Assignment 5

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Question 1:

chapter 13, question 1: Explain the following terms:

optimization: the process of selecting values of decision variables that minimize or maximize some quantity of interest

objective function: The quantity we seek to minimize or maximize is called the objective function.

optimal solution: Any set of decision variable values that maximizes or minimizes (in generic terms, optimizes) the objective function is called an optimal solution.

constraint: limitations or requirements that decision variables must satisfy.

constraint function: A constraint function is a function of the decision variables in the problem.

feasible solution: Any solution that satisfies all constraints of a problem is called a feasible solution.

binding constraint: A binding constraint is one for which the *Cell Value* is equal to the right-hand side of the value of the constraint.

slack: the slack is the difference between the right- and left-hand sides of a constraint.

Chapter 13, question 2: Explain how Solver identifies a unique optimal solution, alternative optimal solutions, an unbounded problem, and an infeasible problem.

When a model has a unique optimal solution, it means that there is exactly one solution that will result in the maximum (or minimum) objective.

If a model has alternate optimal solutions, the objective is maximized (or minimized) by more than one combination of decision variables, all of which have the same objective function value. Solver does not tell you when alternate solutions exist and only reports one of the many possible alternate optimal solutions.

A problem is unbounded if the objective can be increased or decreased without bound while the solution remains feasible. A model is unbounded if Solver reports “The Set Cell values do not converge.”

Finally, an infeasible model is one for which no feasible solution exists; that is, when there is no solution that satisfies all constraints together. When a problem is infeasible, Solver will report “Solver could not find a feasible solution.”

Chapter 13, question 3: List the important guidelines to follow for modeling optimization problems on spreadsheets.

The most challenging aspect of model formulation is identifying constraints.

Constraints generally fall into one of the following categories:

Simple Bounds. Simple bounds constrain the value of a single variable.

Limitations. Limitations usually involve the allocation of scarce resources.

Requirements. Requirements involve the specification of minimum levels of performance.

Proportional Relationships. Proportional relationships are often found in problems involving mixtures or blends of materials or strategies.

Balance Constraints. Balance constraints essentially state that “input = output” and ensure that the flow of material or money is accounted for at locations or between time periods.

Chapter 13, question 4: What Excel functions should you avoid when implementing linear optimization models on spreadsheets?

Common Excel functions to avoid are ABS, MIN, MAX, INT, ROUND, IF, and COUNT.

Question 2:

In order to answer part one of the question:

N= number of load Regular loom	N’= number of load Special loom
R=Regular loom capacity	S= Special loom capacity
B= Buy (outsourcing)	D= Demand
M=Manufacturing	

Total time= weeks* days* hours

R1= N1*0* Total time* Number of Machine(15)

R2= N2*5.2*Total time* Number of Machine(15)

R3= N3*4.4*Total time* Number of Machine(15)

S1= N'1*0* Total time* Number of Machine(3)

S2= N'2*5.2*Total time* Number of Machine(3)

S3= N'3*4.4*Total time* Number of Machine(3)

M1= (R1+S1)   M2= (R2+S2)   M3= (R3+S3)

M1 +B1= D1= 45,000   M2+ B2 = D2 =76,500   M2+ B3 = D3 = 10,000

And the cost for each product is:

C= Mill cost   O= outsourcing cost   T= Total cost

M1*C1+ B1*O1= T1

M2*C2+B2*O2=T2

M3*C3+B3*O3=T3

Total Cost= T1+T2+T3

and we want to minimize the T. The constraints to ensure meeting production requirements are:

