Note: This lecture is best taken with Excel@ file LectureSIM.xls. Please pause the video and open Excel@ LectureSIM.xls, then continue. You may like to pause whenever you need to understand and repeat what is covered here.

SIMULATION

The objectives of simulation:

1) To estimate the unknown population mean μ_0 (the average profit) with the confidence interval developed through the grant mean and the standard deviation of MonteCarlito,

$$\bar{\bar{x}} \pm z\, s_{\bar{x}} \qquad \bar{p} \pm z\sqrt{\bar{p}(1-\bar{p})/n}$$

2) To estimate the unknown population proportion (of loss) with the confidence interval developed through the grant proportion of MonteCarlito

3) The value of z is given by =NORMSINV(1-α), Z = 1.96 for 1-α = 0.95

4) Conclusions of simulation study:
   a) We are 95% sure that the unknown true population mean (profit) is between the calculated lower and upper limits for the mean.
   b) We are 95% sure that the unknown true population proportion (loss) is between the calculated lower and upper limits for the proportion.

Product P and Profitability Analysis I

Suppose you are a manager in P Manufacturing that makes Product P only. The demands for Product P are 100 units per week at $90 per unit. The overhead (fixed) cost is $3,000 that includes $1,500 of operators' salaries, $1,000 equipment depreciation and $500 of utilities.

There are two raw materials: Steel Widget and Metal Bracket for products P. The unit costs for raw materials are $25.00 and $20.00 for Steel Widget, and Metal Bracket, respectively.

You are going to decide how many Ps to make in order to break-even (the net profit is zero) for the company

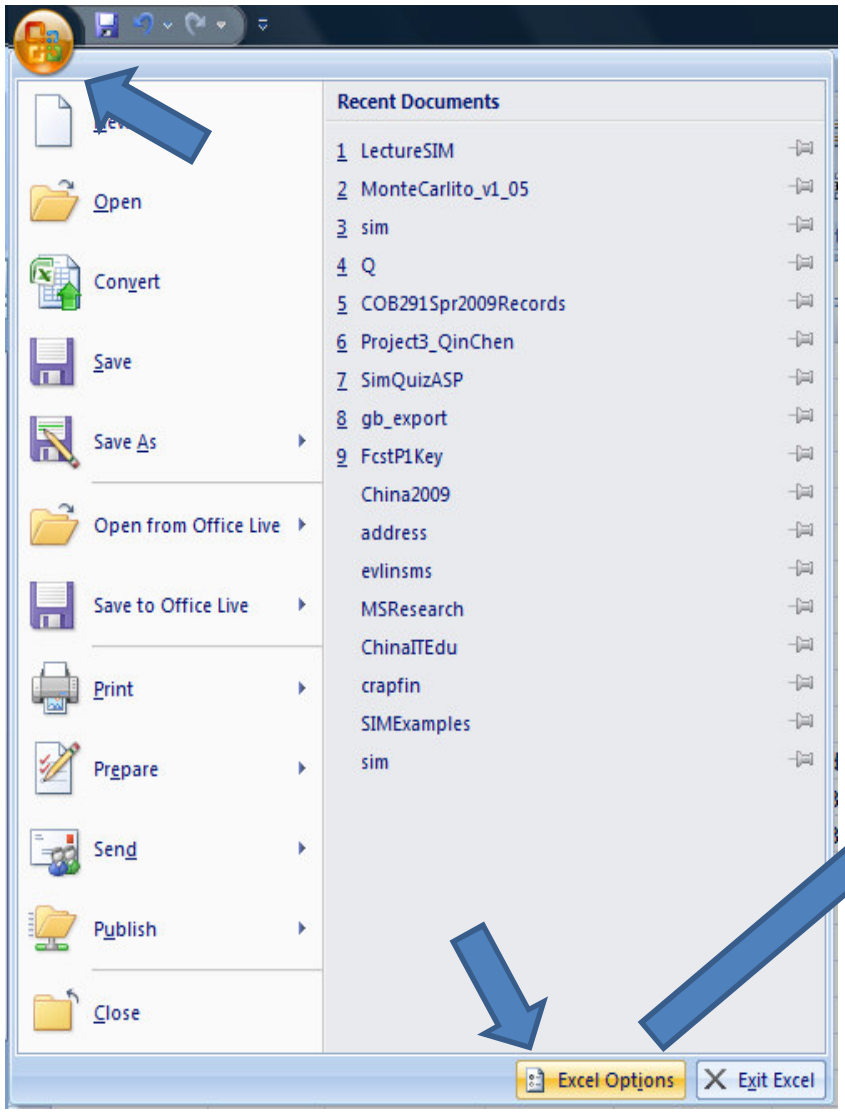
$$Breakeven(Units) = FixedCost / (SellingPrice - VariableCost) = \$3000 / (\$90 - \$45)$$

$$Profit / Loss = \$90 \times DemandD - \$3{,}000 - \$45 \times DemandD$$

Case 1: Given: Demand D
to Estimate Profit/Loss

You may want to Pause the Video to open Excel@ file LectureSIM.xls before continue

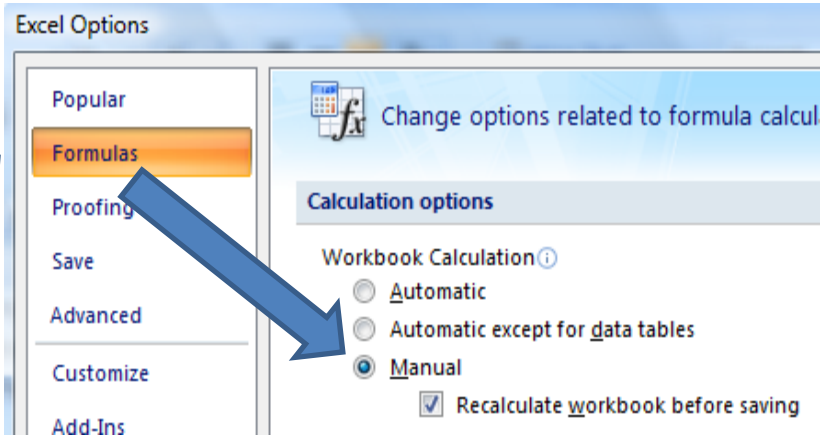
Set Excel@ Manual calculations of formulas and Press F9 to recalculate



Remember to Press F9 to recalculate

Your computer may work really slow if you do not set up Manual calculations of formulas when doing simulation.

Remember to set it back to automatic when finish simulations.



Using Excel@ to calculate Breakeven Point:

	A	B	C	D	E
1	Exercise 1: Simple Simulation Process				
2			Breakeven for Product P		=B7/(B4-B5)
3			Flip Two Coins	Chance	
4	Sell Price sp	90	HH	1/4	100
5	Unit Cost v	45	HT, TH	1/2	75
6			TT	1/4	50
7	Fixed Cost FC	3000			
8					
9	Wk Demand D	100			

ATMBlank | ATM | ATM1 | **BE1** | BE2 | BE3

$$Breakeven\ Point(Units) = \frac{FixedCost}{SellPrice - UnitVarCost}$$

$$= \frac{\$3{,}000}{\$90 - \$45} = 66.67 \approx 67\ Units$$

Set up Excel@ formulas to calculate Profit/Loss:

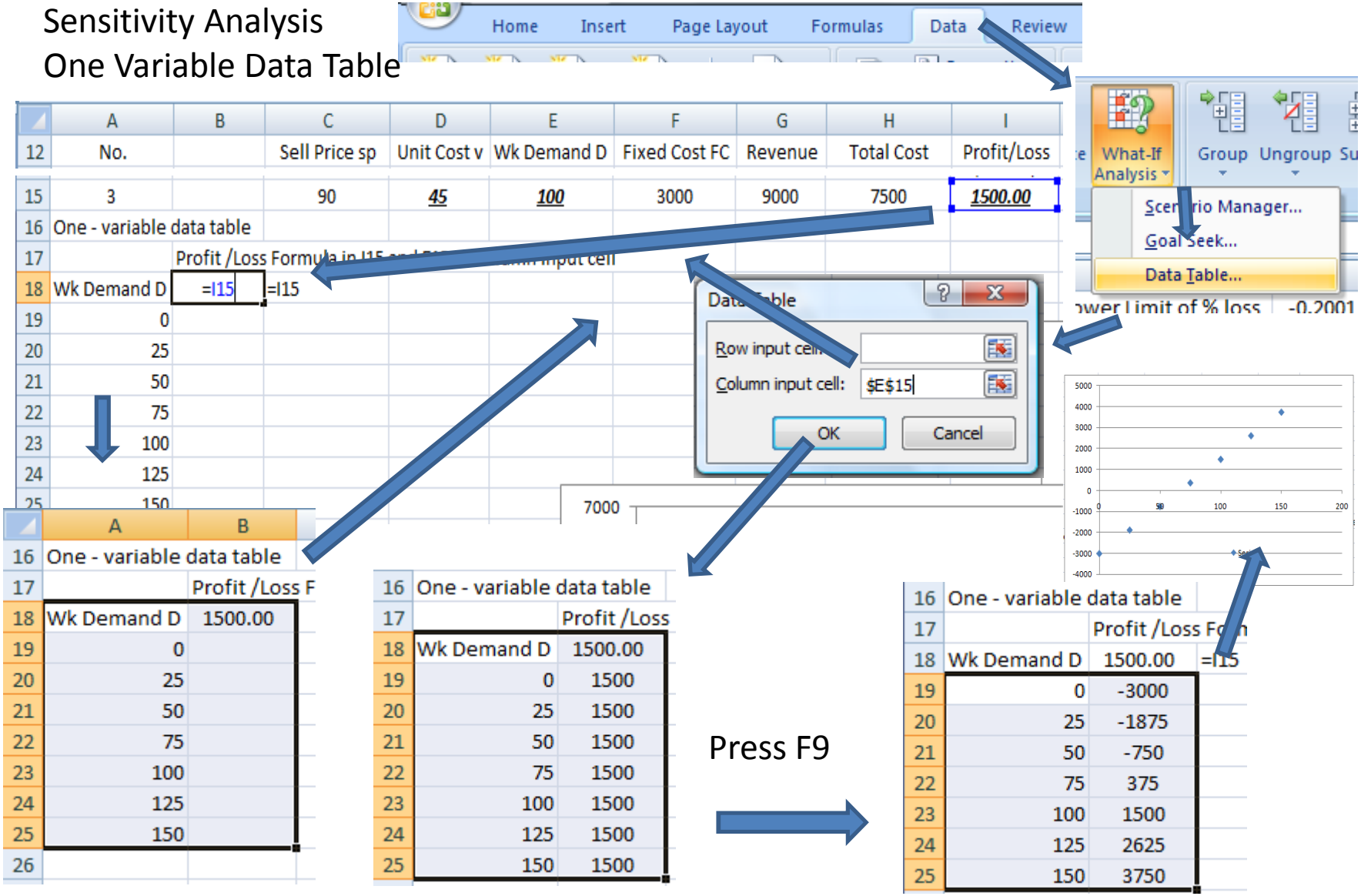
$$Profit/Loss = \$90 \times DemandD - \$3{,}000 - \$45 \times DemandD$$

