DECISION MODELLING

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DECISION MODELLING

- WHY DO WE NEED MODELS?
  - APPROXIMATION OF REALITY
  - UNDERSTAND PAST
  - PREDICT FUTURE
  - SEPARATE UNPREDICTABLE AND PREDICTABLE
  - A PICTURE, A SPREADSHEET, A SET OF MATHEMATICAL RELATIONSHIPS.

- WHAT IS A DECISION MODEL?
  - IS A MODEL THAT CAN BE USED TO UNDERSTAND, ANALYSE, OR FACILITATE MAKING A DECISION.

DECISION MODELING

- DEVELOPING STRATEGIES TO DEAL WITH:
  - WHAT PRICE TO CHARGE FOR A PRODUCT
  - WHERE TO LOCATE A NEW FACILITY
  - HOW MANY PEOPLE TO HIRE
  - WHERE TO ALLOCATE ADVERTISING BUDGETS
  - HOW TO SCHEDULE PRODUCTION
- QUANTITATIVE DECISION MODELS CAN GREATLY ASSIST IN THESE TYPES OF DECISIONS.
- SPREADSHEETS, IN PARTICULAR, PROVIDE A CONVENIENT MEANS TO MANAGE DATA, CONSTRUCT MODELS, AND ANALYSE THEM FOR GAINING INSIGHT AND SUPPORTING DECISIONS.

DECISION MODELLING

- MANY TIMES THERE IS NOT ONE RIGHT ANSWER TO A PROBLEM.
- ANALYTICAL SOLUTIONS VARY AS WE CHANGE ASSUMPTIONS AND INPUTS TO OUR ANALYSES
- FORMAL APPROACHES TO CHANGING ASSUMPTIONS AND INPUTS TO BETTER UNDERSTAND POSSIBLE OUTCOMES OF OUR ANALYSES
- THREE APPROACHES: SCENARIO ANALYSIS, SENSITIVITY ANALYSIS AND SIMULATION

MODELING AND DECISION TREES

- DECISION MODELS CHARACTERIZE THE RELATIONSHIPS BETWEEN DATA, UNCONTROLLABLE VARIABLES, AND DECISION VARIABLES AND THE OUTPUTS OF INTEREST TO THE DECISION MAKER.
- A SPREADSHEET IS ONE WAY OF EXPRESSING A DECISION MODEL THROUGH THE FORMULAS ENTERED IN THE CELLS THAT REFLECT THE RELATIONSHIPS AMONG THE MODEL COMPONENTS. FOR ANY SET OF INPUTS, THE SPREADSHEET CALCULATES SOME OUTPUT MEASURES OF INTEREST.
- SPREADSHEETS ARE IDEAL VEHICLES FOR IMPLEMENTING DECISION MODELS BECAUSE OF THEIR VERSATILITY IN MANAGING DATA, EVALUATING DIFFERENT SCENARIOS, AND PRESENTING RESULTS IN A MEANINGFUL FASHION.

DECISION MODELS – OUTSOURCING EXAMPLE

- DECISION MODELS ARE MODELS THAT CAN BE USED TO UNDERSTAND, ANALYZE, OR FACILITATE MAKING A DECISION

	A	B	
1	**Outsourcing Decision Model**		
2			
3	**Data**		
4			
5	**Manufactured in-house**		
6	Fixed cost	$	50,000
7	Unit variable cost	$	125
8			
9	**Purchased from supplier**		
10	Unit cost	$	175
11			
12	**Model**		
13			
14	Demand volume		1500
15			
16	Total manufacturing cost	$	237,500
17	Total purchased cost	$	262,500
18	Difference	$	(25,000)
19			
20	Decision	Manufacture	

