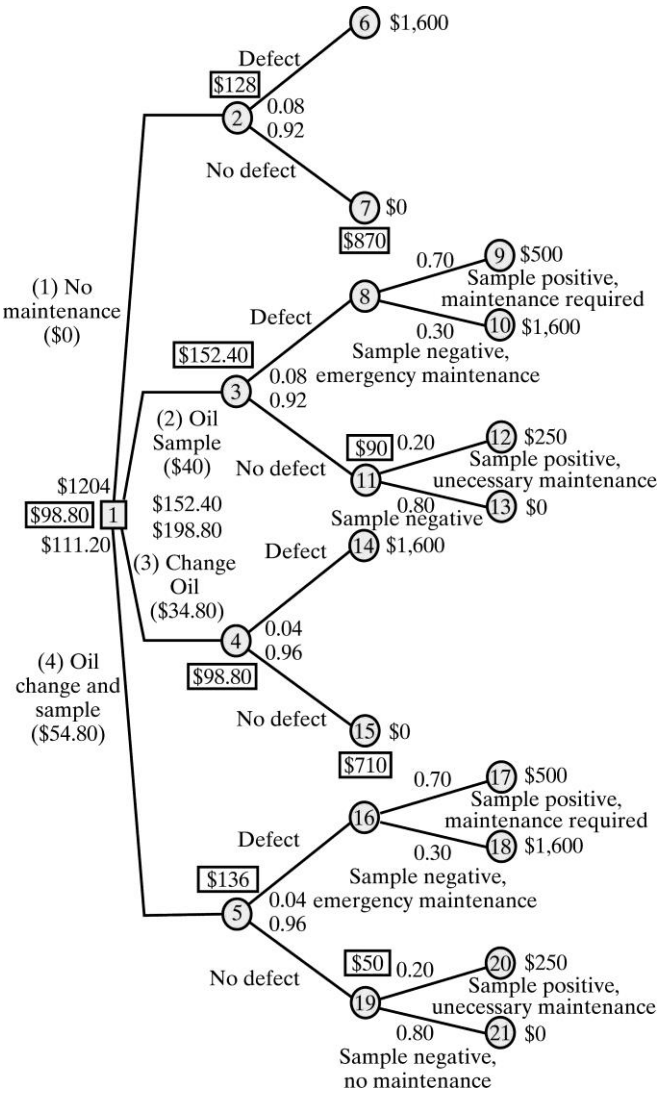
The cost of the snow blower ($575) is much more than the annual cost of the snow shoveler, thus on the basis of one year the snow shoveler should not be purchased. However, the snow blower could be used for an extended period of time such that after approximately 6 years the cost of the snow blower would be recouped. Thus, the decision hinges on weather or not the decision maker thinks 6 years is too long to wait to recoup the cost of the snow blower.

S1-33.



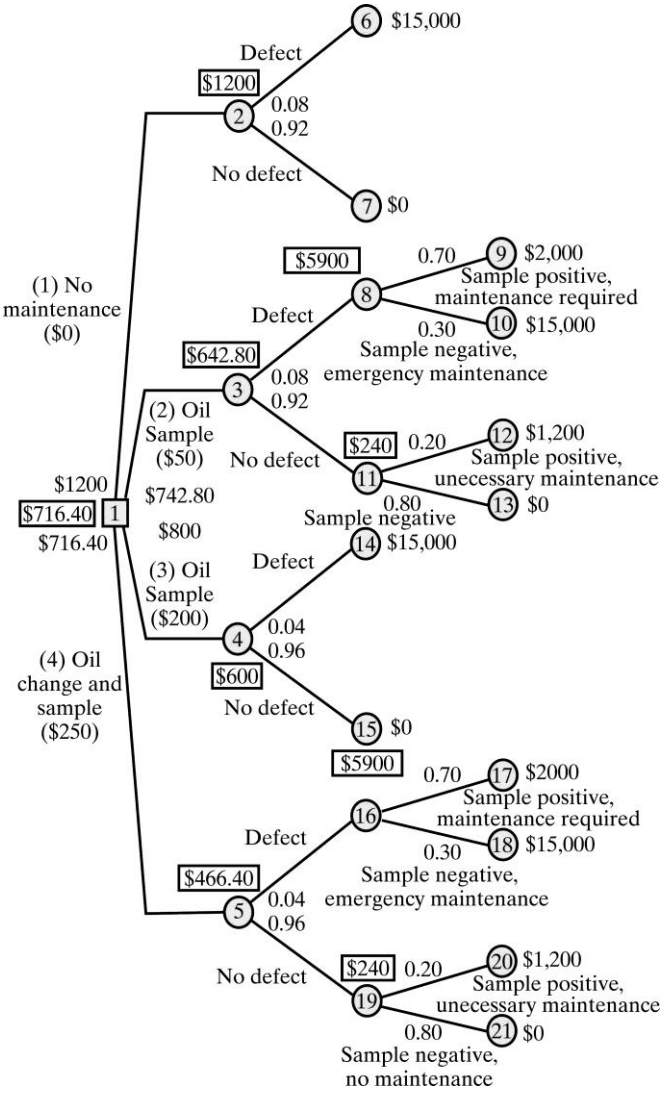
Since cost of installation ($900,000) is greater than expected value of not installing ($552,000), do not install an emergency power generator