	A	B	C	D	E	F	G	H	I
9	Wk Demand D	100							
10									
11			=$B$4	=$B$5	75	=$B$7	=C13*E13	=F13+D13*E13	=G13-H13
12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
13	1								

12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
13	1		90	45	75	3000	6750	6375	375.00
14	2		90	45	50	3000	4500	5250	(750.00)
15	3		90	***45***	***100***	3000	9000	7500	***1500.00***

Use of One and Two Variable Data Tables in Excel@ for Sensitivity Analysis

Sensitivity Analysis
One Variable Data Table



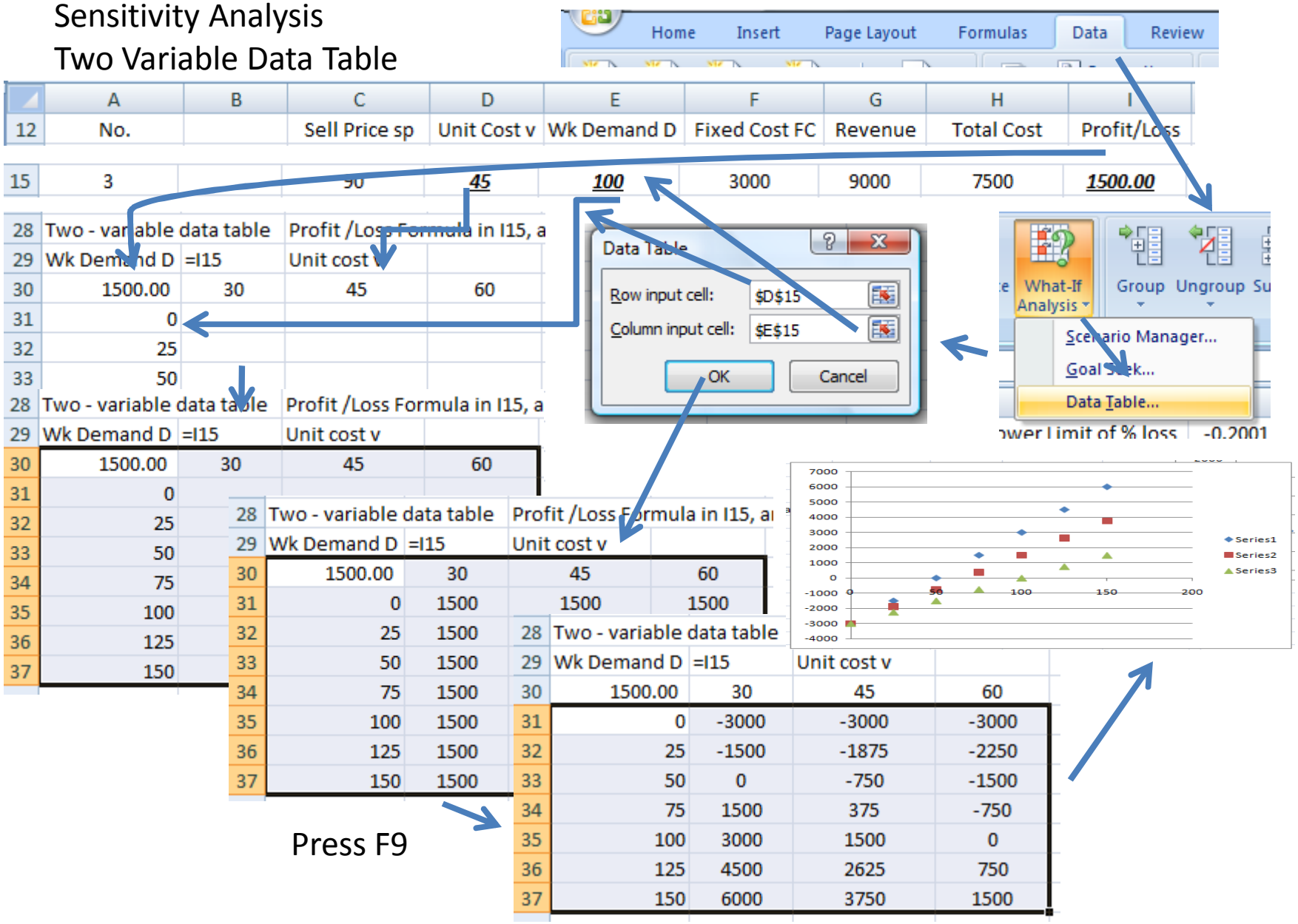
	A	B	C	D	E	F	G	H	I
12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
15	3		90	45	100	3000	9000	7500	1500.00
16	One - variable data table								
17		Profit /Loss Formula in I15 and I... input cell							
18	Wk Demand D	=I15	=I15						
19	0								
20	25								
21	50								
22	75								
23	100								
24	125								
25	150								

	A	B
16	One - variable data table	
17		Profit /Loss F
18	Wk Demand D	1500.00
19	0	
20	25	
21	50	
22	75	
23	100	
24	125	
25	150	
26		

16	One - variable data table	
17		Profit /Loss
18	Wk Demand D	1500.00
19	0	1500
20	25	1500
21	50	1500
22	75	1500
23	100	1500
24	125	1500
25	150	1500

16	One - variable data table		
17		Profit /Loss Fo...	
18	Wk Demand D	1500.00	=I15
19	0	-3000	
20	25	-1875	
21	50	-750	
22	75	375	
23	100	1500	
24	125	2625	
25	150	3750	

Sensitivity Analysis
Two Variable Data Table



	A	B	C	D	E	F	G	H	I
12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
15	3		90	***45***	***100***	3000	9000	7500	***1500.00***

28	Two - variable data table		Profit /Loss Formula in I15, a	
29	Wk Demand D	=I15	Unit cost v	
30	1500.00	30	45	60
31	0			
32	25			
33	50			

28	Two - variable data table		Profit /Loss Formula in I15, a	
29	Wk Demand D	=I15	Unit cost v	
30	1500.00	30	45	60
31	0			
32	25			
33	50			
34	75			
35	100			
36	125			
37	150			

28	Two - variable data table		Profit /Loss Formula in I15, a	
29	Wk Demand D	=I15	Unit cost v	
30	1500.00	30	45	60
31	0	1500	1500	1500
32	25	1500		
33	50	1500		
34	75	1500		
35	100	1500		
36	125	1500		
37	150	1500		

28	Two - variable data table			
29	Wk Demand D	=I15	Unit cost v	
30	1500.00	30	45	60
31	0	-3000	-3000	-3000
32	25	-1500	-1875	-2250
33	50	0	-750	-1500
34	75	1500	375	-750
35	100	3000	1500	0
36	125	4500	2625	750
37	150	6000	3750	1500

Calculate Mean and Standard Deviation of Profit and Percentage of Loss

	A	B	C	H	I	J	K	L	M	N
1	Exercise 1: Simple Simulation Proce									
2			Breakeve				n	3	=COUNT(I13:I15)	
3			Flip Two				Average Profit	375.00	=AVERAGE(I13:I15)	
4	Sell Price sp	90	HH				Standard Deviation	1125	=STDEV(I13:I15)	
5	Unit Cost v	45	HT, T				Standard Error	649.52	=L4/SQRT(L2)	
6			TT				t Critical Value	4.303	=TINV(0.05,L2-1)	
7	Fixed Cost FC	3000					Margin of Error	2794.65	=L6*L5	
8							95% CI Lower Limit	(2419.65)	=L3-L7	
9	Wk Demand D	100					95% CI Upper Limit	3169.65	=L3+L7	
10										
11			=B	=F13+D13*E13	=G13-H13		No. of losses	1	=COUNTIF(I13:I15,"<0")	
12	No.		Sell Pric	Total Cost	Profit/Loss		Possibility of loss	0.3333	=L11/L2	
13	1		90	6375	375.00		Standard deviation of loss	0.2722	=SQRT(L12*(1-L12)/L2)	
14	2		90	5250	(750.00)		z critical value	1.960	=NORMSINV(0.975)	
15	3		90	7500	***1500.00***		Margin of Error of loss	0.5334	=L14*L13	
							95% CI Lower Limit of % loss	-0.2001	=L12-L15	
							95% CI Upper Limit of % loss	0.8668	=L12+L15	

	A	B	C	D	E	F	G	H	I
1	Exercise 2: Use of Random Number Generation in Simulation								
2			Breakeven for Product P						
3			Flip Two Coir	Chance	From Prob	To Prob	Wk Demand D		
4	Sell Price sp	90	HH	0.25	0	0.25	100		
5	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
6			TT	0.25	0.75	1.00	50		
7	Fixed Cost FC	3000							
8									
9	Wk Demand D	100							
10									
11									
12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
13	1	0.6589	90	45	75	3000	6750	6375	375.00
14	2	0.8656	90	45	50	3000	4500	5250	(750.00)
15	3	0.1365	90	45	100	3000	9000	7500	1500.00
16					=VLOOKUP(B18,$E$4:$G$6,3)				
17	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
18	4	0.6589	90	45	75	3000	6750	6375	375.00
19	5	0.8656	90	45	50	3000	4500	5250	(750.00)
20	6	0.1365	90	45	100	3000	9000	7500	1500.00

ATM | ATM1 | BE1 | **BE2** | B

	K	L	M	N
		No.1-3	No.4-6	
	n	3	3	=COUNT(I18:I20)
	Average Profit	375.00	375.00	=AVERAGE(I18:I20)
	Standard Deviation	1125	1125	=STDEV(I18:I20)
	Standard Error	649.52	649.52	=M4/SQRT(M2)
	t Critical Value	4.303	4.303	=TINV(0.05,M2-1)
	Margin of Error	2794.65	2794.65	=M6*M5
	95% CI Lower Limit	(2419.65)	(2419.65)	=M3-M7
	95% CI Upper Limit	3169.65	3169.65	=M3+M7

Use Discrete Probability in simulation

Eyeball

=VLOOKUP() with given random numbers

Collect statistics for the mean and standard deviation of profit and the number of losses

	A	B	C	D	E	F	G	H	I
1	Exercise 2: Use of Random Number Generation in Simulation								
2			Breakeven for Product P						
3			Flip Two Coir	Chance	From Prob	To Prob	Wk Demand D		
4	Sell Price sp	90	HH	0.25	0	0.25	100		
5	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
6			TT	0.25	0.75	1.00	50		
7	Fixed Cost FC	3000							
8									
9	Wk Demand D	100							
10									
11									
12	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
13	1	0.6589	90	45	75	3000	6750	6375	375.00
14	2	0.8656	90	45	50	3000	4500	5250	(750.00)
15	3	0.1365	90	45	100	3000	9000	7500	1500.00
16					=VLOOKUP(B18,$E$4:$G$6,3)				
17	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
18	4	0.6589	90	45	75	3000	6750	6375	375.00
19	5	0.8656	90	45	50	3000	4500	5250	(750.00)
20	6	0.1365	90	45	100	3000	9000	7500	1500.00
21					=VLOOKUP(B23,$E$4:$G$6,3)				
22	No.	=RAND()	Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
23	7	0.9181	90	45	50	3000	4500	5250	(750.00)
24	8	0.1763	90	45	100	3000	9000	7500	1500.00
25	9	0.5888	90	45	75	3000	6750	6375	375.00