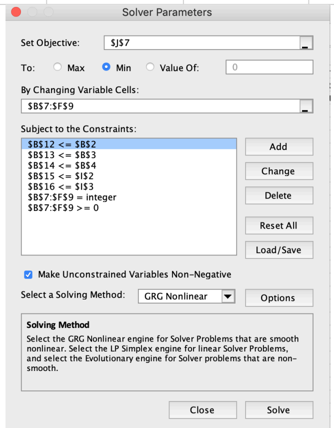
D1= 45,000   D2=76,500   D3= 10,000

Total time for special machine= 6552

Total time for regular machine= 32760

Base on these formulas, I made my model and use the solver in order to minimize the total cost. You can see the result in picture 1

product	Demand (yard)	Special capacity (yard/hour)	Regular capacity (yard/hour)	Manufacture cost ($/yard)	Outsource cost ($/yard)		time to delivery (weeks)	13	
1	45000	4.7	0	0.65	0.85		Total time for Regular (hour	32760	
2	76500	5.2	5.2	0.61	0.75		Total time for Special (hour	6552	
3	10000	4.4	4.4	0.5	0.65				
product	T 1 Regular	T2 Special	Regular capacity (yard)	Special capacity(yard)	Outsource (yard)	Manufacuring	manufacure cost($)	Outsource cost($)	Total cost ($)
1	10920	2184	0	30794.4	14205.6	30794.4	20016.36	12074.76	83756.12
2	10920	2184	76500	0	0	76500	46665	0	
3	10920	2184	10000	0	0	10000	5000	0	
constraint1	45000								
constraint2	76500								
constraint3	10000								
constraint4	32760								
constraint5	6552								



Picture 1

Base on the picture 1, The minimum total cost to meet the demand is 83756.12 and we need to manufacture 30794.4 of F1, 76500 of F2 and 10000 of F3 and buy 14205.6 of F1 from outsources.

In order to answer part two, we need to change the total time and special loom capacity.

The new total time is 13*24*5, and 0.5* special loom capacity.

you can see the result in picture 2

A	B	C	D	E	F	G	H	I
product	Demand (yard)	Special capacity (yard/hour)	Regular capacity (yard/hour)	Manufacture cost ($/yard)	Outsource cost ($/yard)		time to delivery (weeks)	13
1	45000	2.35	0	0.65	0.85		Total time for Regular (hour	23400
2	76500	2.6	5.2	0.61	0.75		Total time for Special (hour	4680
3	10000	2.2	4.4	0.5	0.65			
product	Outcouring (yard)	Regular capacity (yard)	Special capacity(yard)	Manufacuring	manufacure cost($)	Outsource cost($)	Total cost ($)	
1	34002	0	10998	10998	7148.7	28901.7	87715.4	
2	0	76500	0	76500	46665	0		
3	0	10000	0	10000	5000	0		
constraint1	45000							
constraint2	76500							
constraint3	10000							

Picture 2

As you can see the total cost change from 83756.12 to 87715.4 , and we need to manufacture 10998 of F1, 76500 of F2 and 10000 of F3 and buy 10998 of F1

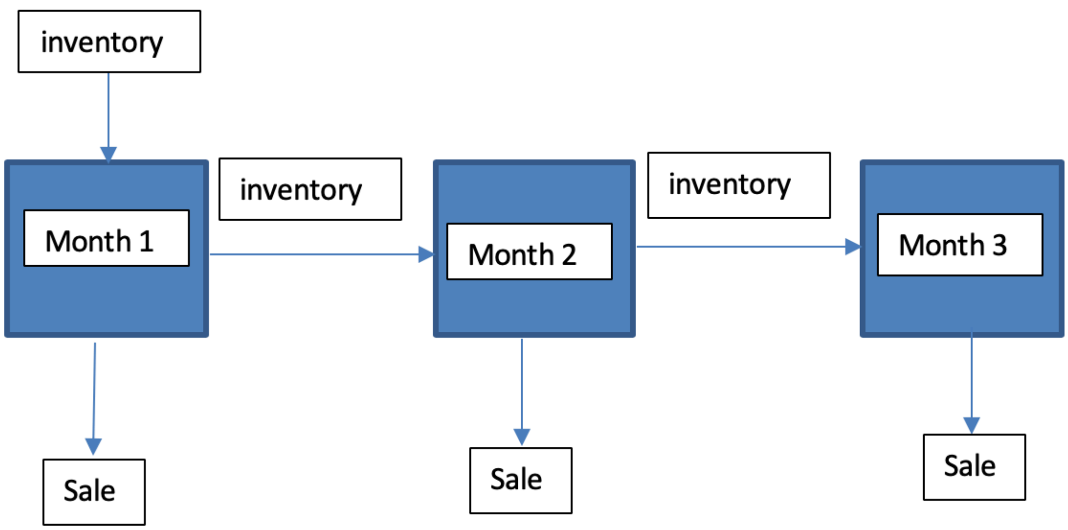
Question 3: Chapter 13, problem 23

My first assumption that I have is the cost of the product increase at first month, so we have same price in all of these three months and it does not change.