S1-34.



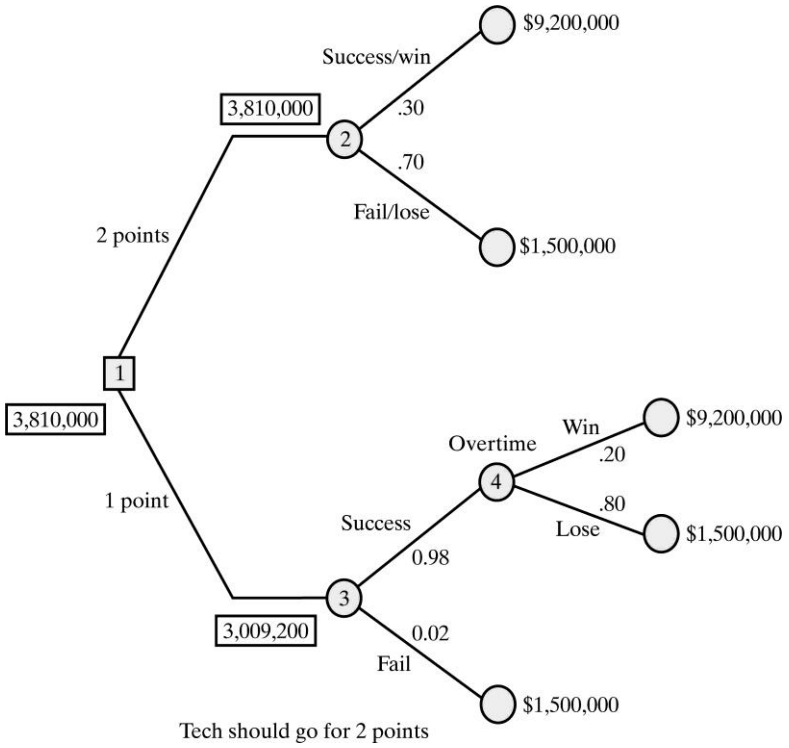
Select strategy 3; Change oil regularly; EV = $98.80

S1-35.



Select Strategy 4; Change oil and sample; EV = $716.40

S1-36. a.