=VLOOKUP() with given random numbers

=VLOOKUP() with =RAND()

ATM | ATM1 | BE1 | **BE2** | BE3

Use random number generator in simulation

	K	L	M	N	O
		No.1-3	No.4-6	No.7-9	
	n	3	3	3	=COUNT(I23:I25)
	Average Profit	375.00	375.00	750.00	=AVERAGE(I23:I25)
	Standard Deviation	1125	1125	649.5191	
	Standard Error	649.52	649.52	375.00	
	t Critical Value	4.303	4.303	4.303	
	Margin of Error	2794.65	2794.65	1613.49	
	95% CI Lower Limit	(2419.65)	(2419.65)	(863.49)	
	95% CI Upper Limit	3169.65	3169.65	2363.49	

	A	B	C	D	E	F	G	H	I
1	Exercise 2: Use of Random Number Generation in Simulation								
2			Breakeven for Product P						
3			Flip Two Coir	Chance	From Prob	To Prob	Wk Demand D		
4	Sell Price sp	90	HH	0.25	0	0.25	100		
5	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
6			TT	0.25	0.75	1.00	50		
7	Fixed Cost FC	3000							
8									
9	Wk Demand D	100							
10									
11									
12	No.		Sell Price sp	Unit Cost v	Wk I				
13	1	0.6589	90	45					
14	2	0.8656	90	45					
15	3	0.1365	90	45					
16					=VL				
17	No.		Sell Price sp	Unit Cost v	Wk I				
18	4	0.6589	90	45					
19	5	0.8656	90	45					
20	6	0.1365	90	45					
21					=VLOOKUP(B23,$E$4:$G$6,3)				
22	No.	=RAND()	Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
23	7	0.5963	90	45	75	3000	6750	6375	375.00
24	8	0.7780	90	45	50	3000	4500	5250	(750.00)
25	9	0.1635	90	45	100	3000	9000	7500	1500.00
26					=VLOOKUP(RAND(),$E$4:$G$6,3)				
27	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
28	10		90	45	100	3000	9000	7500	1500.00
29	11		90	45	75	3000	6750	6375	375.00
30	12		90	45	50	3000	4500	5250	(750.00)

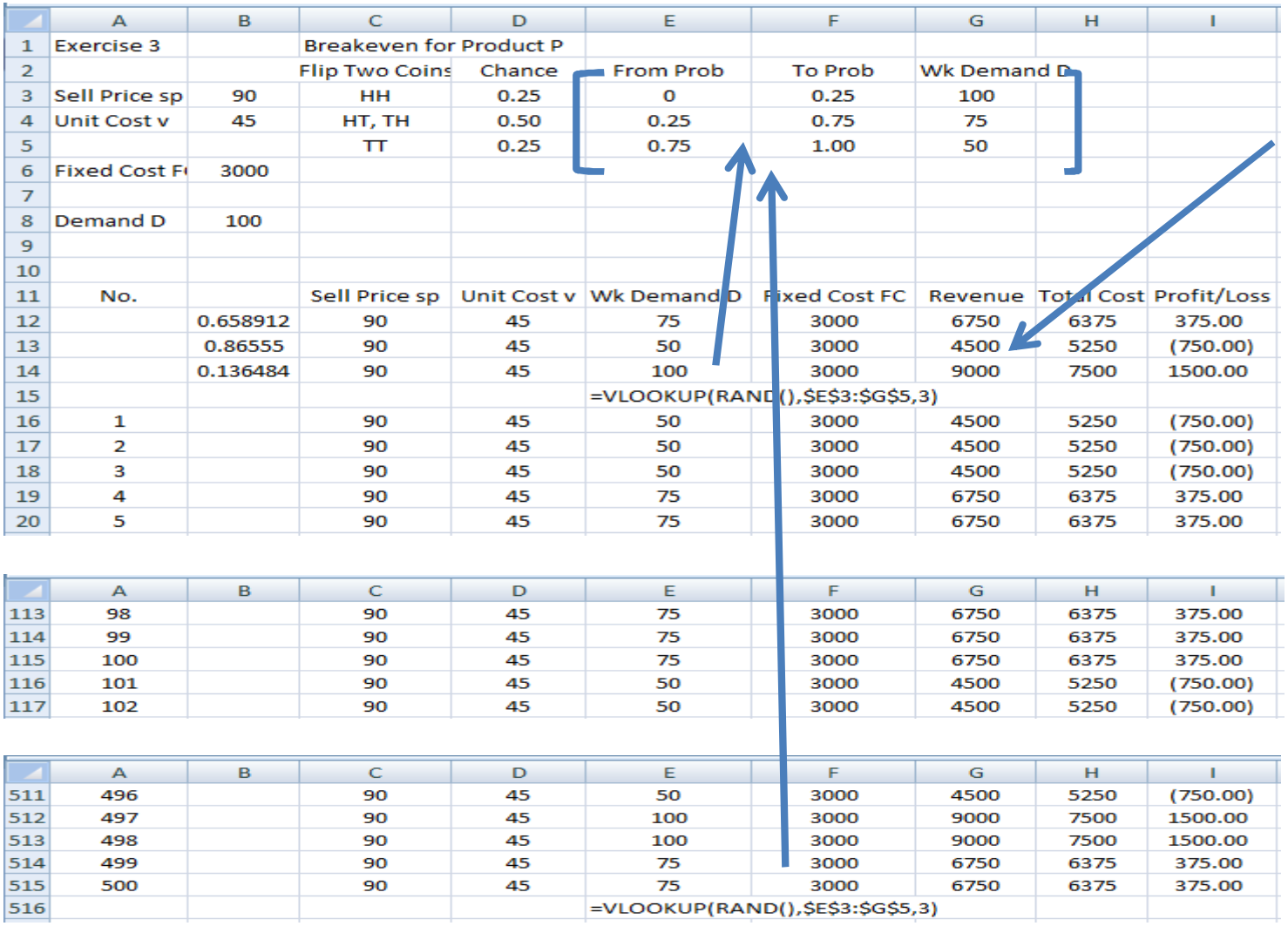
ATM | ATM1 | BE1 | **BE2** | BE3

Use random number generator in simulation

	K	L	M	N	O	P
		No.1-3	No.4-6	No.7-9	No.10-12	
	n	3	3	3	3	=COUNT(I28:I30)
	Average Profit	375.00	375.00	375.00	750.00	=AVERAGE(I28:I30)
	Standard Deviation	1125	1125	1125	649.5191	
	Standard Error	649.52	649.52	649.52	375	
	t Critical Value	4.303	4.303	4.303	4.303	
	Margin of Error	2794.65	2794.65	2794.65	1613.495	
	95% CI Lower Limit	(2419.65)	(2419.65)	(2419.65)	(863.49)	
	95% CI Upper Limit	3169.65	3169.65	3169.65	2363.49	

=VLOOKUP() with =RAND()

=VLOOKUP(RAND())



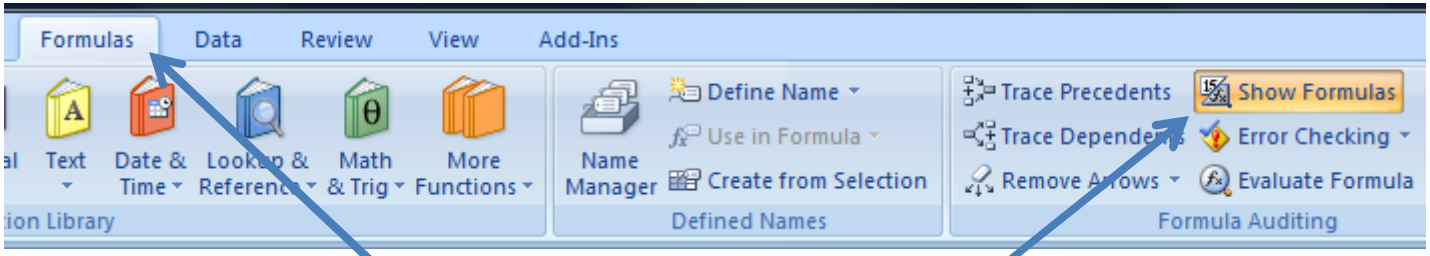
	A	B	C	D	E	F	G	H	I
1	Exercise 3		Breakeven for Product P						
2			Flip Two Coins	Chance	From Prob	To Prob	Wk Demand D		
3	Sell Price sp	90	HH	0.25	0	0.25	100		
4	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
5			TT	0.25	0.75	1.00	50		
6	Fixed Cost F	3000							
7									
8	Demand D	100							
9									
10									
11	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
12		0.658912	90	45	75	3000	6750	6375	375.00
13		0.86555	90	45	50	3000	4500	5250	(750.00)
14		0.136484	90	45	100	3000	9000	7500	1500.00
15					=VLOOKUP(RAND(),$E$3:$G$5,3)				
16	1		90	45	50	3000	4500	5250	(750.00)
17	2		90	45	50	3000	4500	5250	(750.00)
18	3		90	45	50	3000	4500	5250	(750.00)
19	4		90	45	75	3000	6750	6375	375.00
20	5		90	45	75	3000	6750	6375	375.00

	A	B	C	D	E	F	G	H	I
113	98		90	45	75	3000	6750	6375	375.00
114	99		90	45	75	3000	6750	6375	375.00
115	100		90	45	75	3000	6750	6375	375.00
116	101		90	45	50	3000	4500	5250	(750.00)
117	102		90	45	50	3000	4500	5250	(750.00)

	A	B	C	D	E	F	G	H	I
511	496		90	45	50	3000	4500	5250	(750.00)
512	497		90	45	100	3000	9000	7500	1500.00
513	498		90	45	100	3000	9000	7500	1500.00
514	499		90	45	75	3000	6750	6375	375.00
515	500		90	45	75	3000	6750	6375	375.00
516					=VLOOKUP(RAND(),$E$3:$G$5,3)				

It is very useful to have a few rows without random numbers to verify correctness of formulas

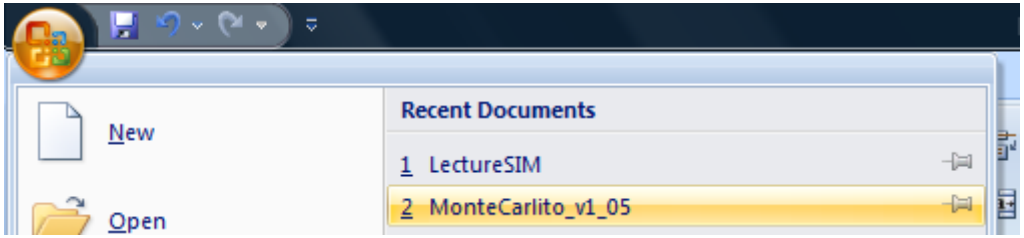
Double verify the correctness of equations in the first and last rows before production runs of the simulation