The second assumption is we can inventory **at least** 100 pound of each product. And when we start we have 100 pound of each product as inventory.

Moreover, I assumed each product have their own machine to produce, so they produce simultaneously.

For each product we have the figure like picture 3.



picture 3

The total time that we have to produce the products each month is 4(week)* 7(day) *8(hour each shift)* 2(shifts) = 448

For each product:

produced= 1/speed of produce *total time of working

stock= inventory+ produced

cost= produced* rate of cost

inventory of month n= stock of month (n-1) - demand of month (n-1) maintaining inventor = 0.12* product cost

And my constraints are:

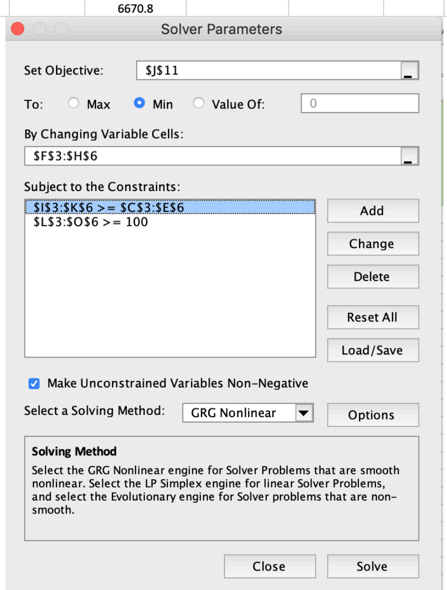
Each month, for each product, stock should be equal or more than demand

Each month, for each product, we have at least 100 pound inventory.

Then I use solver to find the minimum total cost.You can see the result in picture 4

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	inventory (lb)	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	=L3+F3	=G3+M3	=H3+N3	100	=I3-C3	=J3-D3	=H3-E3
2	0.05	1000	900	500	1000	900	600	=L4+F4	=G4+M4	=H4+N4	100	=I4-C4	=J4-D4	=H4-E4
3	0.2	600	60	500	600	60.00000000000(	600	=L5+F5	=G5+M5	=H5+N5	100	=I5-C5	=J5-D5	=H5-E5
4	0.11	0	200	500	100	100	600	=L6+F6	=G6+M6	=H6+N6	100	=I6-C6	=J6-D6	=H6-E6
Total time														
=7*8*2*4														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	Inventory cost($)	Inventory cost($)	Inventory cost($)		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		=SUM(C12:H					
1	9	=B12*F3	=B12*G3	=B12*H3	=0.12*C12	=0.12*D12	=0.12*E12							
2	6.75	=B13*F4	=B13*G4	=B13*H4	=0.12*C13	=0.12*D13	=0.12*E13							
3	5.25	=B14*F5	=B14*G5	=B14*H5	=0.12*C14	=0.12*D14	=0.12*E14							
4	7.5	=B15*F6	=B15*G6	=B15*H6	=0.12*C15	=0.12*D15	=0.12*E15							
		:ost of product			l cost of inventor									
		=SUM(C12:E1!			=SUM(F12:H15)									

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	inventory (lb)	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	1100	900	1200	100	100	100	100
2	0.05	1000	900	500	1000	900	600	1100	1000	700	100	100	100	100
3	0.2	600	60	500	600	60	600	700	160	700	100	100	100	100
4	0.11	0	200	500	100	100	600	200	300	700	100	200	100	100
Total time														
448														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	Inventory cost($)	Inventory cost($)	Inventory cost($)		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		62260.8					
1	9	9000	7200	9900	1080	864	1188							
2	6.75	6750	6075	4050	810	729	486							
3	5.25	3150	315	3150	378	37.8	378							
4	7.5	750	750	4500	90	90	540							
		Total cost of production ($)			Total cost of inventory ($)									
		55590			6670.8									



