Decision Analysis

Topics to be covered:

1. Decisions versus outcomes
2. Review of Contingency Table and Basic Probabilities – read the DAReview.doc
3. Payoff Tables and Features of Decision Problems
4. Decision Rules
    a. Nonprobabilistic rules
        i. MaxiMax
        ii. MaxiMin
        iii. MiniMax Regret
    b. Probabilistic rules
        i. Maximize Expected Monetary Value (EMV)
        ii. Minimize Expected Regret or Expected Opportunity Loss (EOL)
5. Expected Value for Perfect Information (EVPI)
6. Decision Trees and Use of Excel@ in Decision Analysis
7. Sensitivity Analysis and Graphic Sensitivity Analysis
8. Expected Value for Sample Information (EVSI)
9. Summary of Decision Analysis

Good Decisions versus Good Outcomes

	Good Outcome	Bad Outcome	
Good Decision	65	5	70
Bad Decision	5	25	30
	70	30	100

P(Good Outcome | Good Decision)=65/70=92.86% P(Bad outcome | Good Decision)=5/70=7.14%

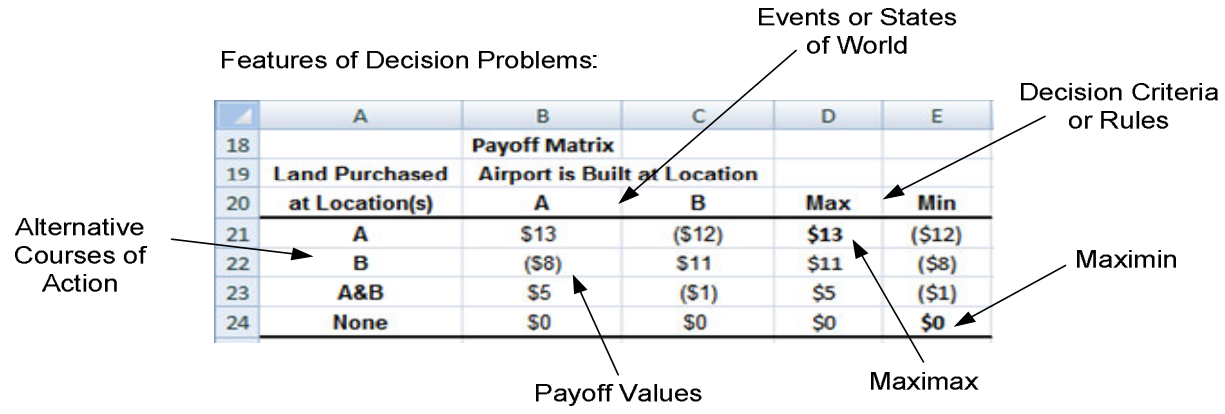
P(Good Outcome | Bad Decision)=5/30=16.67% P(Bad Outcome | Bad Decisioin)=25/30=83.33%

Review of Contingency Table and Basic Probabilities – read the DAReview.doc

Payoff Tables and Features of Decision Problems

	A	B	C
1			
2	**Magnolia Inns**	**Parcel of Land Near Location**	
3		**A**	**B**
4	**Current purchase price**	**$18**	**$12**
5	**Present value of future cash flows if hotel and airport are built at this location**	**$31**	**$23**
6	**Present value of future sales price of parcel if the airport is not built at this location**	**$6**	**$4**
7			
8	**(Note: All values are in millions of dollars.)**		
9			
10	**Computations to get the Payoff Matrix**		
11	**Land Purchased**	**Airport is Built at Location**	
12	**at Location(s)**	**A**	**B**
13	**A**	= 31 - 18 = 13	= 6 - 18 = (12)
14	**B**	= 4 - 12 =(8)	=23-12
15	**A&B**	=31 - 18 + 4 - 12	=23 - 12 + 6 - 18 = (1)
16	**None**	0	0
17			
18		**Payoff Matrix**	
19	**Land Purchased**	**Airport is Built at Location**	
20	**at Location(s)**	**A**	**B**
21	**A**	$13	($12)
22	**B**	($8)	$11
23	**A&B**	$5	($1)
24	**None**	$0	$0

Features of Decision Problems:



	A	B	C	D	E
18		**Payoff Matrix**			
19	**Land Purchased**	**Airport is Built at Location**			
20	**at Location(s)**	**A**	**B**	**Max**	**Min**
21	**A**	$13	($12)	**$13**	($12)
22	**B**	($8)	$11	$11	($8)
23	**A&B**	$5	($1)	$5	($1)
24	**None**	$0	$0	$0	**$0**

	A	B	C	D	E	F
1	**Payoff Matrix**					
2	**Land Purchased**	**Airport is Built at Location**				
3	**at Location(s)**	**A**	**B**			
4	**A**	$13	($12)			
5	**B**	($8)	$11			
6	**A&B**	$5	($1)			
7	**None**	$0	$0			
8						
9	**Regret or Opportunity Loss**					
10	**Land Purchased**	**Airport is Built at Location**				
11	**at Location(s)**	**A**	**B**			
12	**A**					
13	**B**					
14	**A&B**					
15	**None**					
16	**Probability(pj)**					
17						
18						
19	**Payoff Matrix**					
20	**Land Purchased**	**Airport is Built at Location**				
21	**at Location(s)**	**A**	**B**			
22	**A**	$13	($12)			
23	**B**	($8)	$11			
24	**A&B**	$5	($1)			
25	**None**	$0	$0			
26	**Probability(pj)**					
27						
28	**Expected Value with Perfect Information (EVwPI)**					
29						
30	**Maximum of EMV**					
31						
32	**Expected Value of Perfect Information (EVPI)**					
33						
34	**Sensitivity Analysis**					
35						
36	**Decision Tree**					
37						
38	**Use Decision Tree for EVwPI**					