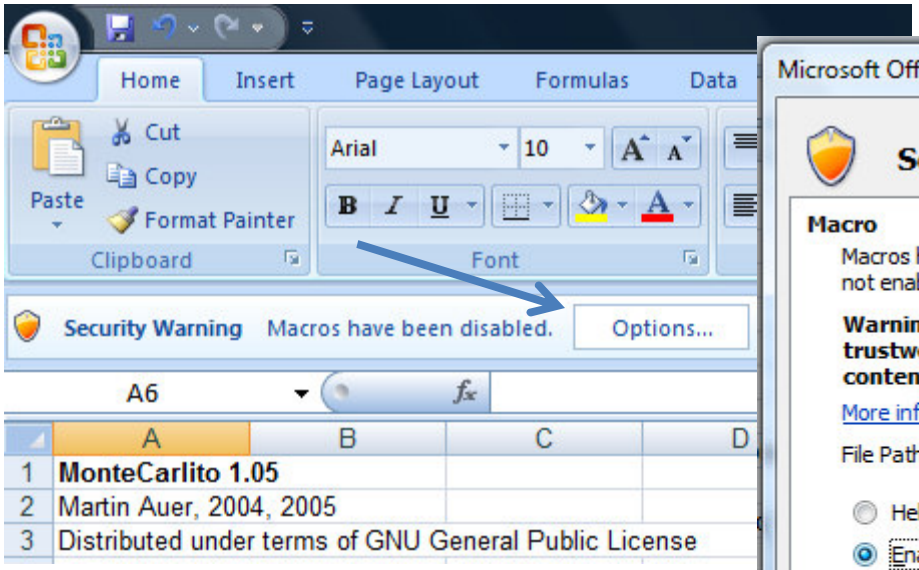


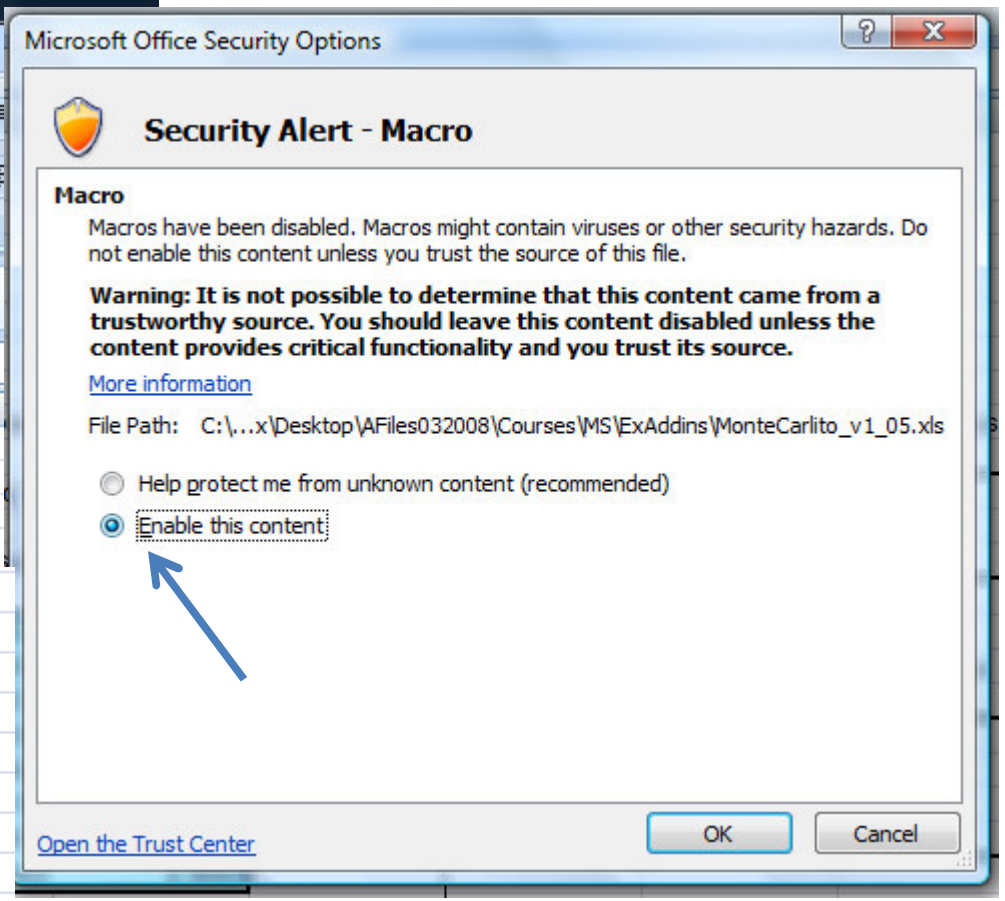
	A	B	C	D	E	F	G	H	I	J	K	L
1	Exercise 3		Breakeve								n	=COUNT(I12:I14)
2			p Two Coi	Chance	From Prob	To Prob	Wk Demanc				Average Profit	=AVERAGE(I12:I14)
3	Sell Price s	90	HH	0.25	0	=D3	100				Standard Deviation	=STDEV(I12:I14)
4	Unit Cost v	=25+20	HT, TH	0.5	=F3	=F3+D4	75				Standard Error	=L3/SQRT(L1)
5			TT	0.25	=F4	=F4+D5	50				t Critical Value	=TINV(0.05,L1-1)
6	Fixed Cost	3000									Margin of Error	=L5*L4
7											95% CI Lower Limit	=L2-L6
8	Demand D	100									95% CI Upper Limit	=L2+L6
9												
10											No. of losses	
11	No.		ell Price s	Unit Cost v	Wk Demand D	xed Cost	Revenue	Total Cost	Profit/Loss		Possibility of loss	
12		0.658911	=$B$3	=$B$4	75	=$B$6	=C12*E12	=F12+D12*E12	=G12-H12		Standard deviation of loss	
13		0.865550	=$B$3	=$B$4	50	=$B$6	=C13*E13	=F13+D13*E13	=G13-H13		z critical value	
14		0.136484	=$B$3	=$B$4	100	=$B$6	=C14*E14	=F14+D14*E14	=G14-H14		Margin of Error of loss	
15					=VLOOKUP(RAND(),$E$3:$G$5,3)						95% CI Lower Limit of % loss	
16	1		=$B$3	=$B$4	=VLOOKUP(RAND(),$E$3:$G$5,3)	=$B$6	=C16*E16	=F16+D16*E16	=G16-H16		95% CI Upper Limit of % loss	
17	2		=$B$3	=$B$4	=VLOOKUP(RAND(),$E$3:$G$5,3)	=$B$6	=C17*E17	=F17+D17*E17	=G17-H17			

Use Formulas/Show formulas or CTRL+` to show formulas in Excel@ worksheet
Additional adjustment to column width may be needed and use Print Preview/Page setup/Fit into 1 or 2 pages to produce professional printouts.