	A	B
1	**Outsourcing Decision Model**	
2		
3	**Data**	
4		
5	**Manufactured in-house**	
6	Fixed cost	50000
7	Unit variable cost	125
8		
9	**Purchased from supplier**	
10	Unit cost	175
11		
12	**Model**	
13		
14	Demand volume	1500
15		
16	Total manufacturing cost	=B6+B7*B14
17	Total purchased cost	=B14*B10
18	Difference	=B16-B17
19		
20	Decision	=IF(B18<=0, "Manufacture", "Outsource")

OUTSOURCING MODEL

- MODEL COMPONENTS
  - *F* = FIXED COST OF IN-HOUSE MANUFACTURING
  - *V* = UNIT VARIABLE COST OF IN-HOUSE MANUFACTURING
  - C = UNIT COST OF OUTSOURCING
  - *D* = DEMAND VOLUME
- TOTAL MANUFACTURING COST = *TMC* = $F + V * D$
- TOTAL OUTSOURCING COST = *TOC* = $C * D$.

AIRLINE PRICING MODEL

	A	B
1	**Airline Pricing Model**	
2		
3	**Data**	
4	Airplane capacity	300
5	Fixed cost	$ 90,000
6	Demand function	
7	slope	-2.33
8	intercept	1900
9		
10	**Model**	
11		
12	Revenue	
13	Unit price	$ 500.00
14	Demand	733
15	Number of flights/day	3
16	Total Revenue	$366,666.67
17	Cost	
18	Fixed Cost	$270,000.00
19		
20	Profit	$96,666.67

	A	B
1	**Airline Pricing Model**	
2		
3	**Data**	
4	Airplane capacity	300
5	Fixed cost	90000
6	Demand function	
7	slope	=-7/3
8	intercept	1900
9		
10	**Model**	
11		
12	Revenue	
13	Unit price	500
14	Demand	=B8+B7*B13
15	Number of flights/day	=ROUNDUP(B14/B4,0)
16	Total Revenue	=B13*B14
17	Cost	
18	Fixed Cost	=B5*B15
19		
20	Profit	=B16-B18

SCENARIO ANALYSIS

- HELPS US TO FORMALIZE ONE OR MORE POSSIBLE ANSWERS TO QUESTIONS ABOUT THE FUTURE.
  - WHAT WOULD THE NPV OF A PARTICULAR CAPITAL PROJECT BE IF INTEREST RATES WERE TO INCREASE AND THE PROJECT LIFETIME WAS DECREASED BY 5 YEARS?
- STORY DRIVEN ACROSS ONE OR MORE VARIABLES

SENSITIVITY ANALYSIS

- WHAT-IF ANALYSIS – EVALUATE HOW SPECIFIC COMBINATIONS OF MODEL INPUTS THAT REFLECT KEY MODEL ASSUMPTIONS AFFECT MODEL OUTPUTS (OFTEN CALLED SENSITIVITY ANALYSIS).
- CHANGING VALUES OF AN INPUT TO A MODEL OR FORMULA INCREMENTALLY AND MEASURING THE RELATED CHANGE IN OUTCOMES.
  - WHAT WOULD THE NPV OF A CAPITAL PROJECT BE AS INTEREST RATES MOVE FROM 1% TO 15%?
- NUMERICAL VALUES IN A WHAT IF ANALYSIS ON ONE OR MORE VARIABLES

SIMULATION

- ITERATING THROUGH POSSIBLE VALUES OF ONE OR MORE VARIABLES OF A MODEL, IN ORDER TO CAPTURE POSSIBLE AND ULTIMATELY LIKELY OUTCOMES.
- DETERMINISTIC (ITERATE OVER ALL POSSIBLE OUTCOMES)
- NON DETERMINISTIC / RANDOM (ITERATE OVER VALUES BASED ON SOME ASSUMPTION)
  - EG, GIVEN A 40% PROBABILITY OF A €5 INCREASE IN UNIT COST IN THE NEXT 12 MONTHS, WHAT IS EXPECTED PROFIT PER UNIT.
- NUMERIC VALUES IN A WHAT IF ANALYSIS ON ONE OR MORE VARIABLES ACROSS A RANGE OF PROBABLE VALUES.