(Decision.xlsx/ImnsBlank)

None Probabilistic Decision Rules

	A	B	C	D	E
1	**Magnolia Inns**	**Payoff Matrix**	**MiniMax Regret or Opportunity Loss**		
2	**Land Purchased**	**Airport is Built at Location**			
3	**at Location(s)**	**A**	**B**		
4	**A**	$13	($12)		
5	**B**	($8)	$11		
6	**A&B**	$5	($1)		
7	**None**	$0	$0		
8					
9	**Regret or Opportunity Loss = Max(Possible Profit for an Event) - Actual Profit for an Action taken**				
10					
11	**Land Purchased**	**Airport is Built at Location**			
12	**at Location(s)**	**A**	**B**		
13	**A**	= 13 - 13 = 0	= 11 - (-12) = 23		
14	**B**	= 13 - (-8) = 21	= 11 - 11 = 0		
15		= 13 - 5 = 8	= 11 - (-1) = 12		
16	**None**	= 13 - 0 = 13	= 11 - 0 = 11		
17					
18	**Regret or Opportunity Loss**	=MAX($B$4:$B$7)-B4	=MAX($C$4:$C$7)-C4		
19	**Land Purchased**	**Airport is Built at Location**		**MiniMax Regret or Opportunity Loss**	
20	**at Location(s)**	**A**	**B**	**Max**	
21	**A**	$0	$23	$23	=MAX(B21:C21)
22	**B**	$21	$0	$21	
23	**A&B**	$8	$12	$12	**←Minimum**
24	**None**	$13	$11	$13	

(Decision.xls/lmns1Reg)

Probabilistic Methods

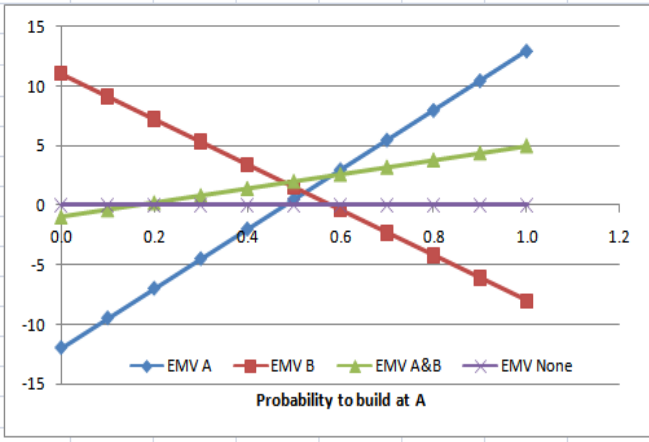
Expected Monetary Value (EMVi) = $\sum_j r_{ij} p_j$

	A	B	C	D	E
1	**Maximize Expected Monetary Value = Sum of Payoffs times its Probabilities**				
2		Payoff Matrix			
3	Land Purchased	Airport is Built at Location		=SUMPRODUCT($B$10:$C$10,B5:C5)	
4	at Location(s)	A	B	EMV	
5	**A**	**13**	-12	-2	
6	**B**	-8	**11**	3.4	**←Maximum**
7	**A&B**	5	-1	1.4	
8	**None**	0	0	0	
9					
10	**Probability (p_j)**	0.4	0.6		

	A	B	C	D	E	F	G	H
12	**Minimize Expected Regret or Expected Opportunity Loss (EOL)**							
13	**Regret or Opportunity Loss**							
14	**Land Purchased**	**Airport is Built at Location**		=SUMPRODUCT($B$90:$C$90,B85:C85)				
15	**at Location(s)**	**A**	**B**	**EOL**				
16	**A**	$0	$23	$13.80				
17	**B**	$21	$0	$8.40	**←Minimum**			
18	**A&B**	$8	$12	$10.40				
19	**None**	$13	$11	$11.80				
20								
21	**Probability (p_j)**	0.4	0.6					
22								
23	EMV and EOL always result in the same decision alternative							
24								
25	Expected Value of Perfect Information (EVPI) = Expected Profit under certainty - expected monetary value of the best alternative							
26	EVPI is also called Expected Opportunity L oss (EOL) from the best decision							
27				**Expected Value under Certainty or with Perfect Information**	**EMV of Best Action or Maximum of EMV**	**EVPI**		
28	**Computation for EVPI**	5.2	6.6	11.8	3.4	8.4		
29								
30	EVPI = EV w PI - Max EMV = Minimum of EOL							

