EMIS 5357/7357 Spring 2019 Homework 4
Due Friday, May 10, 2019 by 11:59pm
9 points
ASSIGNMENT DONE BY-
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You can work with at most one other person in the class. Every student must upload his assignment to Canvas. The deliverables are one zip file labeled HW4_FirstName_LastName.zip (no other extension will be accepted: .7z, .tar, .gz) that include a write-up in Word containing the answers to the questions below and the software code such as Excel or AMPL. Make sure to include your name in both the Word and the software files.

EMIS 5357 and 7357 students have the same assignment.

Problem 1 (5 points): "Production Scheduling with Changeover Costs" in hw4-text.pdf
(3 pts) Then introduce binary variables that are 1 when a certain product is produced and 0 otherwise, and binary variables that are 1 when there is a changeover and 0 otherwise. You must figure out how to detect changeover based on the binary variables about production of each product and create constraints that enforce that.(1pt) Then prepare the managerial report asked in the text (1pt).

Problem 2 (4 points): "CAFE Compliance in the Auto Industry" in hw4-text.pdf
You can use Excel Solver or AMPL to solve the problem.
2/3 pt per question.

PROBLEM 1: "Production Scheduling with Changeover Costs"

SOLUTION 1:

A mixed integer programming model can be used advantageously to assist in developing recommendations. We describe such a model here; it has 48 decision variables and 64 constraints. We show here how to use Microsoft Excel to formulate and solve the problem. The spreadsheet at the end shows how we set up the problem and the optimal solution. We describe the model now.

Variables

There are variables for production, inventory, setup, and changeover in each week.

P_i = number of P-Heads produced in week i

H_i = number of H-Heads produced in week i

IP_i = number of P-Heads in inventory at end of week i

IH_i = number of H-Heads in inventory at end of week i

SP_i = 1 if line is setup for P in week i, 0 if setup for H

$Change_i$ = 1 if a changeover occurs at the beginning of week i, 0 otherwise

Constraints

There are constraints for production capacity, inventory balance, maintenance of safety stock, and enforcement of changeovers. Also, Excel requires that you identify the 0-1 (binary) variables in the Solver dialog box. The constraints as specified in the Excel Solver dialog box are as follows (references are to cells of the spreadsheet):

B20:C27 ≤ B34:C41 production capacity, or nonnegativity of slack

G20:G27 ≥ H34:H41 forces $Change_i$ to 1 when a changeover occurs
G20:G27 ≥ I34:I41

D20:E27 ≥ D6:E13 ending inventory ≥ safety stock

D34:E41 = B6:C13 beg. inv. + production - end inv. = demand
F18:F25 = Bin setup variables must be binary

Even though the $Change_i$ variable must also be integer it is not necessary to require it because minimization will never let it be any bigger than it has to be. And, the second set of constraints force it to be ≥ 1 whenever the setup variable changes from 1 to 0 or from 0 to 1.

Objective

We want to minimize total cost which is represented by cell J23 in the spreadsheet. It is the sum of production cost, inventory cost, and changeover cost.

The Spreadsheet

The first 14 rows of the spreadsheet contain the data for the problem; information on demand, safety stock, various costs and beginning inventories are given. Cells B20:G27, as shown contain the optimal solution to the problem. Before solving, those cells were empty.

The spreadsheet formulation and solution are shown.