EXCEL

- SCENARIO ANALYSIS: GOAL SEEK, ,SCENARIO MANAGER
- SENSITIVITY ANALYSIS: SOLVER
- SIMULATION ANALYSIS: DATA TABLES

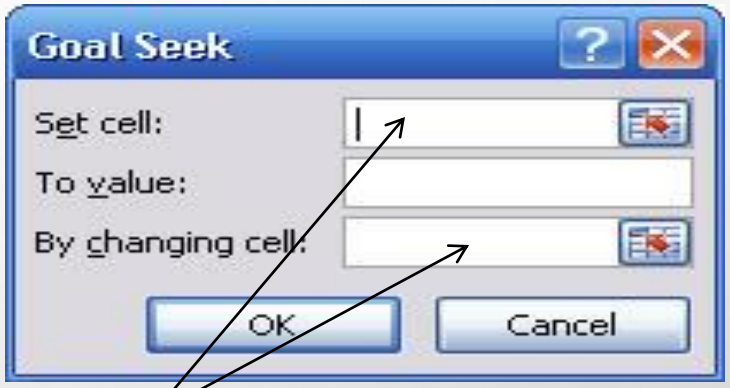
DECISION MODELING

- GOAL SEEK
  - GOAL SEEKING IS THE ABILITY TO CALCULATE BACKWARDS TO OBTAIN AN INPUT THAT WOULD RESULT IN A GIVEN OUTPUT.
  - ALSO CALLED WHAT IF ANALYSIS OR BACK SOLVING.
  - EXCEL ALLOWS YOU TO ADJUST A VALUE IN A FORMULA TO ACHIEVE A SPECIFIC GOAL. OR PUT ANOTHER WAY, EXCEL ALLOWS YOU TO DISCOVER THE INPUT VALUES NEEDED TO ACHIEVE A SPECIFIC GOAL.

GOAL SEEK

- FIND THE VALUE OF AN INPUT THAT PRODUCES A KNOWN RESULT WITHIN A SPREADSHEET
- EXAMPLE: FIND THE BREAKEVEN POINT IN THE OUTSOURCING DECISION MODEL

	A	B	
1	**Outsourcing Decision Model**		
2			
3	**Data**		
4			
5	**Manufactured in-house**		
6	Fixed cost	$	50,000
7	Unit variable cost	$	125
8			
9	**Purchased from supplier**		
10	Unit cost	$	175
11			
12	**Model**		
13			
14	Demand volume		1500
15			
16	Total manufacturing cost	$	237,500
17	Total purchased cost	$	262,500
18	Difference	$	(25,000)
19			
20	Decision	Manufacture	



Set cell is B18;
To value = 0;
By changing cell is B14

DECISION MODELING

- SCENARIO ANALYSIS IS A PROCESS OF ANALYZING POSSIBLE FUTURE EVENTS BY CONSIDERING ALTERNATIVE POSSIBLE OUTCOMES.
- SCENARIO ANALYSIS IS ONE OF THE MAIN FORMS OF PROJECTION DOES NOT TRY TO SHOW ONE EXACT PICTURE OF THE FUTURE.
- SCENARIO MANAGER IN EXCEL IS A TOOL THAT ALLOWS USERS TO DEAL WITH CHANGING UP TO 32 VARIABLES SIMULTANEOUSLY.
- USUALLY A MINIMUM OF THREE SCENARIOS ARE DEVELOPED, BEST CASE, LIKELY CASE, WORST CASE.