b. $.98\left[9.2x+1.5(1-x)\right]+(.02)(1.5)=3.810$

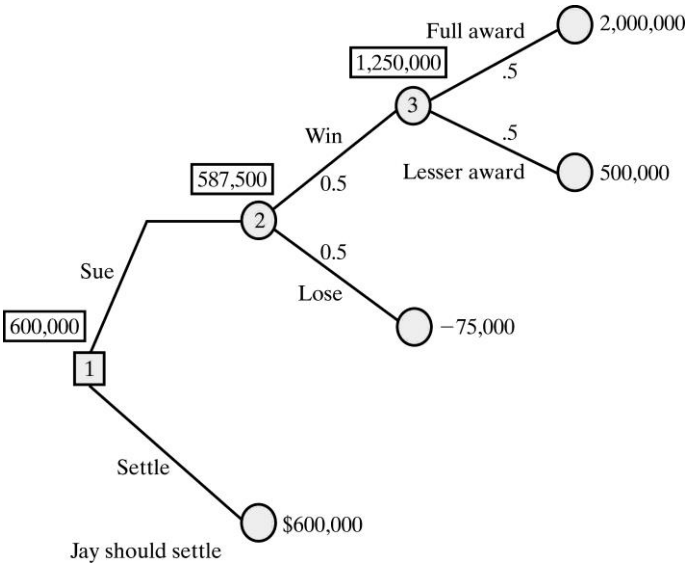
$$.98\left[7.7x+1.5\right]+.030=3.810$$

$$7.546x+1.47+.030=3.810$$

$$7.546x=2.31$$

$x=.306$ probability of winning in overtime

S1-37.



S1-38. The following table includes the medical costs for all the final nodes in the decision tree.

Expense	Plan 1	Plan 2	Plan 3
100	481	160	318
500	884	560	438
1,500	984	1,290	738
3,000	1,134	1,440	1,188
5,000	1,334	1,640	1,788
10,000	1,834	2,140	3,288