(Decision.xls/Imns2EVPI)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Sensitivity Analysis**													
2							1	set up Payoff Matrix and Sensitivity Analysis Table as Given here						
3		Payoff Matrix					2	select cells A14 through E25						
4	Land Purchased	Airport is Built at Location		=SUMPRODUCT($B$79:$C$79,B74:C74)			3	Click Data, Data Tools, What-if Analysis, Data Table						
5	at Location(s)	A	B	EMV			4	Specify B11 (prob. To build at A) as Column Input Cell						
6	**A**	**13**	-12	-2			5	Click OK						
7	**B**	-8	**11**	3.4	←Maximum		6	Highlight A15:E25 to draw Insert/Scatter chart						
8	**A&B**	5	-1	1.4			7	Excel@ Select Data/Edit to match the name with the plot						
9	**None**	0	0	0										
10														
11	**Probability (p_j)**	0.4	0.6											
12														
13		EMV A	EMV B	EMV A&B	EMV None									
14	Probability to build at A	-2	3.4	1.4	0									
15	0.0	-12	11	-1	0									
16	0.1	-9.5	9.1	-0.4	0									
17	0.2	-7	7.2	0.2	0									
18	0.3	-4.5	5.3	0.8	0									
19	**0.4**	**-2**	**3.4**	**1.4**	**0**									
20	0.5	0.5	1.5	2	0									
21	0.6	3	-0.4	2.6	0									
22	0.7	5.5	-2.3	3.2	0									
23	0.8	8	-4.2	3.8	0									
24	0.9	10.5	-6.1	4.4	0									
25	1.0	13	-8	5	0									



(Decision.xls/Imns3SA)

How to set up sensitivity analysis with Excel Data Table for decision analysis

1 set up Payoff Matrix and Sensitivity Analysis Table as Given here
2 select cells A114 through E125
3 Click Data, Data Tools, What-if Analysis, Data Table
4 Specify B111 (prob. To build at A) as Column Input Cell
5 Click OK

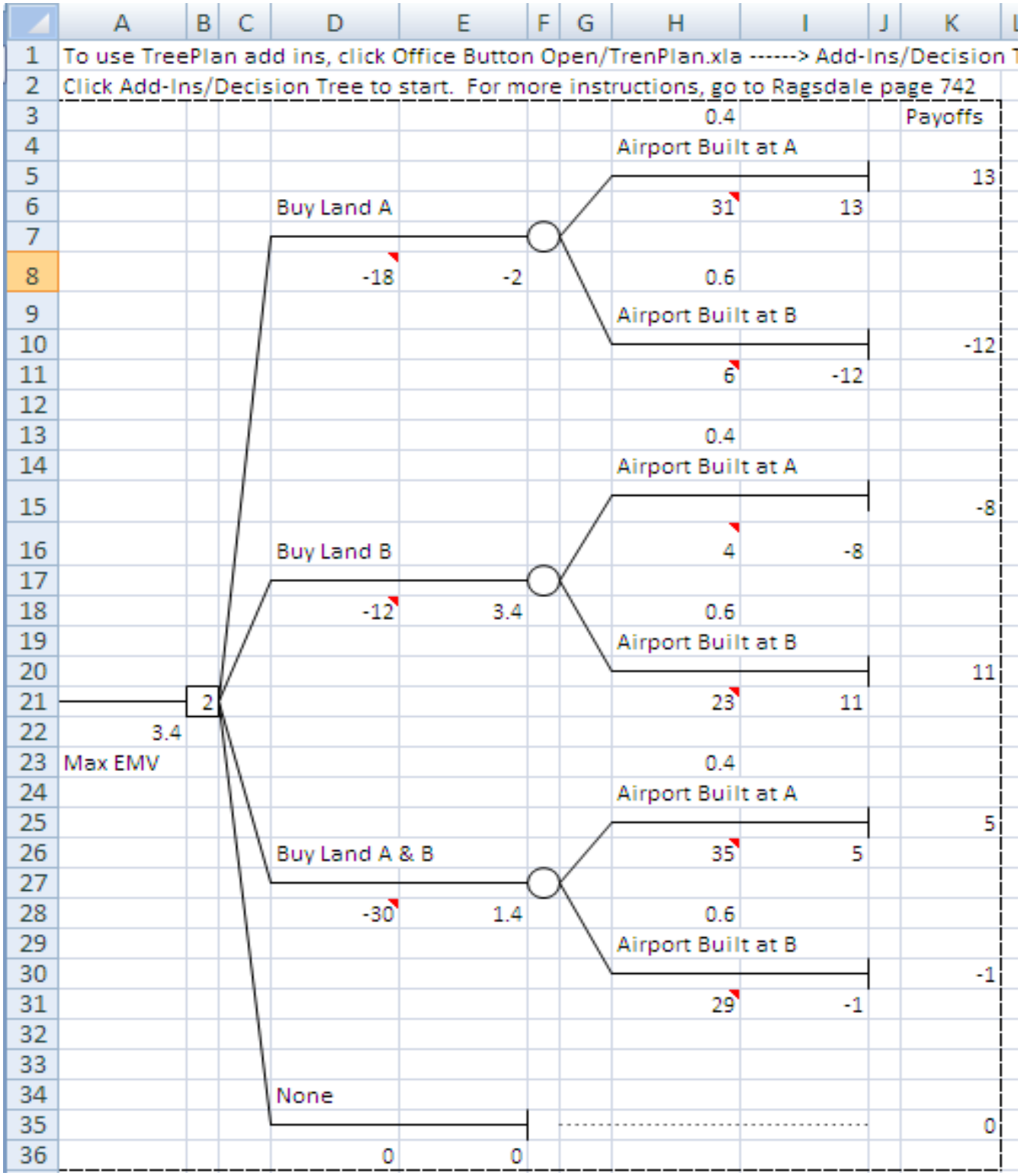
Decision Tree

	A	B	C	D	E	F	G	H
1		Parcel of Land Near Location						
2			A	B				
3		Current purchase price	$18	$12				
4		Present value of future cash flows if hotel and airport are built at this location	$31	$23				
5		Present value of future sales price of parcel if the airport is not built at this location	$6	$4				
6								
7		Payoff Matrix						
8		Land Purchased	Airport is Built at Location					
9		at Location(s)	A	B	EMV			
10		A	**13**	-12	-2			
11		B	-8	**11**	3.4	←Maximum		
12		A&B	5	-1	1.4			
13		None	0	0	0			
14					=SUMPRODUCT($O$19:$P$19,C14:P14)			
15		prob (j).	0.4	0.6				