Picture 4

Base on picture 4, the minimum total cost equal to 62260.8

For part 2, I change the cost of inventory from 0.12*cost of production to 0.022* cost of production. You can see the new result in picture 5.

product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	inventory (lb)	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	=L3+F3	=G3+M3	=H3+N3	100	=I3-C3	=J3-D3	=H3-E3
2	0.05	1000	900	500	1000	900	600	=L4+F4	=G4+M4	=H4+N4	100	=I4-C4	=J4-D4	=H4-E4
3	0.2	600	60	500	600	60.000000000	600	=L5+F5	=G5+M5	=H5+N5	100	=I5-C5	=J5-D5	=H5-E5
4	0.11	0	200	500	100	100	600	=L6+F6	=G6+M6	=H6+N6	100	=I6-C6	=J6-D6	=H6-E6
Total time														
=7*8*2*4														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	nventory cost($	nventory cost($	nventory cost($		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		=SUM(C12:H					
1	9	=B12*F3	=B12*G3	=B12*H3	=0.022*C12	=0.022*D12	=0.022*E12							
2	6.75	=B13*F4	=B13*G4	=B13*H4	=0.022*C13	=0.022*D13	=0.022*E13							
3	5.25	=B14*F5	=B14*G5	=B14*H5	=0.022*C14	=0.022*D14	=0.022*E14							
4	7.5	=B15*F6	=B15*G6	=B15*H6	=0.022*C15	=0.022*D15	=0.022*E15							
		:ost of product			cost of invento									
		=SUM(C12:E1			=SUM(F12:H15									

product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	inventory (lb)	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	1100	900	1200	100	100	100	100
2	0.05	1000	900	500	1000	900	600	1100	1000	700	100	100	100	100
3	0.2	600	60	500	600	60	600	700	160	700	100	100	100	100
4	0.11	0	200	500	100	100	600	200	300	700	100	200	100	100
Total time														
448														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	Inventory cost($)	Inventory cost($)	Inventory cost($)		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		56812.98					
1	9	9000	7200	9900	198	158.4	217.8							
2	6.75	6750	6075	4050	148.5	133.65	89.1							
3	5.25	3150	315	3150	69.3	6.93	69.3							
4	7.5	750	750	4500	16.5	16.5	99							
		Total cost of production ($)		Total cost of inventory ($)										
		55590			1222.98									

Picture 5

Base on picture 5, the total cost change from 62260.8 to 56812.98.

Question 4: This is a continuation of the previous problem. In addition to the assumption "the per-pound cost of holding inventory each month is estimated to be 2.2% of the cost of the product", also assume that the factory now closes during weekends. Run the solver to optimize model to meet demand and minimize total cost. Clearly mention the total cost (production + inventory) of your model.

since the company closes during weekends, the total time change.

The total time that we have to produce the products each month is 4(week)* 5(day) *8(hour each shift)* 2(shifts) = 320

And the inventory cost is equal to 0.022*cost of production* weight of inventory

You can see the result in picture 6.

product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	nventory (lb	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	1100	900	1200	100	100	100	100
2	0.05	1000	900	500	1000	900	600	1100	1000	700	100	100	100	100
3	0.2	600	60	500	600	60	600	700	160	700	100	100	100	100
4	0.11	0	200	500	100	100	600	200	300	700	100	200	100	100
Total time														
320														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	ıventory cost($	ıventory cost($	ıventory cost($)		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		179538					
1	9	9000	7200	9900	19800	15840	21780							
2	6.75	6750	6075	4050	14850	13365	8910							
3	5.25	3150	315	3150	6930	693	6930							
4	7.5	750	750	4500	3300	1650	9900							
		Total cost of production ($)			Total cost of inventory ($)									
		55590			123948									