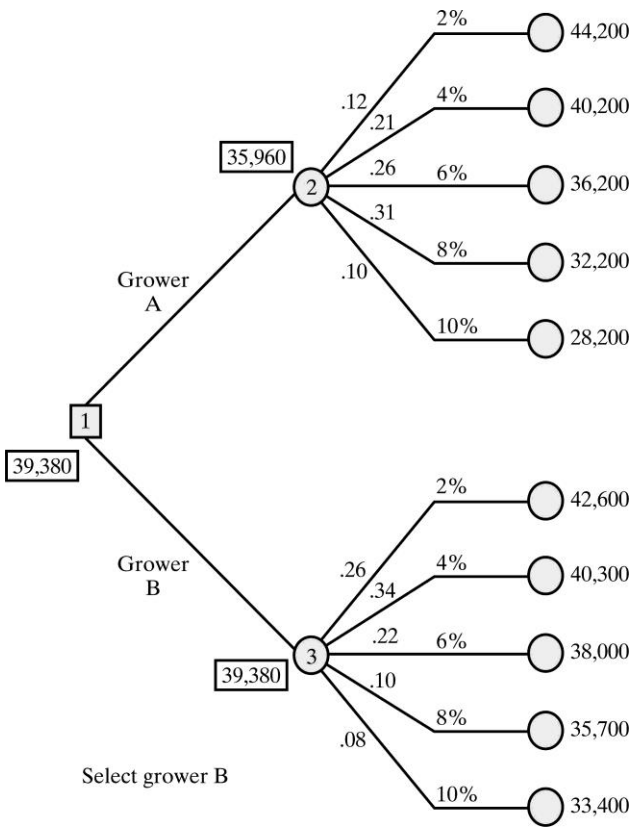
$E(1) = 954$

$E(2) = 976.5$

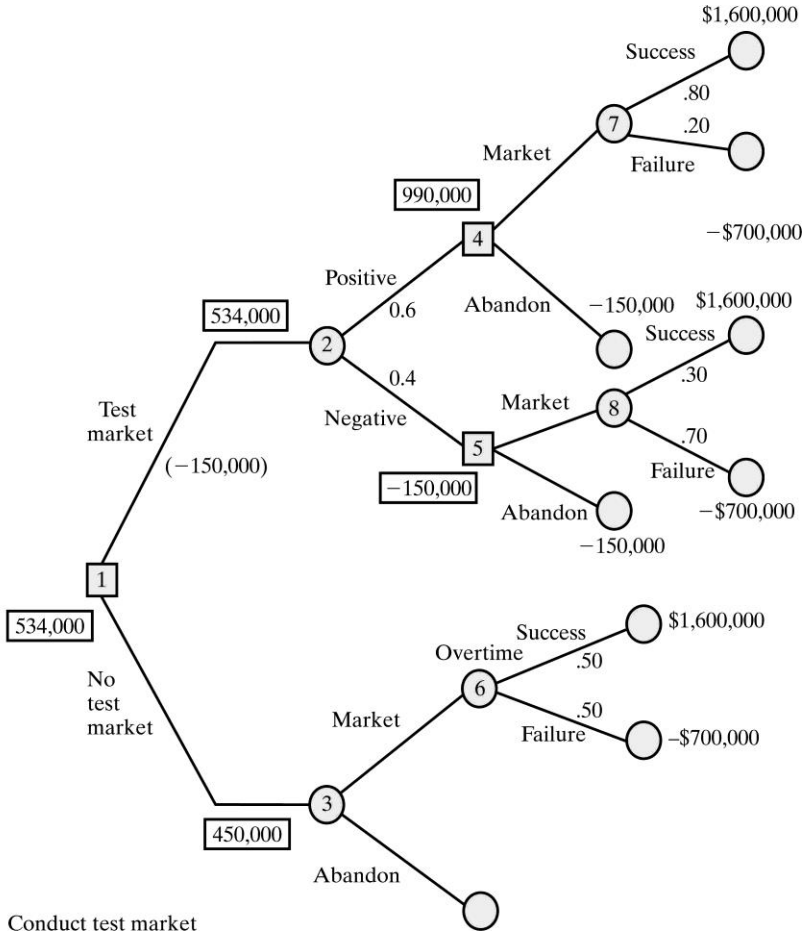
$E(3) = 810$

Select plan 3

S1-39.


2%
44,200
.12
4%
40,200
.21
35,960
.26
6%
36,200
2
.31
8%
32,200
.10
Grower
A
10%
28,200
1
39,380
2%
42,600
Grower
B
.26
4%
40,300
.34
.22
6%
38,000
3
39,380
.10
8%
35,700
.08
Select grower B
10%
33,400

S1-40.


$1,600,000
Success
.80
.20
7
Market
Failure
990,000
4
−$700,000
Positive
0.6
Abandon
−150,000
$1,600,000
534,000
2
Success
.30
0.4
Market
8
Test
market
Negative
.70
5
Failure
(−150,000)
−150,000
Abandon
−$700,000
−150,000
1
534,000
$1,600,000
Success
Overtime
.50
6
No
test
market
Market
.50
Failure
–$700,000
3
450,000
Abandon
Conduct test market

CASE S1.1: *Whither an MBA at Strutledge? -Continued*

a. Maximax: IT, maximum payoff = $517,000
b. Maximin: Health Administration, maximum payoff = –$75,000
c. Equal likelihood: Nursing, maximum payoff = $114,500
d. Hurwicz: Nursing, maximum payoff = $86,000
e. They do not have sufficient insight into the probability of the future success of the programs to indicate either optimism or pessimism; or for "political" reasons they feel it is imprudent to express a "preference."

f. Best decision = Nursing

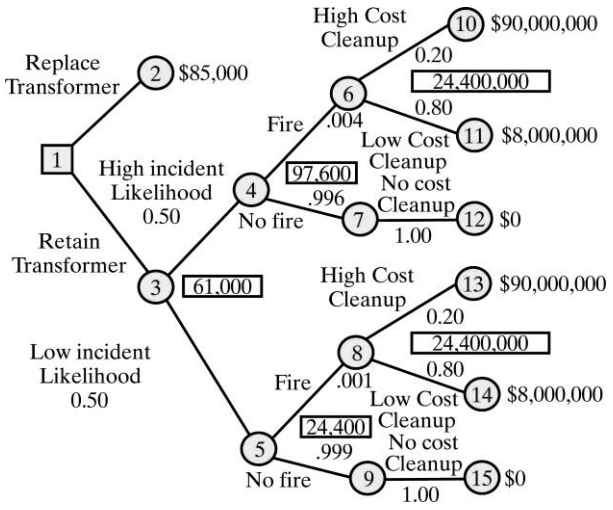
Graduate Program	Expected Value
MBA	–27,470
Computer Science	–45,000
Information Technology	10,790
Nursing	**126,760**
Health Administration	124,250

g. Nursing appears to be the best overall decision.

h. Depends on student answer.

CASE S1.2 : *Transformer Replacement at Mountain State Electric Service*

The decision tree solution for this problem is shown below. The decision should be to retain the existing transformer; the cost of replacement ($85,000) is greater than the cost of retention ($61,000).



CASE S1.3*: Evaluating Projects at Nexcom Systems*

Project	EV
1	404,368
2	434,976
3	**442,891**
4	344,490
5	262,252