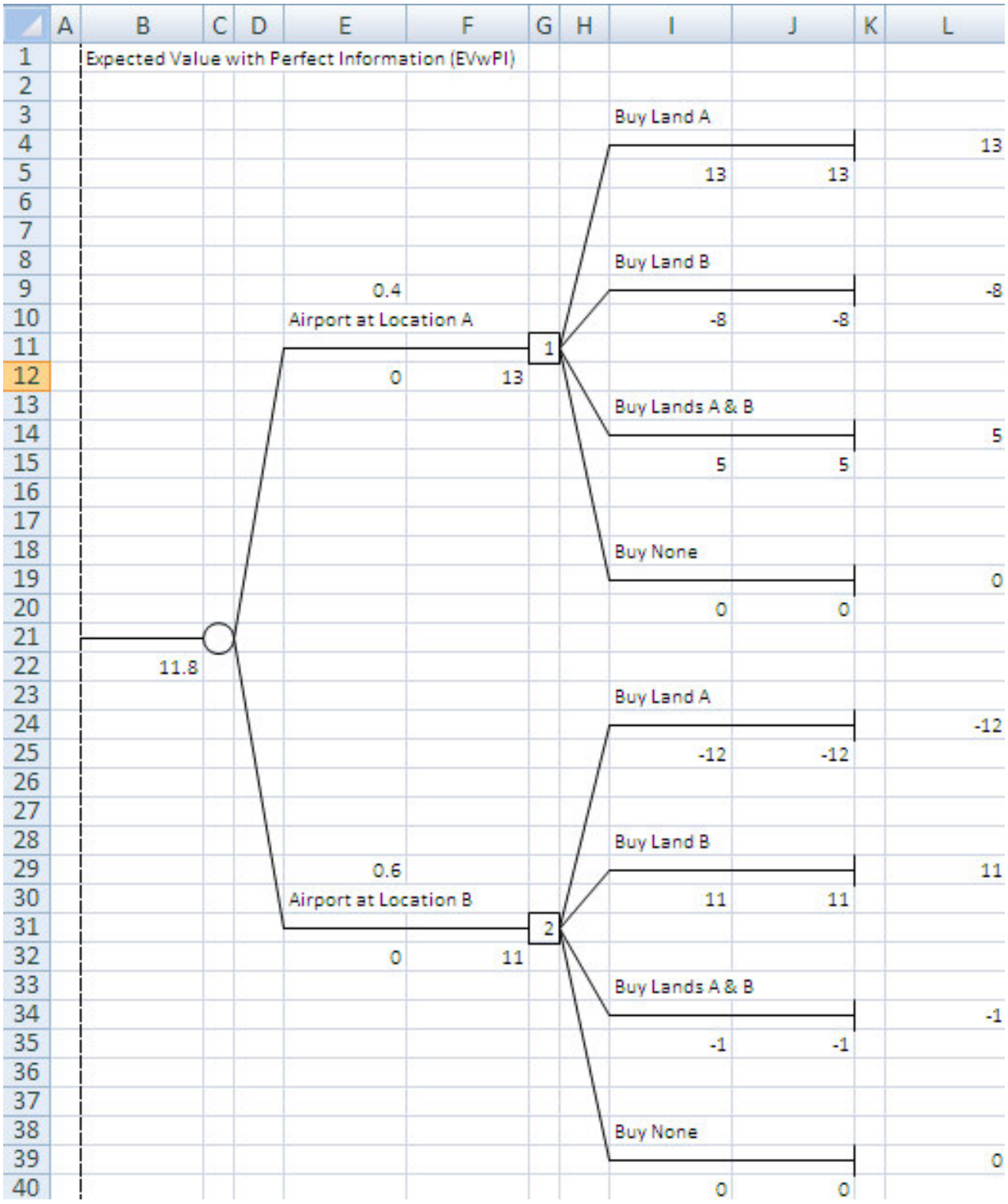
(Decision.xlsx/ImnsTree0)

How to build a Decision Tree with Excel@ TreePlan.xla?