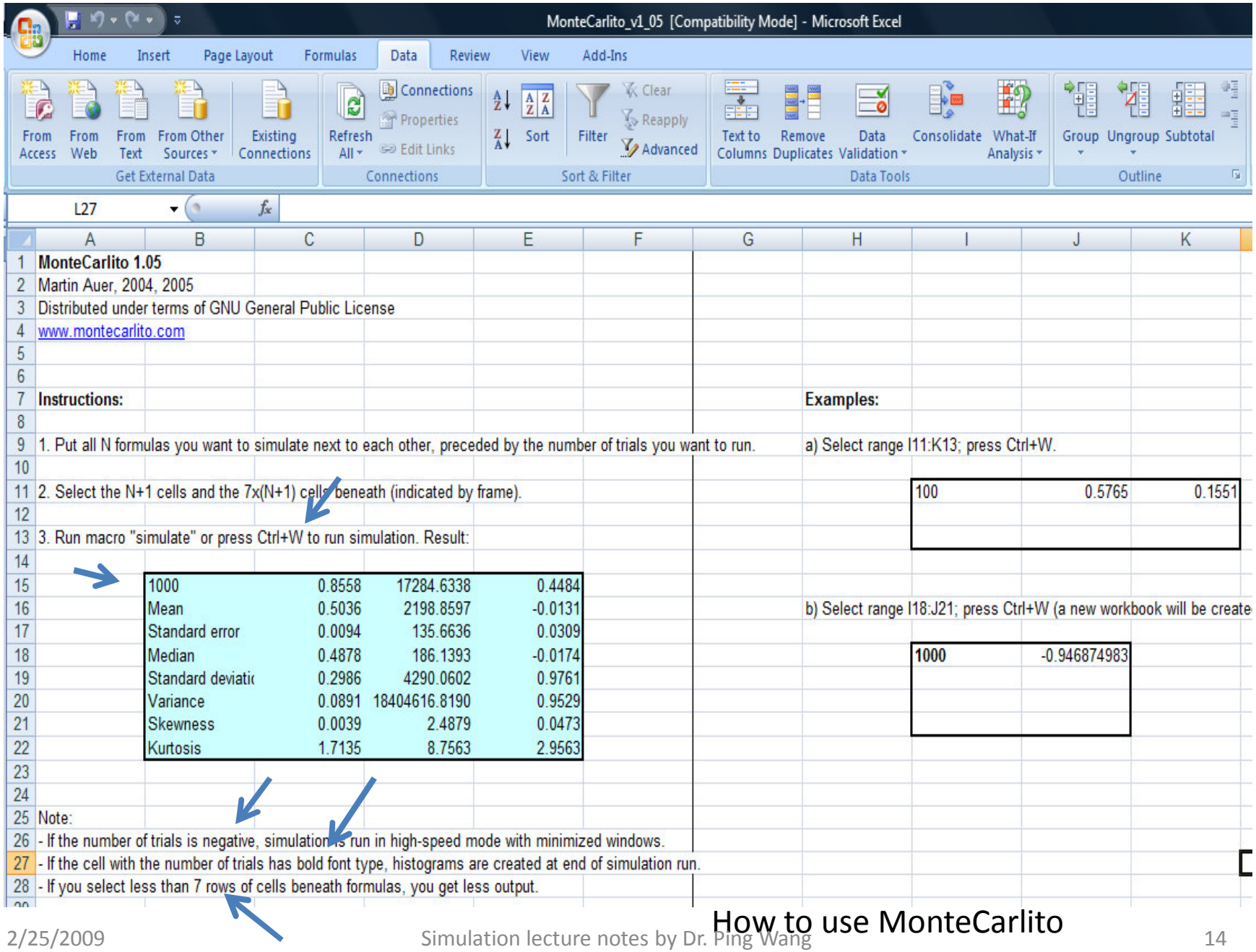
Set up MonteCarlito





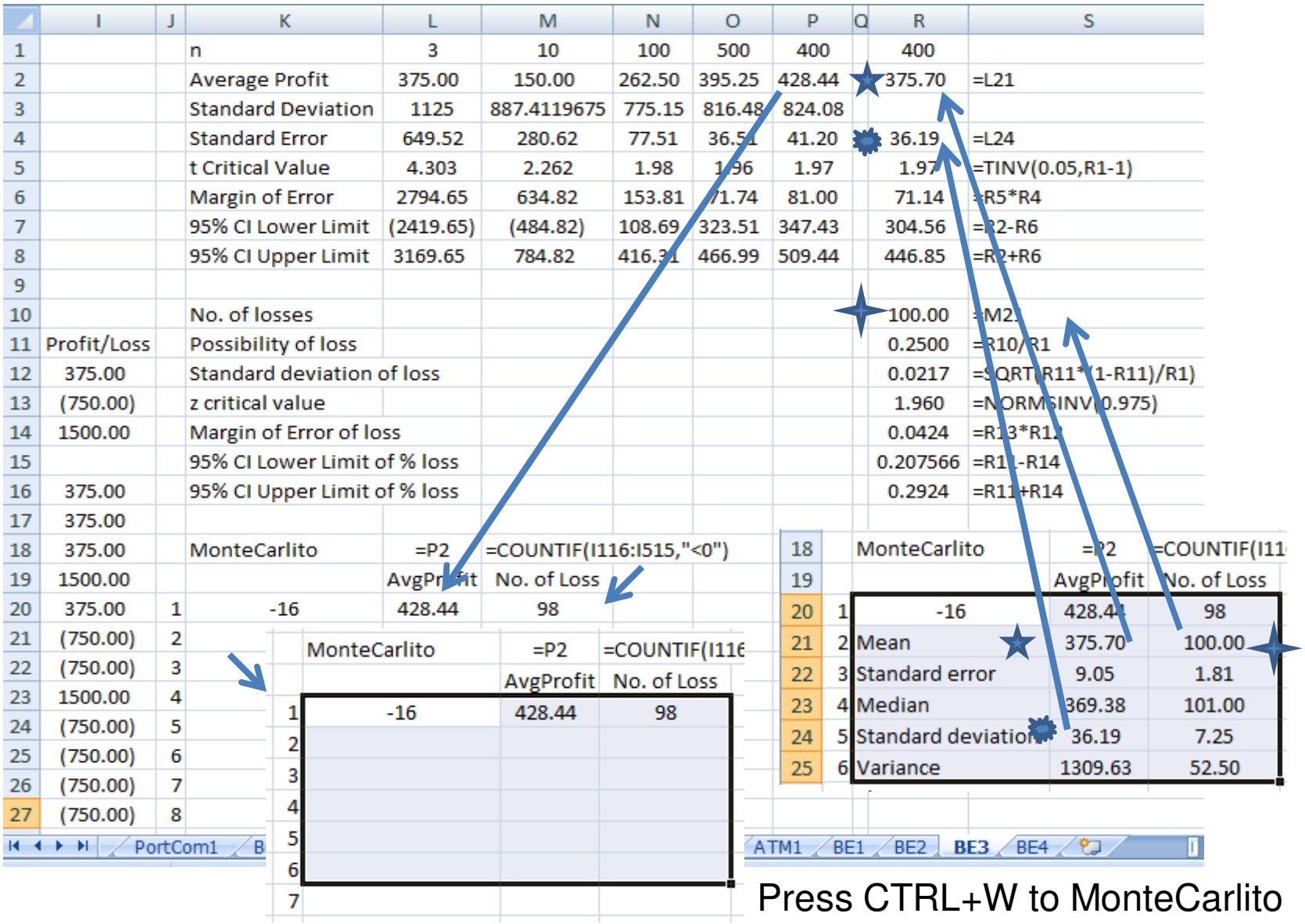


	MonteCarlito	=P2	=COUNTIF(I116:I515,"<0")
		Avg	loss
1	-100	369.38	106
2	Mean	379.47	99.41
3	Standard error	4.42	0.94
4	Median	377.81	100.00
5	Standard deviation	44.19	9.36
6	Variance	1952.87	87.56
7			



How to use MonteCarlito

Use MonteCarlito in simulation



	I	J	K	L	M	N	O	P	Q	R	S
1			n	3	10	100	500	400		400	
2			Average Profit	375.00	150.00	262.50	395.25	428.44		375.70	=L21
3			Standard Deviation	1125	887.4119675	775.15	816.48	824.08			
4			Standard Error	649.52	280.62	77.51	36.51	41.20		36.19	=L24
5			t Critical Value	4.303	2.262	1.98	1.96	1.97		1.97	=TINV(0.05,R1-1)
6			Margin of Error	2794.65	634.82	153.81	71.74	81.00		71.14	=R5*R4
7			95% CI Lower Limit	(2419.65)	(484.82)	108.69	323.51	347.43		304.56	=R2-R6
8			95% CI Upper Limit	3169.65	784.82	416.31	466.99	509.44		446.85	=R2+R6
9											
10			No. of losses							100.00	=M21
11	Profit/Loss		Possibility of loss							0.2500	=R10/R1
12	375.00		Standard deviation of loss							0.0217	=SQRT(R11*(1-R11)/R1)
13	(750.00)		z critical value							1.960	=NORMSINV(0.975)
14	1500.00		Margin of Error of loss							0.0424	=R13*R12
15			95% CI Lower Limit of % loss							0.207566	=R11-R14
16	375.00		95% CI Upper Limit of % loss							0.2924	=R11+R14
17	375.00										
18	375.00		MonteCarlito	=P2	=COUNTIF(I116:I515,"<0")						
19	1500.00			AvgProfit	No. of Loss						
20	375.00	1	-16	428.44	98						
21	(750.00)	2									
22	(750.00)	3									
23	1500.00	4									
24	(750.00)	5									
25	(750.00)	6									
26	(750.00)	7									
27	(750.00)	8									

PortCom1 | B

	MonteCarlito	=P2	=COUNTIF(I116
		AvgProfit	No. of Loss
1	-16	428.44	98
2			
3			
4			
5			
6			
7			

		MonteCarlito	=P2	=COUNTIF(I11
18				
19			AvgProfit	No. of Loss
20	1	-16	428.44	98
21	2	Mean	375.70	100.00
22	3	Standard error	9.05	1.81
23	4	Median	369.38	101.00
24	5	Standard deviation	36.19	7.25
25	6	Variance	1309.63	52.50

ATM1 | BE1 | BE2 | BE3 | BE4

Press CTRL+W to MonteCarlito

Final result of the simulation with MonteCarlito

	A	B	C	D	E	F	G	H	I
1	Exercise 3		Breakeven for Product P						
2			Flip Two Coins	Chance	From Prob	To Prob	Wk Demand D		
3	Sell Price sp	90	HH	0.25	0	0.25	100		
4	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
5			TT	0.25	0.75	1.00	50		
6	Fixed Cost F	3000							
7									
8	Demand D	100							
9									
10									
11	No.		Sell Price sp						
12		0.658912	90						
13		0.86555	90						
14		0.136484	90						
15									
16	1		90						
17	2		90						
18	3		90						
19	4		90						
20	5		90						

	A	B	C
113	98		90
114	99		90
115	100		90
116	101		90
117	102		90

	A	B	C
511	496		90
512	497		90
513	498		90
514	499		90
515	500		90
516			

J	K	L	M	N	O	P	Q	R	S
	n	3	10	100	500	400		400	
	Average Profit	375.00	375.00	510.00	433.50	414.38		379.47	=L21
	Standard Deviation	1125	530.3300859	771.51	797.32	803.45			
	Standard Error	649.52	167.71	77.15	35.66	40.17		44.19	=L24
	t Critical Value	4.303	2.262	1.98	1.96	1.97		1.97	=TINV(0.05,R1-1)
	Margin of Error	2794.65	379.38	153.08	70.06	78.98		86.88	=R5*R4
	95% CI Lower Limit	(2419.65)	(4.38)	356.92	363.44	335.40		292.59	=R2-R6
	95% CI Upper Limit	3169.65	754.38	663.08	503.56	493.35		466.35	=R2+R6
	No. of losses							95	=COUNTIF(I116:I515,"<0")
	Possibility of loss							0.2375	=R10/R1
	Standard deviation of loss							0.0213	=SQRT(R11*(1-R11)/R1)
	z critical value							1.960	=NORMSINV(0.975)
	Margin of Error of loss							0.0417	=R13*R12
	95% CI Lower Limit of % loss							0.195797	=R11-R14
	95% CI Upper Limit of % loss							0.2792	=R11+R14

45	75	3000	6750	6375	375.00	
45	75	3000	6750	6375	375.00	
	=VLOOKUP(RAND(),$E$3:$G$5,3)					

	J	K	L	M	N	O	P	Q	R	S
1		n	3	10	100	500	400		400	
2		Average Profit	375.00	375.00	476.25	375.00	349.69		379.47	=L21
3		Standard Deviation	1125	918.5586535	784.90	815.18	821.58			
4		Standard Error	649.52	290.47	78.49	36.46	41.08		44.19	=L24
5		t Critical Value	4.303	2.262	1.98	1.96	1.97		1.97	=TINV(0.05,R1-1)
6		Margin of Error	2794.65	657.10	155.74	71.63	80.76		86.88	=R5*R4
7		95% CI Lower Limit	(2419.65)	(282.10)	320.51	303.37	268.93		292.59	=R2-R6
8		95% CI Upper Limit	3169.65	1032.10	631.99	446.63	430.45		466.35	=R2+R6
9										
10		No. of losses							99.41	=M21
11		Possibility of loss							0.2485	=R10/R1
12		Standard deviation of loss							0.0216	=SQRT(R11*(1-R11)/R1)
13		z critical value							1.960	=NORMSINV(0.975)
14		Margin of Error of loss							0.0424	=R13*R12
15		95% CI Lower Limit of % loss							0.206174	=R11-R14
16		95% CI Upper Limit of % loss							0.2909	=R11+R14
17										
18		MonteCarlito	=P2	=COUNTIF(I116:I515,"<0")						
19			Avg	loss						
20	1	-100	349.69	111						
21	2	Mean	379.47	99.41						
22	3	Standard error	4.42	0.94						
23	4	Median	377.81	100.00						
24	5	Standard deviation	44.19	9.36						
25	6	Variance	1952.87	87.56						
26	7									

$$\bar{\bar{x}} \pm z\, s_{\bar{x}}$$

We are 95% sure that the unknown true average profit is between 292.59 and 466.35.

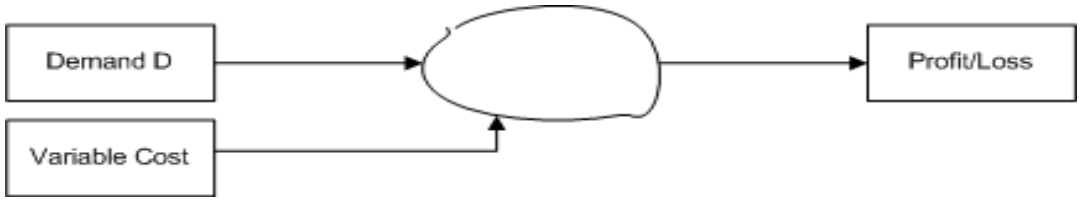
$$\bar{p} \pm z\sqrt{\bar{p}(1-\bar{p})/n}$$

We are 95% sure that the unknown true possibility of loss is between 20.62% and 29.09%.

How to interpret simulation results?