	A	B	C	D	E	F	G	H	I	J
1	Production Scheduling									
2										
3										
4		Product Demand		Safety Stock					P	H
5	Week	P	H	P	H			Production Cost	225	310
6	1	55	38	44	30.4			Max Weekly Rate	100	80
7	2	55	38	35.2	24			Changeover Cost	500	500
8	3	44	30	0	0			Weekly Inv. Rate	0.00375	0.00375
9	4	0	0	36	38.4			Weekly Inv. Cost	0.84375	1.1625
10	5	45	48	36	38.4			Beginning Inv.	125	143
11	6	45	48	28.8	46.4					
12	7	36	58	28	45.6					
13	8	35	57	28	46.4					
14	9	35	58							
15										
16	Model									
17										
18										
19	Week	P	H	Inv. P	Inv. H	Setup P	Changeover			
20	1	18.00	0.00	88.00	105.00	1.00	0.00		Prod. Cost	117374
21	2	100.00	0.00	133.00	67.00	1.00	0.00		Inv. Cost	1280.35125
22	3	100.00	0.00	189.00	37.00	1.00	0.00		Changeover Cost	500
23	4	0.00	1.40	189.00	38.40	0.00	1.00		Min Total Cost	119154.3513
24	5	0.00	48.00	144.00	38.40	0.00	0.00			
25	6	0.00	56.00	99.00	46.40	0.00	0.00			
26	7	0.00	57.20	63.00	45.60	0.00	0.00			
27	8	0.00	57.80	28.00	46.40	0.00	0.00			
28										
29										
30				Inventory Balance						
31				Beginning Inv. + Prod.						
32		Production Capacity		- Ending Inv.				Changeover Def.		
33	Week	P	H	P	H		Week	To P if 1	To H if 1	
34	1	100	0	55	38		1	0.00	0.00	
35	2	100	0	55	38		2	0.00	0.00	
36	3	100	0	44	30		3	0.00	0.00	
37	4	0	80	0	0		4	-1.00	1.00	
38	5	0	80	45	48		5	0.00	0.00	
39	6	0	80	45	48		6	0.00	0.00	
40	7	0	80	36	58		7	0.00	0.00	
41	8	0	80	35	57		8	0.00	0.00	

Managerial Report:

The spreadsheet contains the optimal solution. The minimum total cost is $119,154.35. The components of that cost are production: $117,374, inventory: $1280.35 and changeover: $500. From cells F20:F27 we see that the line will be setup to produce P-Heads in weeks 1-3 and H-Heads in weeks 4-8. Cell G23 shows that there will be a changeover from producing P-Heads to H-Heads at the beginning of week 4.

By adjusting the data for this problem (e.g. beginning inventories and the various costs) a number of variations of this problem can be created with the same basic model. Also, one might want to vary the safety stock requirements and the number of weeks in the planning horizon to create other variations of the problem.

PROBLEM 2: "CAFE COMPLIANCE IN THE AUTO INDUSTRY"

SOLUTION 2:

1. I computed an expression of total profit contribution as a function of the price for each car and the price of light trucks that is shown below.

QUESTION 1	Passenger car	light truck
price	Pc	Pt
qty	750-Pc	830-Pt
revenue	Pc*(750-Pc)	Pt*(830-Pt)
cost	15*(750-Pc)	17*(830-Pt)
contribution	(Pc-15)*(750-Pc)	(Pt-17)*(830-Pt)
total contribution	(Pc-15)*(750-Pc)+(Pt-17)*(830-Pt)	

2. Using an Excel Solver the price for each car so that the total profit contribution is maximized is 382.499 for passenger car and 423.499 for light truck. To maximize the total profit contribution for the car is 135056.25 and for truck it is 165242 , the total contribution is 300298.5.

QUESTION 2	Passenger car	light truck
price	382.4999998	423.499999
qty	367.5000002	406.500001
revenue	140568.75	172152.75
cost	5512.500003	6910.500016
contribution	135056.25	165242.25
total contribution	300298.5	

3. The quantity sold of passenger car and light truck are 368 and 407 respectively. They both are rounded up to the nearest upper one.

QUESTION 3	Passenger Car	Light truck
quantity sold	368	407

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both quantities are rounded up to the nearest value.

4. Using an Excel Sheet given in the question we obtain the café average as 25 and number of vehicles 3 and 2 for passenger car and light truck respectively as shown below.

QUESTION 4	MPG	No. of vehicles	Café weight
Passener car	30	3	0.1
Light Truck	20	2	0.1
		5	0.2
café average	25		

5. The fleet size assuming it from the question number 3 but without rounding it of is equivalent to 23.02622.

QUESTION 5	MPG	No. of vehicles	Café weight
Passener car	28.28278551	367.5000002	12.99376966
Light Truck	19.71379793	406.500001	20.62007547
	0	774.0000012	33.61384512
café average	23.0262262		

6. Adding the constraint of Café average to be 25 maximum total profit contribution subject to meet the constraint is shown below.

QUESTION 6	Passenger car	light truck	total
price	382.4999998	423.499999	805.9999988
qty	397.8224441	443.5997212	841.4221653
revenue	140568.75	172152.75	312721.5
cost	0	0	0
contribution	5.92623E+12	8.87138E+12	14797601215417.90
MPG	30	20	47.99658344
Café weight	12.25000001	20.32500005	33.65688661
café average	25		