product	rate of producing (hour/lb)	Demand (lb)	Demand (lb)	Demand (lb)	producing(lb)	producing(lb)	producing(lb)	stock (lb)	stock (lb)	stock (lb)	inventory (lb)	inventory (lb)	inventory (lb)	inventory (lb)
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3	Month 0	Month 1	Month 2	Month 3
1	0.06	1000	800	1000	1000	800	1100	=L3+F3	=G3+M3	=H3+N3	100	=I3-C3	=J3-D3	=H3-E3
2	0.05	1000	900	500	1000	900	600	=L4+F4	=G4+M4	=H4+N4	100	=I4-C4	=J4-D4	=H4-E4
3	0.2	600	60	500	600	60.00000000(	600	=L5+F5	=G5+M5	=H5+N5	100	=I5-C5	=J5-D5	=H5-E5
4	0.11	0	200	500	100	100	600	=L6+F6	=G6+M6	=H6+N6	100	=I6-C6	=J6-D6	=H6-E6
Total time														
=5*8*2*4														
product	cost ($/lb)	Total cost($)	Total cost($)	Total cost($)	ıventory cost($	ıventory cost($	ıventory cost($		Total cost					
		Month 1	Month 2	Month 3	Month 1	Month 2	Month 3		=SUM(C12:I					
1	9	=B12*F3	=B12*G3	=B12*H3	=0.022*C12*I	=0.022*D12*I	=0.022*E12*(							
2	6.75	=B13*F4	=B13*G4	=B13*H4	=0.022*C13*I	=0.022*D13*I	=0.022*E13*(							
3	5.25	=B14*F5	=B14*G5	=B14*H5	=0.022*C14*I	=0.022*D14*I	=0.022*E14*(							
4	7.5	=B15*F6	=B15*G6	=B15*H6	=0.022*C15*I	=0.022*D15*I	=0.022*E15*(							
		ost of product			cost of invent									
		=SUM(C12:E			=SUM(F12:H1									

Picture 6

Base on the picture 6 the total cost change to 179538

part 2: Can you explain a scenario that is beyond the limits/assumptions of your model? In the question, it mentioned that Because of increasing supplier costs, the variable cost of each of the products will increase by 6% at the beginning of month three. But I assume the change is happen before these three month. So If we extant the months even for one more, this model can not predict it. Moreover, I assumed every product produce simultaneously, but if we use the same machine or they have over laps, my model cannot give the correct answer.

———————————————————————————————————

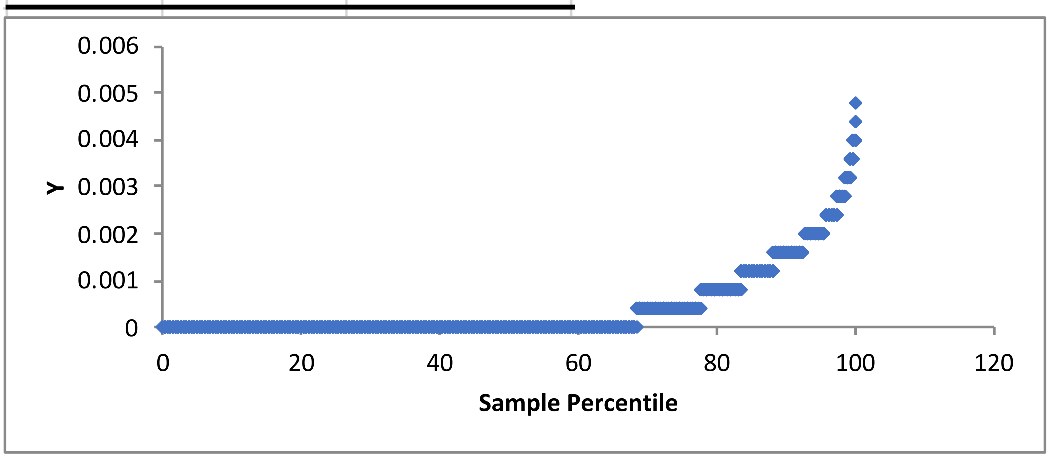
Question 5:

Plot PDF of cost difference using regression method (discussed during week 4)