SCENARIO MANAGER

	Fixed Cost	Unit Variable Cost	Demand Volume
Best case	$40,000	$120	1,800
Worst case	$60,000	$140	1,000
Most likely case	$55,000	$125	1,500

Scenario Summary

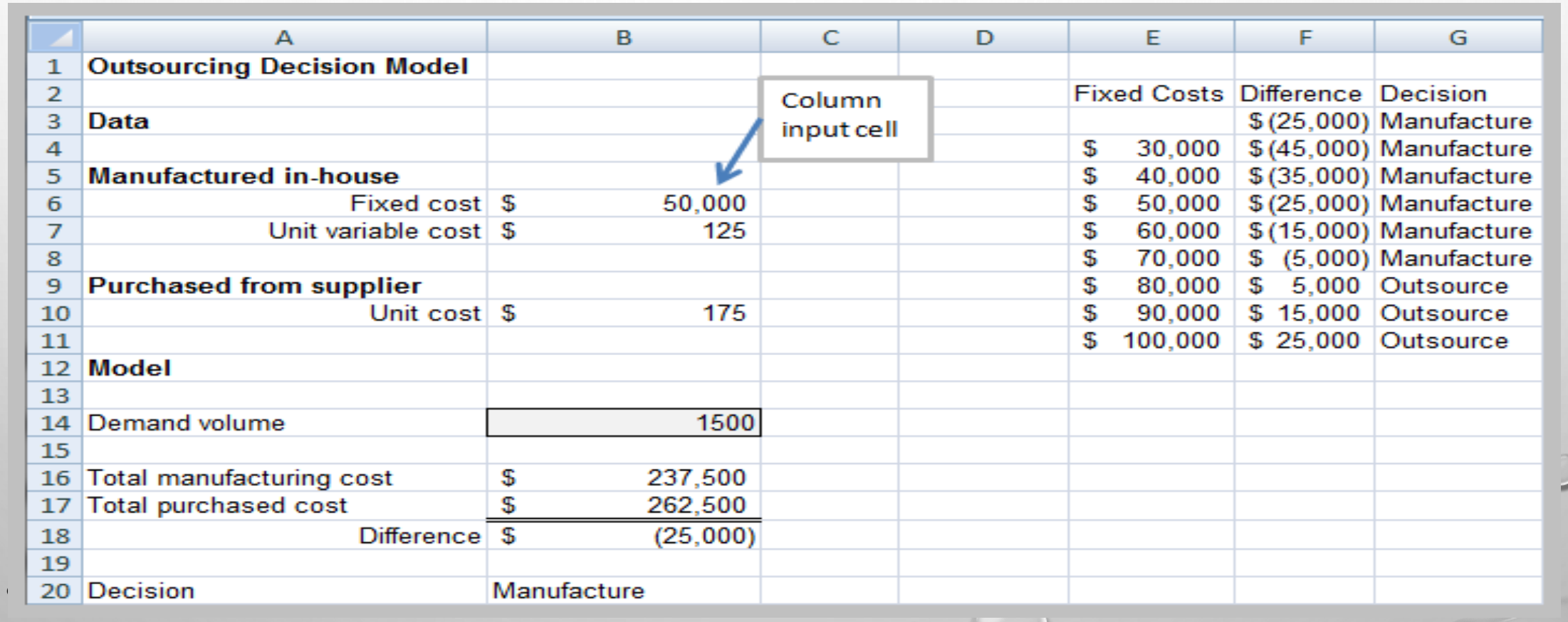
	Current Values:	Best case	Worst case	Most likely case
Changing Cells:				
B6	$ 50,000	$ 40,000	$ 60,000	$ 55,000
B7	$ 125	$ 120	$ 140	$ 125
B14	1500	1800	1000	1500
Result Cells:				
B18	$ (25,000)	$ (59,000)	$ 25,000	$ (20,000)
B20	Manufacture	Manufacture	Outsource	Manufacture