1 To activate TreePlan, click Open/TreePlan.xla (be sure TreePlan.xla is on your computer)
2 To create a Decision Tree, click Add-Ins/Decision Tree to create a tree with two branches as default
3 with cursor point at decision node, click Decision Tree/add branch to add the third branch
4 with cursor point at decision node again, click Decision Tree/add branch to add the fourth branch
5 name the four tree branches according to the A, B, A&B and None
6 associate the costs of land purchases with respective branches using negatives
7 with cursor point at the end of each branch, click Decision Tree/change to event node with two events
8 name the two event branches as Airport Built at A or B respectively
9 match the probabilities for Airport Built at A and B respectively
10 associate the revenues of Buy Land A and Airport Built at A or B
11 with cursor point at the event node (Buy Land A and Airport Built at A or B, click Decision Tree/copy subtree/OK
12 with cursor point at the end of a branch where the new subtree to be connected, click Decision Tree/paste subtree/OK
13 repeat the process for the third branch
14 modify the probabilities and revenues associated with the event branches

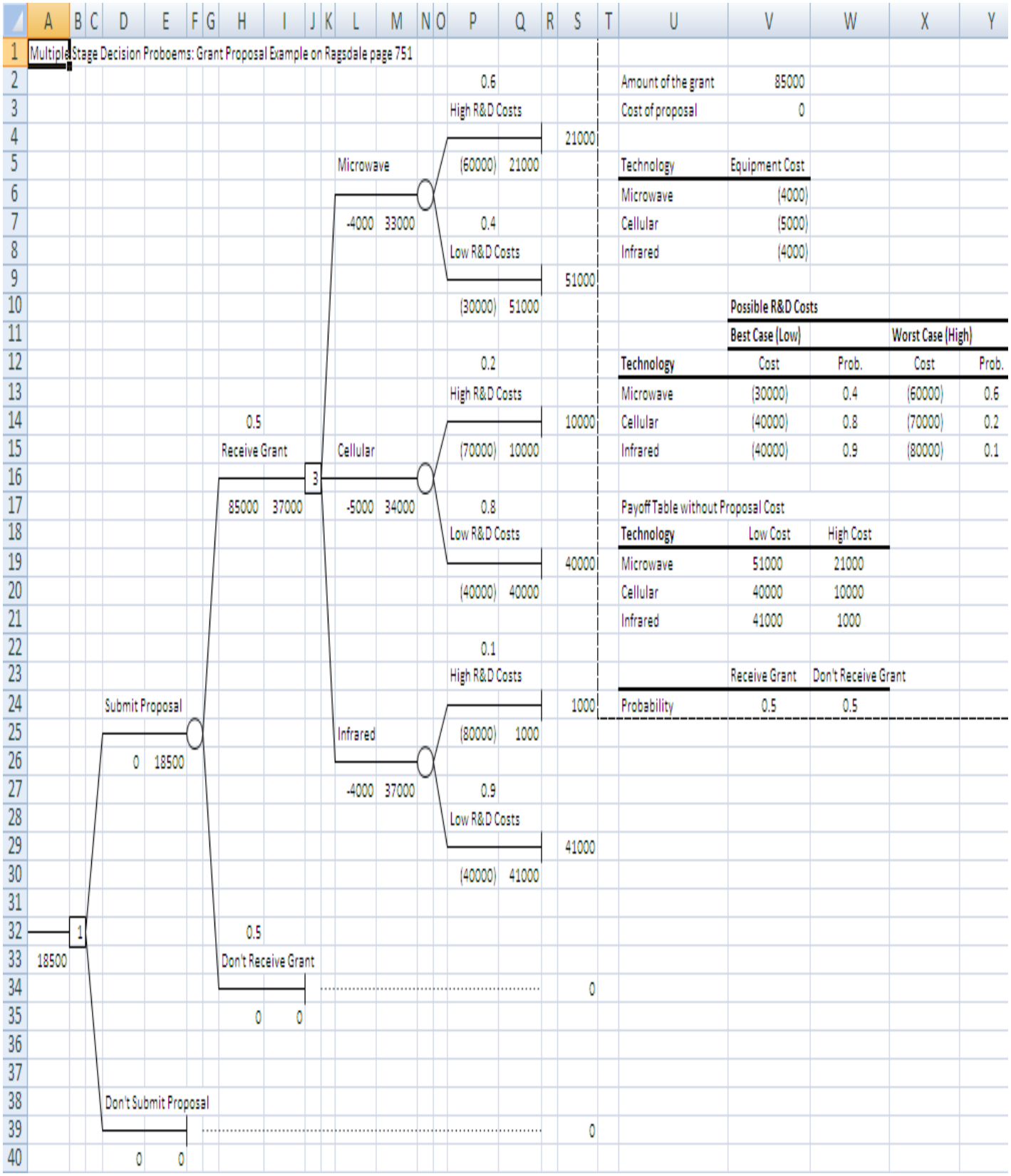


(Decision.xlsx/ImnsTree)