In order to answer this part, I assume the middle of the bin is x and the PDF is y. Then I calculate the x to x^6 and then use the regression method and plot it. You can see the result in picture 7

x	x^2	x^3	x^4	x^5	x^6	y
-99960	9992001600	-9.988E+14	9.98401E+19	-9.98002E+24	9.97602E+29	0
-99880	9976014400	-9.964E+14	9.95209E+19	-9.94014E+24	9.92822E+29	0
-99800	9960040000	-9.94E+14	9.92024E+19	-9.9004E+24	9.8806E+29	0
-99720	9944078400	-9.916E+14	9.88847E+19	-9.86078E+24	9.83317E+29	0
-99640	9928129600	-9.892E+14	9.85678E+19	-9.82129E+24	9.78593E+29	0
-99560	9912193600	-9.869E+14	9.82516E+19	-9.78193E+24	9.73889E+29	0
-99480	9896270400	-9.845E+14	9.79362E+19	-9.74269E+24	9.69203E+29	0
-99400	9880360000	-9.821E+14	9.76215E+19	-9.70358E+24	9.64536E+29	0
-99320	9864462400	-9.797E+14	9.73076E+19	-9.66459E+24	9.59887E+29	0
-99240	9848577600	-9.774E+14	9.69945E+19	-9.62573E+24	9.55258E+29	0
-99160	9832705600	-9.75E+14	9.66821E+19	-9.587E+24	9.50647E+29	0
-99080	9816846400	-9.727E+14	9.63705E+19	-9.54839E+24	9.46054E+29	0

	Coefficients	*Standard Error*
Intercept	0.001518006	2.05492E-05
X Variable 1	-9.17738E-09	7.12527E-10
X Variable 2	-1.10529E-12	2.48233E-14
X Variable 3	3.10924E-18	2.79876E-19
X Variable 4	2.20607E-22	6.78542E-24
X Variable 5	-2.36016E-28	2.4559E-29
X Variable 6	-1.29241E-32	4.89349E-34



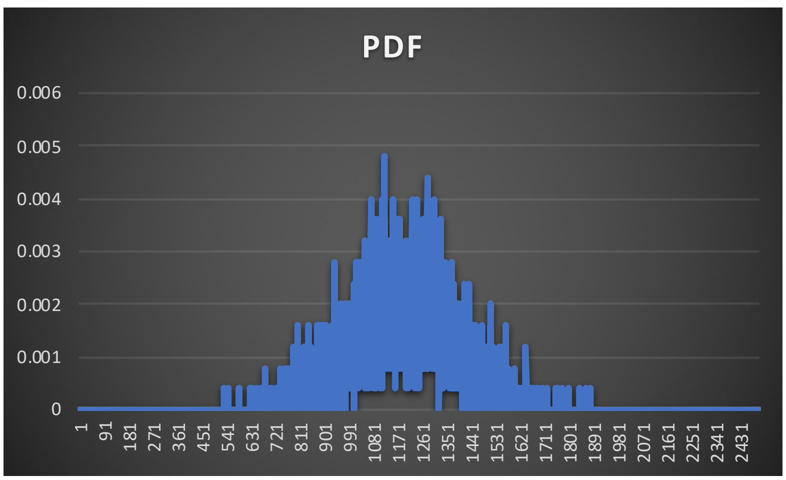
Picture 7

Plot PDF of cost difference column assuming it is normal distribution (discussed during week 4)

In order to answer all of the parts of question, we need the table that you can see in picture 8 and then plot the PDF.