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

DECISION MODELING

- TABLES PROVIDE A STRAIGHTFORWARD VIEW OF YOUR DATA.
- INSTEAD OF CREATING DIFFERENT SCENARIOS YOU CAN CREATE A DATA TABLE TO QUICKLY TRY OUT DIFFERENT VALUES FOR FORMULAS.
  - ONE WAY TABLES PRESENT DATA FOR A SINGLE INPUT VARIABLES AFFECT ON THE OUTCOME.
  - TWO WAY TABLES PRESENT DATA FOR TWO INPUT VARIABLES' AFFECT ON THE OUTCOME

ONE WAY DATA TABLE



	A	B	C	D	E	F	G
1	**Outsourcing Decision Model**						
2					Fixed Costs	Difference	Decision
3	**Data**					$ (25,000)	Manufacture
4					$ 30,000	$ (45,000)	Manufacture
5	**Manufactured in-house**				$ 40,000	$ (35,000)	Manufacture
6	Fixed cost	$ 50,000			$ 50,000	$ (25,000)	Manufacture
7	Unit variable cost	$ 125			$ 60,000	$ (15,000)	Manufacture
8					$ 70,000	$ (5,000)	Manufacture
9	**Purchased from supplier**				$ 80,000	$ 5,000	Outsource
10	Unit cost	$ 175			$ 90,000	$ 15,000	Outsource
11					$ 100,000	$ 25,000	Outsource
12	**Model**						
13							
14	Demand volume	1500					
15							
16	Total manufacturing cost	$ 237,500					
17	Total purchased cost	$ 262,500					
18	Difference	$ (25,000)					
19							
20	Decision	Manufacture					

TWO WAY DATA TABLE

	A	B	C	D	E	F	G	H	I	J	K
1	**Outsourcing Decision Model**										
2			Column input cell		Fixed Cost			Variable Cost			
3	**Data**				Manufacture	$ 100	$ 110	$ 120	$ 130	$ 140	$ 150
4					$ 30,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture
5	**Manufactured in-house**				$ 40,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Outsource
6	Fixed cost	$ 50,000			$ 50,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Outsource
7	Unit variable cost	$ 125			$ 60,000	Manufacture	Manufacture	Manufacture	Manufacture	Outsource	Outsource
8			Row input cell		$ 70,000	Manufacture	Manufacture	Manufacture	Outsource	Outsource	Outsource
9	**Purchased from supplier**				$ 80,000	Manufacture	Manufacture	Manufacture	Outsource	Outsource	Outsource
10	Unit cost	$ 175			$ 90,000	Manufacture	Manufacture	Outsource	Outsource	Outsource	Outsource
11					$ 100,000	Manufacture	Outsource	Outsource	Outsource	Outsource	Outsource
12	**Model**										
13											
14	Demand volume	1500									
15											
16	Total manufacturing cost	$ 237,500									
17	Total purchased cost	$ 262,500									
18	Difference	$ (25,000)									
19											
20	Decision	Manufacture									

DECISION MODELING

- DATA SIMULATIONS USE RANDOM NUMBERS TO SIMULATE REAL WORLD MODELS.
- EXCEL HAS A RAND() FUNCTION FOR GENERATING RANDOM NUMBERS.
- SIMULATIONS LET YOU EXPERIMENT WITH DIFFERENT DECISIONS AND SEE THEIR OUTCOMES
- YOU CAN USE REPEATED SIMULATION "TRIALS" TO ASSESS ODDS OF VARIOUS OUTCOMES
- COMPANIES TYPICALLY USE SIMULATIONS TO ASSESS THE LIKELIHOOD OUTCOMES THAT MAY FOLLOW FROM DIFFERENT ACTIONS

5b) Create 90 simulations of the Passenger Revenue using VLOOKUP, the Likelihood Bins and the RAND function
5c) Create 90 simulations of the average annual profit using the Cost per Mile and Passenger Revenues
5d) Determine the probability of making a profit on the new Chicago - Atlanta Route
5d) Determine the probability of making a profit on the new Chicago - Atlanta Route

Likelihood bins	Passengers per Flight	Annual Passenger Revenue
0%	150	$8,662,500.00
41%	175	$10,106,250.00
71%	185	$10,683,750.00
91%	135	$7,796,250.00

Summary Information	
Average annual profit	$1,448,448
Probability of profit	81%
Establish the route?	