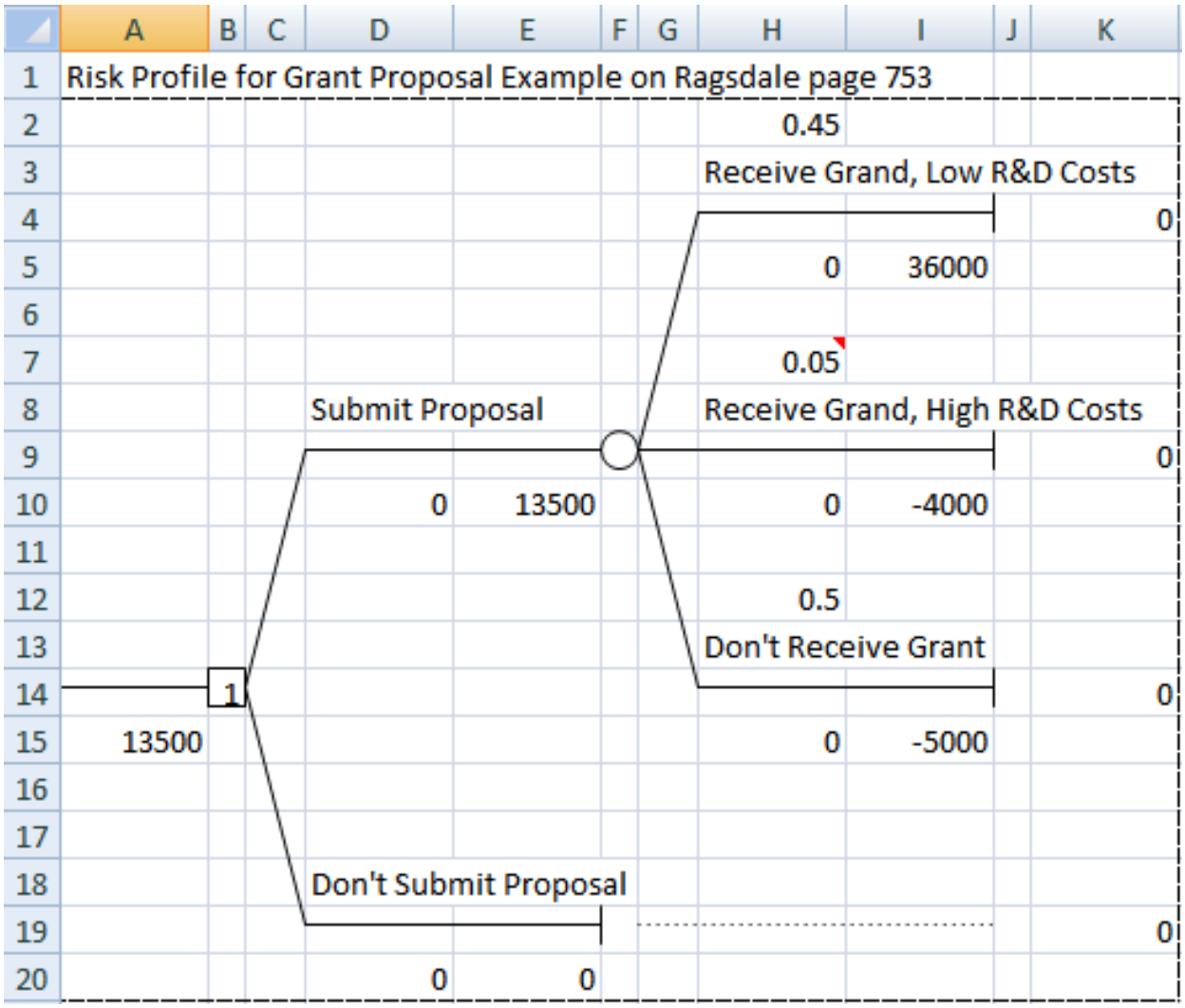
(Decision.xlsx/ImnsEVwPI)

Multiple Stage Decision Analysis:



(Decision.xls/MStageDA)

Develop Risk Profile:

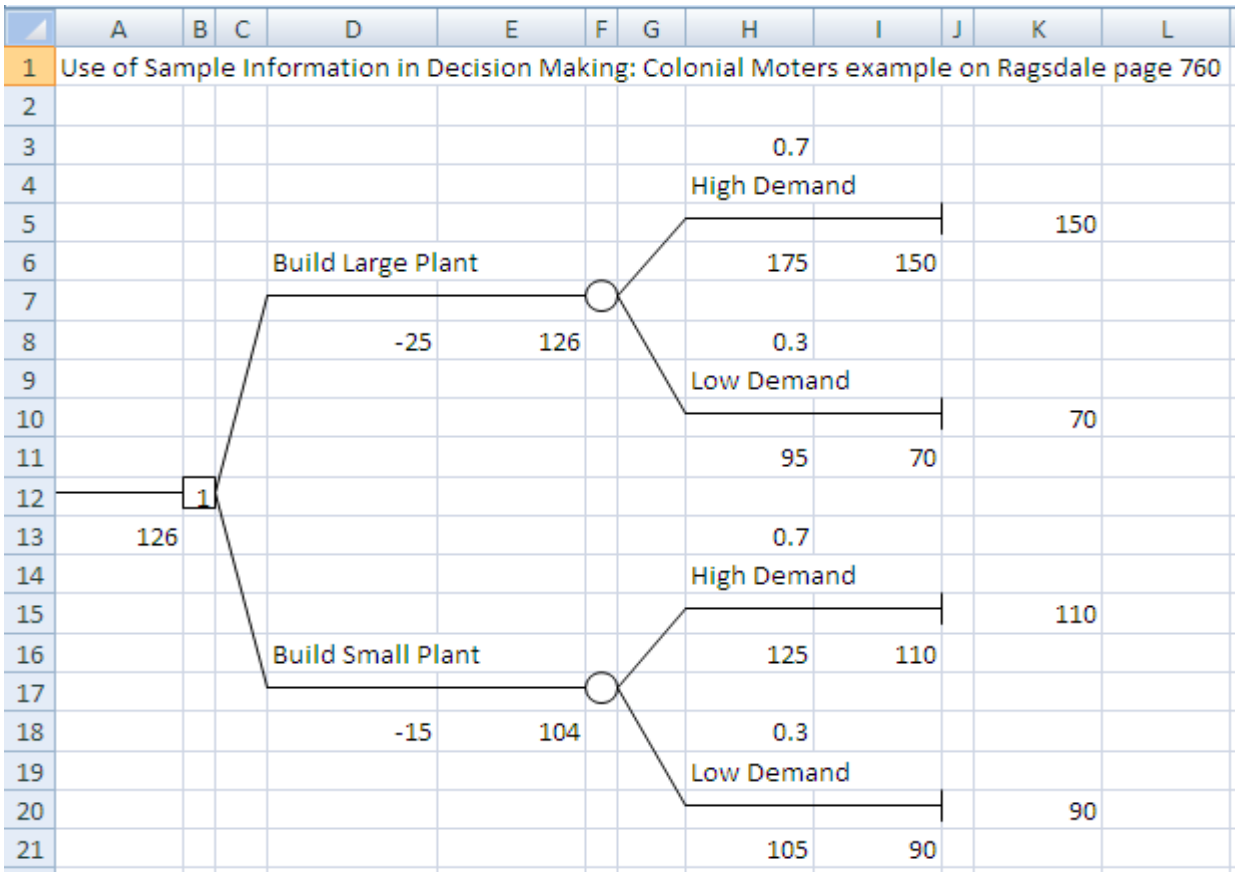


(Decision.xls/Risk)

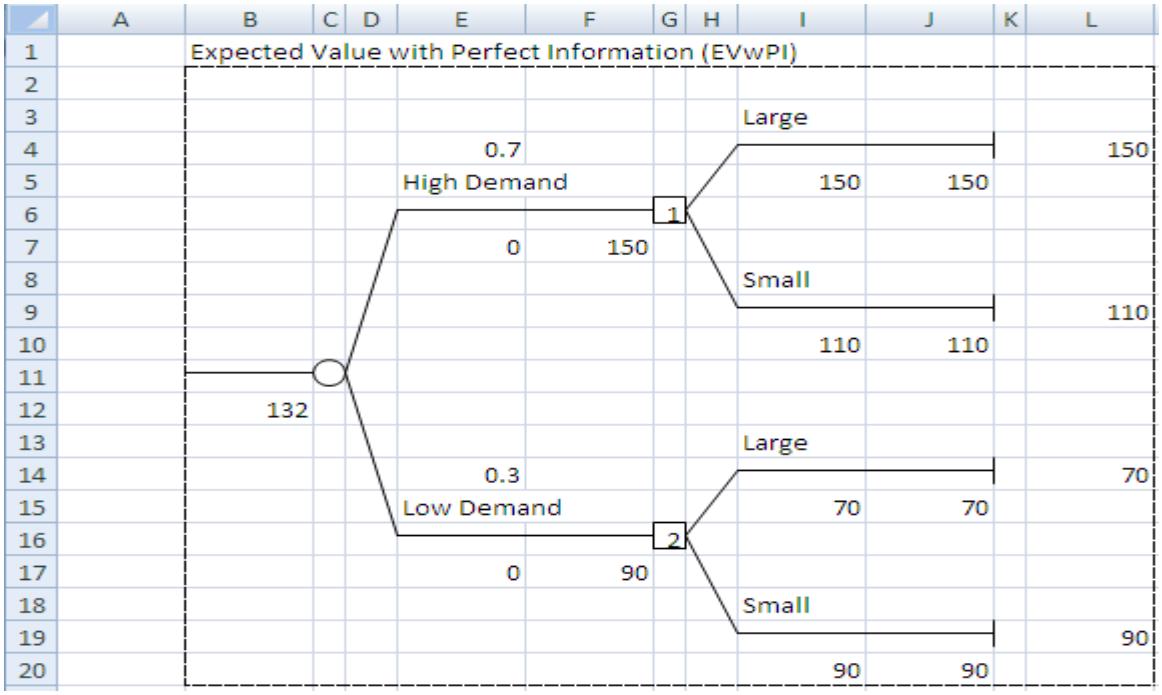
Use of Sample Information in Decision Making: Colonial Moters example on Ragsdale page 760

	A	B	C	D
1	Colonial Motors			
2		Factory Size	Building Cost ($mil)	
3		Large	(25)	
4		Small	(15)	
5				
6	Payoff Table without Building Cost ($mil)			
7	Factory Size	High Demand	Low Demand	
8	Large	175	95	
9	Small	125	105	
10				
11	Payoff Table with Building Cost ($mil)			
12	Factory Size	High Demand	Low Demand	
13	Large			
14	Small			
15				
16		High Demand	Low Demand	
17	Probability			
18				
19	EVwPI			
20	Max EMV			
21	EVPI=EVwPI-Max EMV			
22		High Demand	Low Demand	
23	Prior Probability			
24				
25	Conditional Probabilities or Likelihood of Survey Results Given Demand			
26	P(Survey Rsps|Dmd)	High Demand	Low Demand	
27	Favorable Rsp	0.857	0.223	
28	Unfavorable Rsp	0.143	0.777	
29	Sum Rsps(Col)	1.000	1.000	
30				
31	Joint Probabilities of Survey Rsps and Demand			
32	P(Survey Rsps & Dmd)	High Demand	Low Demand	SumDmd(Row)
33	Favorable Rsp			
34	Unfavorable Rsp			
35	Sum Rsps(Col)			
36				
37	Posterior Probabilities of Demand Given Survey Response			
38	P(Dmd|Survey Rsps)	High Demand	Low Demand	SumDmd(Row)