Case 1: Given: Demand D
to Estimate Profit/Loss

Case 2: Given: Demand D and
Variable Cost
to Estimate Profit/Loss



SUM =NORMINV(RAND(),$G$7,$H$7)

	A	B	C	D	E	F	G	H	I
1	Exercise 4		Breakeven for Product P						
2			Flip Two Coins	Chance	From Prob	To Prob	Wk Demand D		
3	Sell Price sp	90	HH	0.25	0	0.25	100		
4	Unit Cost v	45	HT, TH	0.50	0.25	0.75	75		
5			TT	0.25	0.75	1.00	50		
6	Fixed Cost FC	3000					mean	Std	
7				Normal Distributed		Sell Price sp	90	5	
8	Demand D	100		Uniform Distributed		Unit Cost v	40	50	
9							Low	High	
10				=$G$8+RAND()*($H$8-$G$8)					
11	No.		Sell Price sp	Unit Cost v	Wk Demand D	Fixed Cost FC	Revenue	Total Cost	Profit/Loss
12		0.658912	90	45	75	3000	6750	6375	375.00
13		0.86555	90	45	50	3000	4500	5250	(750.00)
14		0.136484	90	45	100	3000	9000	7500	1500.00
15	=NORMINV(RAND(),$G$7,$H$7)				=VLOOKUP(RAND(),$E$3:$G$5,3)				
16	1		91.81	49.34	50	3000	4590.5472	5466.965	(876.42)
17	2		87.16	46.15	100	3000	8715.9245	7615.332	1100.59
18	3		87.38	46.50	100	3000	8737.5579	7649.805	1087.75
19	4		88.91	42.45	75	3000	6668.4724	6184.096	484.38
20	5	=NORMINV(RAND(),$G$7,$H$7)			100	3000	8633.155	7821.827	811.33
21	6		NORMINV(probability, mean, standard_dev)		50	3000	4557.871	5402.818	(844.95)
22	7		91.67	45.00	75	3000	6875.2577	6374.661	500.60

PortCom1 Butler TutorButler Butler1 ATMBlank ATM ATM1 BE1 BE2 BE3 BE4

	J	K	L	M	N	O	P	Q	R	R	S
1		n	3	10	100	500	400		400	400	
2		Average Profit	375.00	375.00	476.25	375.00	349.69		379.47	373.62	
3		Standard Deviation	1125	918.5586535	784.90	815.18	821.58				
4		Standard Error	649.52	290.47	78.49	36.46	41.08		44.19	45.74	
5		t Critical Value	4.303	2.262	1.98	1.96	1.97		1.97	1.97	,R1-1)
6		Margin of Error	2794.65	657.10	155.74	71.63	80.76		86.88	89.93	
7		95% CI Lower Limit	(2419.65)	(282.10)	320.51	303.37	268.93		292.59	283.69	
8		95% CI Upper Limit	3169.65	1032.10	631.99	446.63	430.45		466.35	463.55	
9											
10		No. of losses							99.41	140.45	
11		Possibility of loss							0.2485	0.3511	
12		Standard deviation of loss							0.0216	0.0239	.*(1-R11)/R1)
13		z critical value							1.960	1.960	NV(0.975)
14		Margin of Error of loss							0.0424	0.0468	
15		95% CI Lower Limit of % loss							0.206174	0.304348	
16		95% CI Upper Limit of % loss							0.2909	0.3979	
17											
18		MonteCarlito	=P2	=COUNTIF(I116:I515,"<0")							
19			Avg	loss							
20	1	-100	349.69	111							
21	2	Mean	379.47	99.41							
22	3	Standard error	4.42	0.94							
23	4	Median	377.81	100.00							
24	5	Standard deviation	44.19	9.36							
25	6	Variance	1952.87	87.56							
26	7										

$$\bar{\bar{x}} \pm z\, s_{\bar{x}}$$

We are 95% sure that the unknown true average profit is between 283.69 and 463.55.

$$\bar{p} \pm z\sqrt{\bar{p}(1-\bar{p})/n}$$

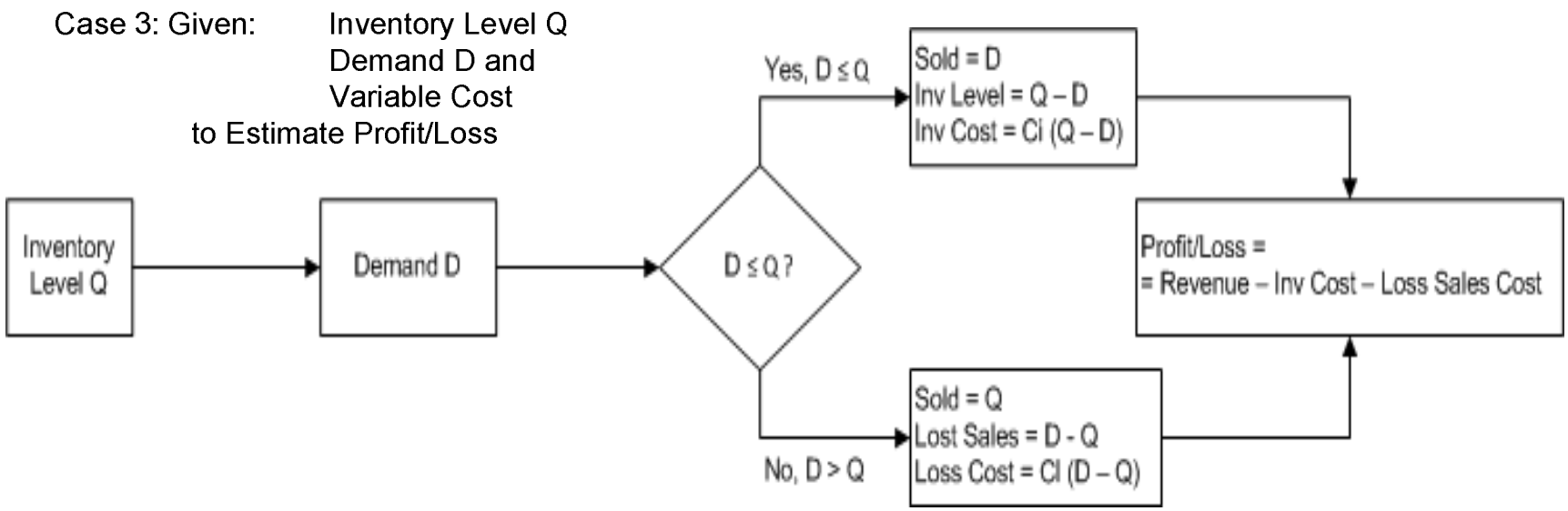
We are 95% sure that the unknown true possibility of loss is between 30.43% and 39.79%.

Less profit and more loss due to more variations

Use MonteCarlito to collect statistics for multiple performance measures

				=AVERAGE(C116:C515)		
	MonteCarlito	=P2	=COUNTIF(I116:I515,"<0")			
		AvgProfit	loss	AvgSPrc	AvgUCt	
1	-100	391.82	140	90.08	44.99	=AVERAGE(D116:D515)
2	Mean	373.62	140.45			
3	Standard error	4.57	1.02			
4	Median	374.01	139.00			
5	Standard deviation	45.74	10.20			
6	Variance	2092.34	104.13			
7						

Press CTRL+W to get Result



IF D<=Q, THEN SOLD = D, INV LEVEL=Q-D, INV COST=Ci (Q-D)
ELSE SOLD = Q, LOST SALES=D-Q, LOSS COST = Cl (D-Q)

PROFIT/LOSS = PRICE * SOLD - INV COST – LOSS COST

In Excel@, use either SOLD=IF(D<=Q,D,Q) or SOLD=MIN(D,Q)
For any leftover, use either LEFTOVER=IF(D<=Q,Q-D,0) or LEFTOVER=MAX(Q-D,0)
For any lostsale, use either LOSTSALE=IF(D<=Q,0,D-Q) or LOSTSALE=MAX(D-Q,0)

Calculate INVCOST=IF(D<=Q,HoldCost*(Q-D),0) or INVCOST=MAX(HoldCost*(Q-D),0)
And SHORTCOST=IF(D<=Q,0,ShortUC*(D-Q)) or SHORTCOST=MAX(ShortUC*(D-Q),0)

Use =IF(), =MIN(), and =MAX() in Inventory simulation

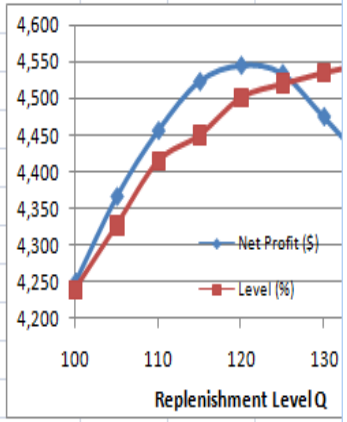
	A	B	C	D	E	F	G	H	I
1	Given	Inventory level Q	100		Demand Mean	100			
2		Unit Inventory holding cost	15		Demand Std	20			
3		Unit Shortage cost	30						
4		Sales price	125						
5		Unit cost	75						
6		Gross Profit /unit	50						
7									
8		1. If D <= Q, then D units are sold, Q - D units leftover							
9		2. If D > Q, then Q units are sold, D - Q units are shotages							
10		Excel formulas to compute Units sold, Units leftover and Units shortages							
11									
12		Demand (D)	Normal (100, 20)		=ROUND(NORMINV(RAND(),100,20),0)				
13		Units sold	If (D <= Q, D, Q)		=IF(B26<=$C$1,B26,$C$1)		=MIN(B26,$C$1)		
14		Units leftover	If (D <Q, Q - D, 0)		=IF(B26<$C$1,$C$1-B26,0)		=MAX($C$1-B26,0)		
15		Units shortage	If (D > Q, D - Q, 0)		=IF(B26>$C$1,B26-$C$1,0)		=MAX(B26-$C$1,0)		
16									
17		Net Profit = Gross Profit * Units Sold - Inventory holding cost * Units leftover - Shortage cost * Units shortages							
18			=$C$6*C26-$C$2*D26-$C$3*F26						
19		Inventory Cost	Unit Inventory holding cost * Units leftover			=$C$2*D26			
20		Shortage Cost	Unit shortage cost * Units shortage			=F26*$C$3			
21			=IF(B24<=$C$1,B24,$C$1)		=$C$2*D24		=F24*$C$3		
22		=ROUND(NORMINV(RAND(),$F$1,$F$2),0)	=IF(B24<$C$1,$C$1-B24,0)			=IF(B24>$C$1,B24-$C$1,0)		=$C$6*C24--E24-G24	
23	No.	Demand (D)	Units Sold	Units Leftover	Inventory Cost	Units Shortage	Shortage Cost	Net Profit	
24	1	108	100	0	0	8	240	4760	
25	2	73	73	27	405	0	0	4055	
26	3	95	95	5	75	0	0	4825	
27	4	119	100	0	0	19	570	4430	
28				=MAX($C$1-B30,0)			=F30*$C$3		
29			=MIN(B30,$C$1)		=$C$2*D30	=MAX(B30-$C$1,0)		=$C$6*C30--E30-G30	
30	5	115	100	0	0	15	450	4550	
31	6	88	88	12	180	0	0	4580	
32	7	116	100	0	0	16	480	4520	