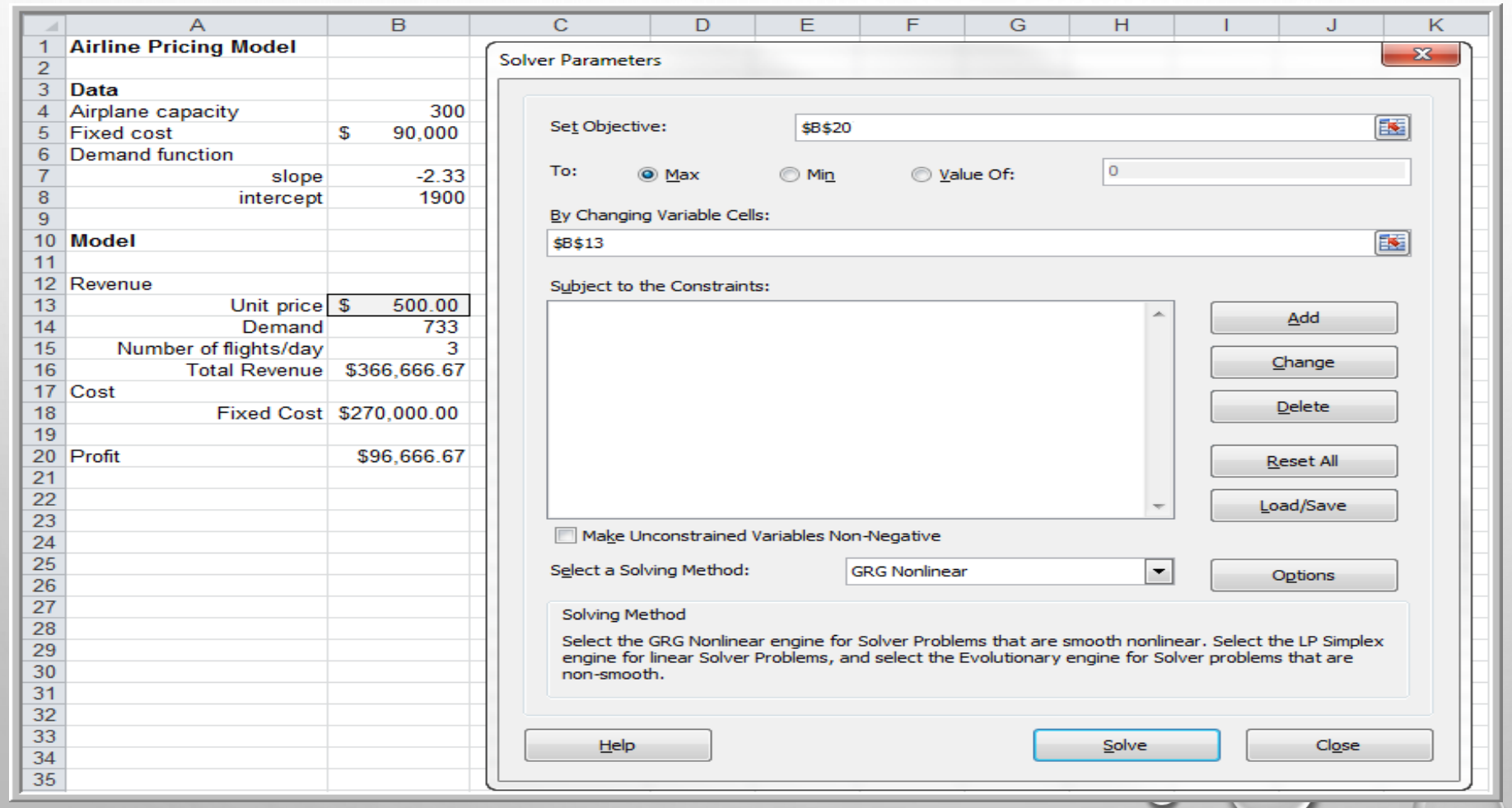
Runs	Cost / Mile	Annual Revenue	Profit
1	$40	$10,106,250	$2,285,328.81
2	$38	$8,662,500	$1,185,536.41
3	$37	$10,683,750	$3,432,810.64
4	$37	$8,662,500	$1,420,183.26
5	$35	$8,662,500	$1,761,723.23
6	$47	$8,662,500	($609,521.20)
7	$40	$8,662,500	$892,272.43
8	$30	$8,662,500	$2,693,852.09
9	$43	$8,662,500	$251,319.06
10	$49	$10,106,250	$456,854.97
11	$43	$10,106,250	$1,643,053.29
12	$41	$10,106,250	$2,093,517.66
13	$32	$8,662,500	$2,309,283.80
14	$47	$10,683,750	$1,413,048.36
15	$45	$8,662,500	($242,446.36)
16	$49	$8,662,500	($1,036,494.35)
17	$50	$10,683,750	$909,970.32
18	$44	$10,683,750	$2,076,814.35
19	$42	$10,106,250	$1,926,409.37
20	$46	$8,662,500	($399,006.66)
21	$47	$7,796,250	($1,510,751.23)
22	$45	$7,796,250	($1,010,427.60)
23	$36	$10,683,750	$3,551,023.30
24	$46	$10,106,250	$1,111,924.31
25	$42	$8,662,500	$470,447.66
26	$43	$10,683,750	$2,289,803.04
27	$39	$8,662,500	$1,074,241.07
28	$32	$10,106,250	$3,897,590.34
29	$43	$10,106,250	$1,601,567.80
30	$48	$10,106,250	$694,139.50
31	$50	$8,662,500	($1,060,957.73)
32	$44	$7,796,250	($760,135.84)
33	$48	$7,796,250	($1,585,636.06)
34	$33	$10,106,250	$3,537,029.53
35	$39	$10,683,750	$2,999,275.53
36	$42	$10,106,250	$1,881,568.28
37	$32	$8,662,500	$2,340,323.15
38	$43	$10,683,750	$2,152,781.86