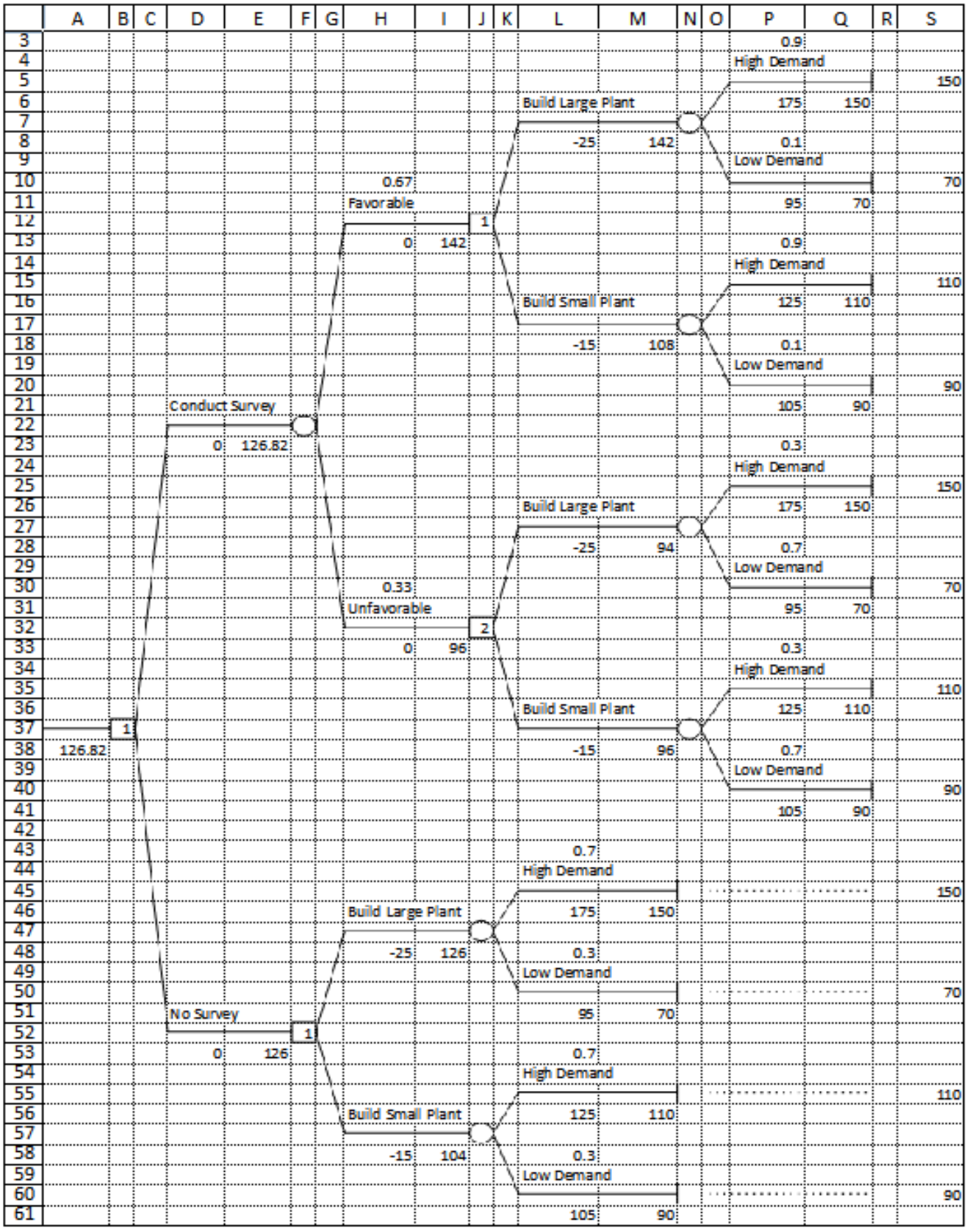
(Decision.xlsx/CMBlank)



(Decision.xls/CMDA)



(Decision.xlsx/CMEVwPI)



(Decision.xlsx/CMEVSI)

	Z	AA	AB	AC
37	Posterior Probabilities of Demand Given Survey Response			
38	P(Dmd|Survey Rsps)	High Demand	Low Demand	SumDmd(Row)
39	Favorable Rsp	0.9	0.1	1
40	Unfavorable Rsp	0.3	0.7	1
41				
42	P(Demand|Favorable)	0.9	0.1	Favorable Rsps
43	Payoff Table with Building Cost ($mil)			
44	Factory Size	High Demand	Low Demand	Favorable Rsps
45	Large	150	70	
46	Small	110	90	
47				
48	P(Demand|Unfavorable)	0.3	0.7	Unfavorable Rsps
49	Payoff Table with Building Cost ($mil)			
50	Factory Size	High Demand	Low Demand	Unfavorable Rsps
51	Large	150	70	
52	Small	110	90	
53				
54		P(Favorable Rsp)	P(Unfavorable Rsp)	
55	Probability of Response	0.667	0.333	
56	Decision on Facility Size			
57				EVwSI
58	Decision on Conduct Survey			
59				
60	Eexpected Value of Sample Information (EVSI) = EV with Sample Info - Max EMV without Sample Info			
61		EVwSI	Max EMV	EVSI
62	EVSI =			
63				
64	Effeciency of Sample Information = E = EVSI/EVPI 100%=			
65				
66		EVwPI	Max EMV	EVPI
67	EVPI = EVwPI - Max EMV =			
68				

(Decision.xlsx/CMEVwSI)