C	D	E	F	G	H	I	J
Lower rang of bin	upper range of bin	No. of value > lower range of bin	No. of value > upper range of bin	Middle of Lower and upper range	Between lower and upper range	PDF	CDF
-100000	=C3	=COUNTIF($A$2:$A$2502,">="&C2)	=COUNTIF($A$2:$A$2502,">="&D2)	=(C2+D2)/2	=E2-F2	=H2/2500	=I2
=C2+80	=C4	=COUNTIF($A$2:$A$2502,">="&C3)	=COUNTIF($A$2:$A$2502,">="&D3)	=(C3+D3)/2	=E3-F3	=H3/2500	=SUM($I$2:I3)
=C3+80	=C5	=COUNTIF($A$2:$A$2502,">="&C4)	=COUNTIF($A$2:$A$2502,">="&D4)	=(C4+D4)/2	=E4-F4	=H4/2500	=SUM($I$2:I4)
=C4+80	=C6	=COUNTIF($A$2:$A$2502,">="&C5)	=COUNTIF($A$2:$A$2502,">="&D5)	=(C5+D5)/2	=E5-F5	=H5/2500	=SUM($I$2:I5)
=C5+80	=C7	=COUNTIF($A$2:$A$2502,">="&C6)	=COUNTIF($A$2:$A$2502,">="&D6)	=(C6+D6)/2	=E6-F6	=H6/2500	=SUM($I$2:I6)
=C6+80	=C8	=COUNTIF($A$2:$A$2502,">="&C7)	=COUNTIF($A$2:$A$2502,">="&D7)	=(C7+D7)/2	=E7-F7	=H7/2500	=SUM($I$2:I7)
=C7+80	=C9	=COUNTIF($A$2:$A$2502,">="&C8)	=COUNTIF($A$2:$A$2502,">="&D8)	=(C8+D8)/2	=E8-F8	=H8/2500	=SUM($I$2:I8)
=C8+80	=C10	=COUNTIF($A$2:$A$2502,">="&C9)	=COUNTIF($A$2:$A$2502,">="&D9)	=(C9+D9)/2	=E9-F9	=H9/2500	=SUM($I$2:I9)
=C9+80	=C11	=COUNTIF($A$2:$A$2502,">="&C10)	=COUNTIF($A$2:$A$2502,">="&D10)	=(C10+D10)/2	=E10-F10	=H10/2500	=SUM($I$2:I10)

C	D	E	F	G	H	I	J
Lower rang of bin	upper range of bin	No. of value > lower range of bin	No. of value > upper range of bin	Middle of Lower and upper range	Between lower and upper range	PDF	CDF
-100000	-99920	2501	2501	-99960	0	0	0
-99920	-99840	2501	2501	-99880	0	0	0
-99840	-99760	2501	2501	-99800	0	0	0
-99760	-99680	2501	2501	-99720	0	0	0
-99680	-99600	2501	2501	-99640	0	0	0
-99600	-99520	2501	2501	-99560	0	0	0
-99520	-99440	2501	2501	-99480	0	0	0
-99440	-99360	2501	2501	-99400	0	0	0
-99360	-99280	2501	2501	-99320	0	0	0



Picture 8

Plot PDF of cost difference using envelop method (discussed during week 5)

the max of PDF is 0.0048 which belong to i= 1125

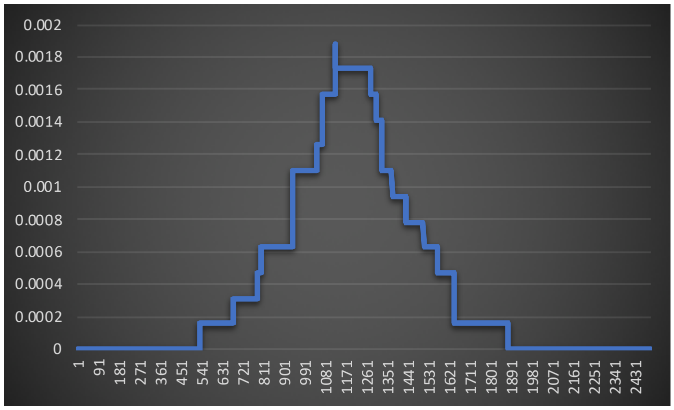
Now we need to calculate:

For bin_i i = 1 to M, Envelop = $max(PDF_1:PDF_i)$ >> =MAX($J$2:J3)

For bin_i i = M+1 to N, Envelop = $max(PDF_i:PDF_N)$ >>=MAX(J1126:$J$2502)

Then multiply each cell by weight which is 1/∑ePDF

You can see the result in picture 9



Picture 9

Optimize MEAN and STD in 5.2 to minimize error between 5.2 and 5.3 models.

After optimization the plot is going to change to picture 10