SIMULATIONS

DECISION MODELING

- OPTIMISATION
- SOLVER IN EXCEL ALLOWS YOU TO FIND AN OPTIMAL (MAX OR MIN) VALUE FOR A FORMULA IN ONE CELL – CALLED THE OBJECTIVE CELL – SUBJECT TO CONSTRAINTS, OR LIMITS, ON THE VALUES OF OTHER FORMULA CELLS ON A WORKSHEET.
- SOLVER WORKS ON A GROUP OF CELLS CALLED DECISION VARIABLES THAT PARTICIPATE IN FORMULAS IN THE OBJECTIVE CELLS. SOLVER ADJUSTS THE VALUES IN THE DECISION CELLS TO SATISFY LIMITS AND PRODUCE THE RESULTS YOU WANT FOR THE OBJECTIVE CELL.
- IT FINDS THE VALUES NEEDED FOR THE BEST OUTCOME.

OPTIMIZATION MODELS: EXCEL *SOLVER*



	A	B
1	**Airline Pricing Model**	
2		
3	**Data**	
4	Airplane capacity	300
5	Fixed cost	$ 90,000
6	Demand function	
7	slope	-2.33
8	intercept	1900
9		
10	**Model**	
11		
12	Revenue	
13	Unit price	$ 500.00
14	Demand	733
15	Number of flights/day	3
16	Total Revenue	$366,666.67
17	Cost	
18	Fixed Cost	$270,000.00
19		
20	Profit	$96,666.67

Solution:
Price = $428.57;
profit = $115,714.28