Ragsdale12_2 | PortCom | PortCom2 | PorCom3 | PortCom1 | Butler | **TutorButler** | Butler1 | ATMBlank | A

Ready

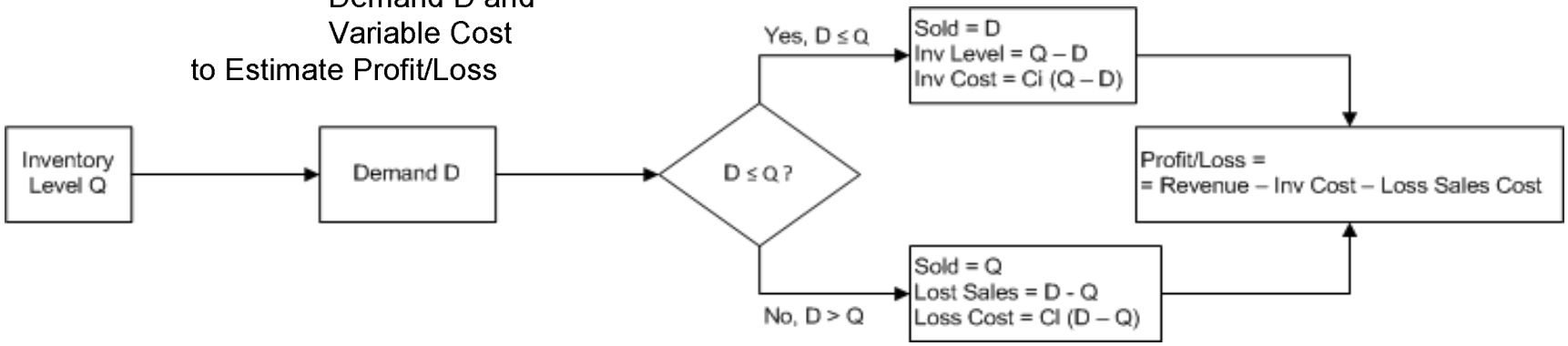
Example of Simulation Process for Inventory Levels

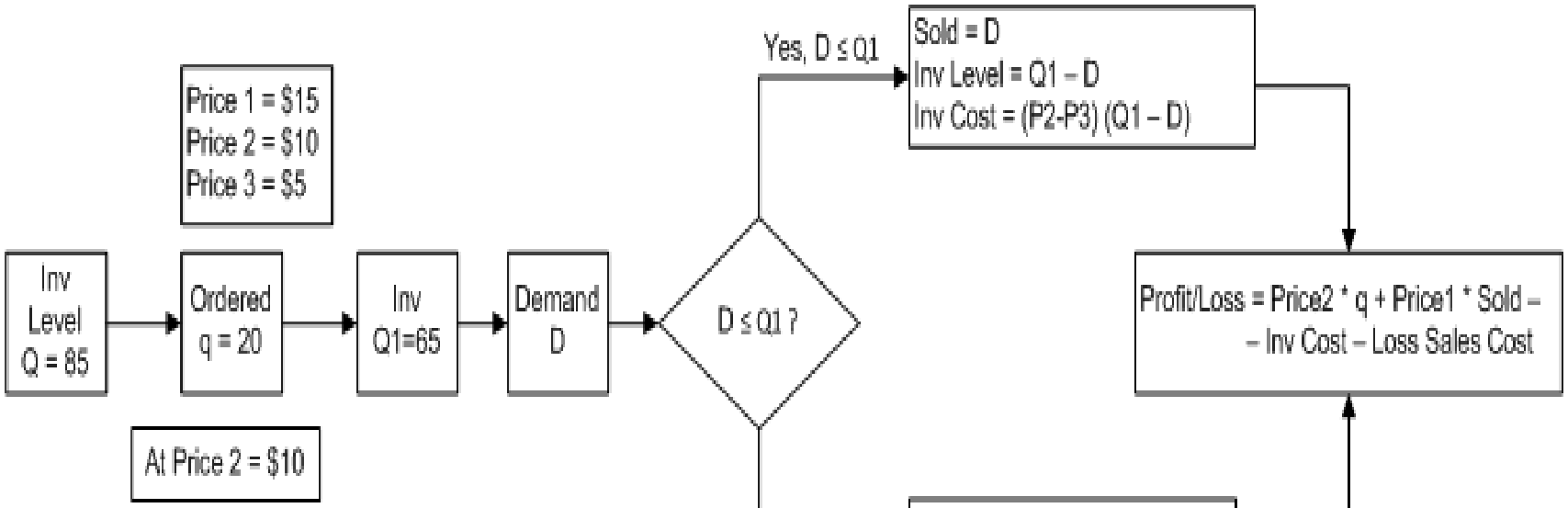
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Butler inventory			Selling Price		$125									
2				Unit Cost		$75									
3	Gross Profit per Unit		$50												
4	Holding Cost per Unit		$15		**Summary Statistics**				**Relationships among Q, Average Net Profit ($) and Service Level (%)**						
5	Shortage Cost per Unit		$30		Mean Profit	$4,508	=AVERAGE(G117:G316)		Replenishment	Average	Service				
6					Std Deviation	1286	=STDEV(G117:G316)		Level Q	Net Profit ($)	Level (%)				
7	**Replenishment Level Q**		***140***		Min Profit	$539	=MIN(G117:G316)		100	4,249	92.02%				
8					Max Profit	$6,992	=MAX(G117:G316)		105	4,366	94.20%				
9	Demand (Normal Distribution)				Service Level	99.92%	=C15/B15		110	4,456	96.38%				
10	Mean	100			Std Error	$91	=F6/SQRT(COUNT(G117:G3		115	4,523	97.27%				
11	Std Deviation	20	=SUM(C17:C316)						***120***	***4,545***	***98.55%***				
12		=SUM(B17:B316)			=IF(B17<=$C$7,$C$4*($C$7-B17),0)				125	4,534	99.02%				
13			=IF(B17<=$C$7,B17,$C$7)						130	4,475	99.40%				
14	Simulation	=NORMINV(RAND(),$B$10,$B$11)				=IF(B17>$C$7,$C$5*(B17-$C$7),0)			135	4,419	99.68%				
15	Total	30365	30342	=$C$3*C17			=D17-E17-F17		140	4,403	99.76%				
16	Month	Demand	sales	Gross Profit	Holding Cost	Shortage Cost	Net Profit								
17	1	95	95	$4,760	672	0	$4,088								
18	2	114	114	$5,714	386	0	$5,328		MonteCarlito	=F5	=F9				
19	3	62	62	$3,098	1171	0	$1,927			AvgProfit	AvgSvrLevel				
20	4	79	79	$3,944	917	0	$3,027	1	-10	4508.34	0.9992				
21	5	79	79	$3,974	908	0	$3,066	2	Mean	4403.06	99.76%				
22	6	121	121	$6,057	283	0	$5,774	3	Standard error	38.25	0.00				
23	7	87	87	$4,356	793	0	$3,562	4	Median	4397.97	1.00				
24	8	97	97	$4,844	647	0	$4,197	5	Standard deviati	120.96	0.00				
25	9	85	85	$4,247	826	0	$3,421	6	Variance	14630.83	0.00				
26	10	110	110	$5,523	443	0	$5,079	7							
27	11	125	125	$6,247	226	0	$6,021								



PortCom1 | Butler | TutorButler | **Butler1** | ATMBlank | ATM | ATM1 | BE1 | BE2 | BE3 | BE4

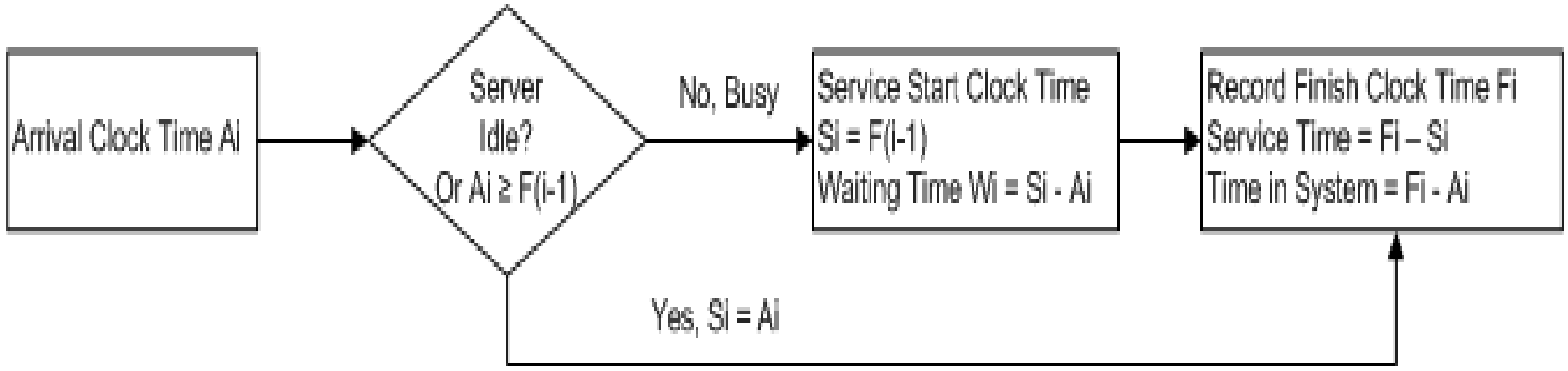
Case 3: Given: Inventory Level Q
Demand D and
Variable Cost
to Estimate Profit/Loss





Case 4: Given: Inventory Level Q
Order Quantity q
Reservation/Booking
Demand D and
Variable Cost
to Estimate Profit/Loss

Case 5: Queue or Waiting Line



	A	B	C	D	E	F	G	H	I	J	K
1	**Wachovia Bank One ATM Simulation Model**							RN			
16	Initial Time	0									
17	**Simulation**		=C21+B22								
18		=$B$4+RAND()*($B$5-$B$4)			=D21-C21	=NORMINV(H3,$F$4,$F$5)					
19		Interarrival	Arrival	Service	Waiting	Service	Completion	Time			
20	Customer	Time	Time	Start Time	Time	Time	Time	in System	RN For IATM	RN For ST	z(RN SvrT)
21	1	2	2	2	0	5	7	5			
22	2	1	3	7	4	3	10	7			
23	3	8	11	11	0	4	15.000	4			
24	4	3.926	14.926	15	0.0744	1.728	16.728	1.802	0.9814	0.2932	-0.5441
25	5	2.189	17.115	17.115	0	1.294	18.409	1.294	0.5473	0.079	-1.4118
26	6	1.224	18.339	18.409	0.070	2.359	20.768	2.429	0.306	0.7634	0.7173
27	7	0.286	18.624	20.768	2.143	1.461	22.228	3.604	0.0714	0.1404	-1.0785

PortCom | PortCom2 | PorCom3 | PortCom1 | Butler | TutorButler | Butler1 | ATMBlank | ATM | ATM1 | B

Sample Set up for Queuing or Waiting Line Simulation

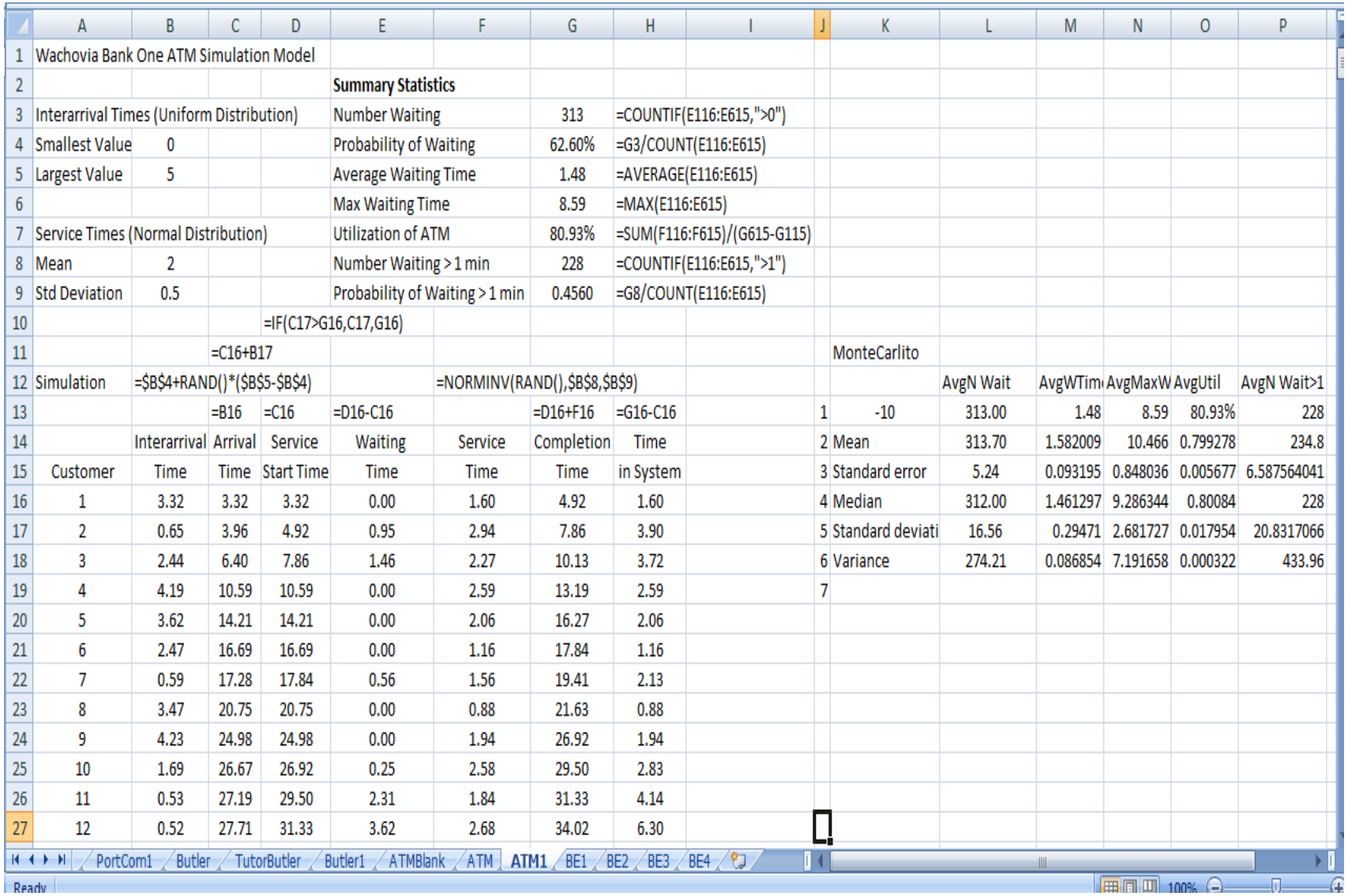
	A	B	C	D	E	F	G	H	I	J	K
1	**Wachovia Bank One ATM Simulation Model**							RN			
2								0.9814			
3	**Interarrival Times (Uniform Distribution)**				**Service Times (Normal Distribution)**			0.2932			
4	Smallest Value	0			Mean	2		0.5473			
5	Largest Value	4			Std Deviation	0.5		0.079			
6								0.306			
7	**RN**	**Interarrival Time**						0.7634			
8	0.3693	1.4772	=$B$4+RAND()*($B$5-$B$4)					0.0714			
9								0.1404			
10											
11											
12	**RN**	**Service Time**									
13	0.7955	2.4128	=NORMINV(A13,$F$4,$F$5)								
14											
15											
16	Initial Time	0									
17	**Simulation**		=C21+B22								
18		=$B$4+RAND()*($B$5-$B$4)			=D21-C21	=NORMINV(H3,$F$4,$F$5)					
19		Interarrival	Arrival	Service	Waiting	Service	Completion	Time			
20	Customer	Time	Time	Start Time	Time	Time	Time	in System	RN For IATM	RN For ST	z(RN SvrT)
21	1	2	2	2	0	5	7	5			
22	2	1	3	7	4	3	10	7			
23	3	8	11	11	0	4	15.000	4			
24	4	3.926	14.926	15	0.0744	1.728	16.728	1.802	0.9814	0.2932	-0.5441
25	5	2.189	17.115	17.115	0	1.294	18.409	1.294	0.5473	0.079	-1.4118
26	6	1.224	18.339	18.409	0.070	2.359	20.768	2.429	0.306	0.7634	0.7173
27	7	0.286	18.624	20.768	2.143	1.461	22.228	3.604	0.0714	0.1404	-1.0785

PortCom | PortCom2 | PorCom3 | PortCom1 | Butler | TutorButler | Butler1 | ATMBlank | ATM | ATM1 | B

Ready

Use a few easy examples to verify the logics before using random numbers

The Process of Queuing or Waiting Line Simulation

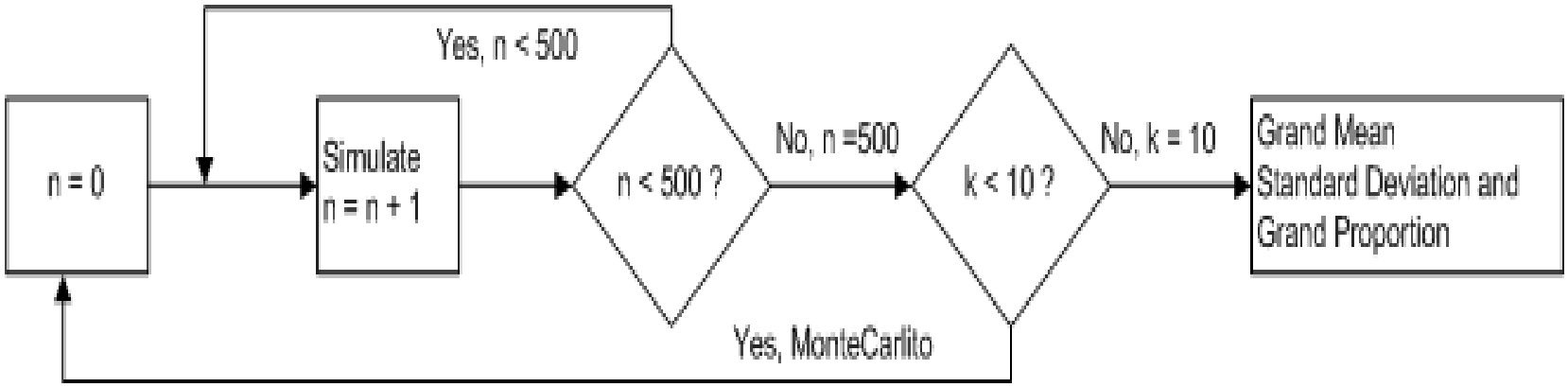


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Wachovia Bank One ATM Simulation Model															
2					**Summary Statistics**											
3	Interarrival Times (Uniform Distribution)				Number Waiting		313	=COUNTIF(E116:E615,">0")								
4	Smallest Value	0			Probability of Waiting		62.60%	=G3/COUNT(E116:E615)								
5	Largest Value	5			Average Waiting Time		1.48	=AVERAGE(E116:E615)								
6					Max Waiting Time		8.59	=MAX(E116:E615)								
7	Service Times (Normal Distribution)				Utilization of ATM		80.93%	=SUM(F116:F615)/(G615-G115)								
8	Mean	2			Number Waiting > 1 min		228	=COUNTIF(E116:E615,">1")								
9	Std Deviation	0.5			Probability of Waiting > 1 min		0.4560	=G8/COUNT(E116:E615)								
10				=IF(C17>G16,C17,G16)												
11			=C16+B17								MonteCarlito					
12	Simulation	=$B$4+RAND()*($B$5-$B$4)				=NORMINV(RAND(),$B$8,$B$9)						AvgN Wait	AvgWTim	AvgMaxW	AvgUtil	AvgN Wait>1
13			=B16	=C16	=D16-C16		=D16+F16	=G16-C16		1	-10	313.00	1.48	8.59	80.93%	228
14		Interarrival	Arrival	Service	Waiting	Service	Completion	Time		2	Mean	313.70	1.582009	10.466	0.799278	234.8
15	Customer	Time	Time	Start Time	Time	Time	Time	in System		3	Standard error	5.24	0.093195	0.848036	0.005677	6.587564041
16	1	3.32	3.32	3.32	0.00	1.60	4.92	1.60		4	Median	312.00	1.461297	9.286344	0.80084	228
17	2	0.65	3.96	4.92	0.95	2.94	7.86	3.90		5	Standard deviati	16.56	0.29471	2.681727	0.017954	20.8317066
18	3	2.44	6.40	7.86	1.46	2.27	10.13	3.72		6	Variance	274.21	0.086854	7.191658	0.000322	433.96
19	4	4.19	10.59	10.59	0.00	2.59	13.19	2.59		7						
20	5	3.62	14.21	14.21	0.00	2.06	16.27	2.06								
21	6	2.47	16.69	16.69	0.00	1.16	17.84	1.16								
22	7	0.59	17.28	17.84	0.56	1.56	19.41	2.13								
23	8	3.47	20.75	20.75	0.00	0.88	21.63	0.88								
24	9	4.23	24.98	24.98	0.00	1.94	26.92	1.94								
25	10	1.69	26.67	26.92	0.25	2.58	29.50	2.83								
26	11	0.53	27.19	29.50	2.31	1.84	31.33	4.14								
27	12	0.52	27.71	31.33	3.62	2.68	34.02	6.30								

PortCom1 | Butler | TutorButler | Butler1 | ATMBlank | ATM | ATM1 | BE1 | BE2 | BE3 | BE4

Ready

Simulation Overview:



The objectives of simulation:

To estimate the unknown population mean μ_0 (the average profit) and
To estimate the unknown population proportion (of loss)

$$\bar{\bar{x}} \pm z\, s_{\bar{x}} \qquad\qquad \bar{p} \pm z\sqrt{\bar{p}(1-\bar{p})/n}$$

Simulation as a tool in business decision making is very powerful, flexible and easy to use. Enjoy Simulating.