BUSN9087: Managerial Report

Report

Author: Corinne Batho-Newton

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Table of Contents

1.0 Introduction

TelecomOne is a manufacturer of fibre optic telecommunication equipment, fulfilling the demands of markets in Atlanta, Boston, Chicago, Denver, Omaha and Portland. It has plants in Baltimore, Memphis, Wichita, Wyoming and Salt Lake City. It is trying to minimise its costs for meeting demand, by identifying which plants should be shut down, and how the unit production for each market should be split between the remaining plants. This report aims to identify what the minimum costs for meeting the market demand are, how the quantity of production units produced should be split between each plant, and which (if any) of the plants should be closed to minimise costs.

2.0 Method Used for Solution

An Excel solver with linear programming was used to determine the optimal solution for the problem. To simplify the problem and identify what calculations needed to be made for the solver, a formula for the problem was defined.

2.1 Optimisation formula

The Decision variables, objective function and constraints are defined. **i** refers to the plants, and **j** refers to the markets…

2.1.1 Decision Variables

Xi = if plant i is in operation. E.g. if X0 = 1 - plant Baltimore is in operation, or if X1 = 0 - plant Memphis is not in operation.

Yij = allocation of demand from market j to plant i.

2.1.2 Objective Function

Minimise Cost of meeting demand:

$$\Sigma i \ (Fi \ Xi) + \Sigma i \Sigma j \ (Vij \ Yij)$$

Where…

Fi = fixed costs of plant i.

Vij = the variable costs (production, inventory and transportation costs) for each plant i to provide one unit to market **j**.

2.1.3 Constraints

1. Demand constraints: The demand of each market **j** must be satisfied. Each market **j** will have the following constraint, where **Dj** is the demand from market **j**…

$$\Sigma i \; Yij \geq Dj$$

2. Capacity constraints: The production of each plant must not exceed its total capacity it is capable of producing. Each plant **i** will have the following constraint, where **Ci** is the capacity of plant **i**…

$$\Sigma j \; Yij \leq Xi * Ci$$

…note that **Xi * Ci** means if the plant is not in operation, the capacity will be 0.

3. Non-negativity constraints: The allocation of demand cannot be a negative number, the decision variable for demand allocation will have the following constraint…

$$Yij \geq 0$$

4. Binary constraints: The decision variable for whether plant **i** is open or not can only be **0 or 1**…

$$\mathbf{Xi = 0 \text{ or } 1}$$

2.2 Model

Table of Data Given

	Vij Production, Inventory and Transportation Costs (1000 $)							
	Atlanta	**Boston**	**Chicago**	**Denver**	**Omaha**	**Portland**	**Ci Capacity (1000 units)**	**Fi Monthly Fixed Costs (1000$)**
Baltimore	1675	400	685	1630	1160	2800	18	7650
Wyoming	1460	1940	970	100	495	1200	24	3500
Salt Lake City	1925	2400	1425	500	950	800	27	5000
Memphis	380	1355	543	1045	665	2321	22	4100
Wichita	922	1646	700	508	311	1797	31	2200
Dj Monthly Demand (1000 units)	10	8	14	6	7	11		

Decsion Table

	Yij Quanity of demand met							
i Plants	Atlanta	Boston	Chicago	Denver	Omaha	Portland	**Xi** Is plant open?	**Ci** Capacity
Baltimore								18
Wyoming								24
Salt Lake City								0
Memphis								22
Wichita								0

Minimise total cost (1000 $):	

Constraints

Capacity			
Baltimore	10	<=	18
Wyoming	24	<=	24
Salt Lake C	0	<=	0
Memphis	22	<=	22
Wichita	0	<=	0

Demand			
Atlanta	10	=	10
Boston	8	=	8
Chicago	14	=	14
Denver	6	=	6
Omaha	7	=	7
Portland	11	=	11

Binary Constraints		
1	=	1 or 0
1	=	1 or 0
0	=	1 or 0
1	=	1 or 0
0	=	1 or 0

Non-negativity Constraints		
Yij	>=	0

Figure 1: Image of model built.

After defining the formula, the model shown in figure 1 was created. First the given data and information about the plant and market costs, capacity and demand was replicated as shown in the first "Table of Data Given". A secondary "Decision Table" was defined, including…

- the decision values for **Yij** - the quantity of units each plant (**i**) will provide for each market (**j**),
- the binary values **Xi** - whether each plant is in operation,
- and finally the new capacity **Ci** - which multiples the original capacity given by the corresponding **Xi** value (meaning if a plant is not in operation, its capacity will be set to 0.

Next the objective cell was defined, which calculated the SumProduct of **Yij** and **Vij** (total variable costs given the allocated units for each plant) + the SumProduct of **Xi** and **Fi** (total fixed monthly costs considering which plants are in operation.) This calculation is visualised in figure 2. This objective cell gives the total costs for meeting market demands for which the aim is to minimise. Finally the constraints were defined, as illustrated at the end of figure 1.

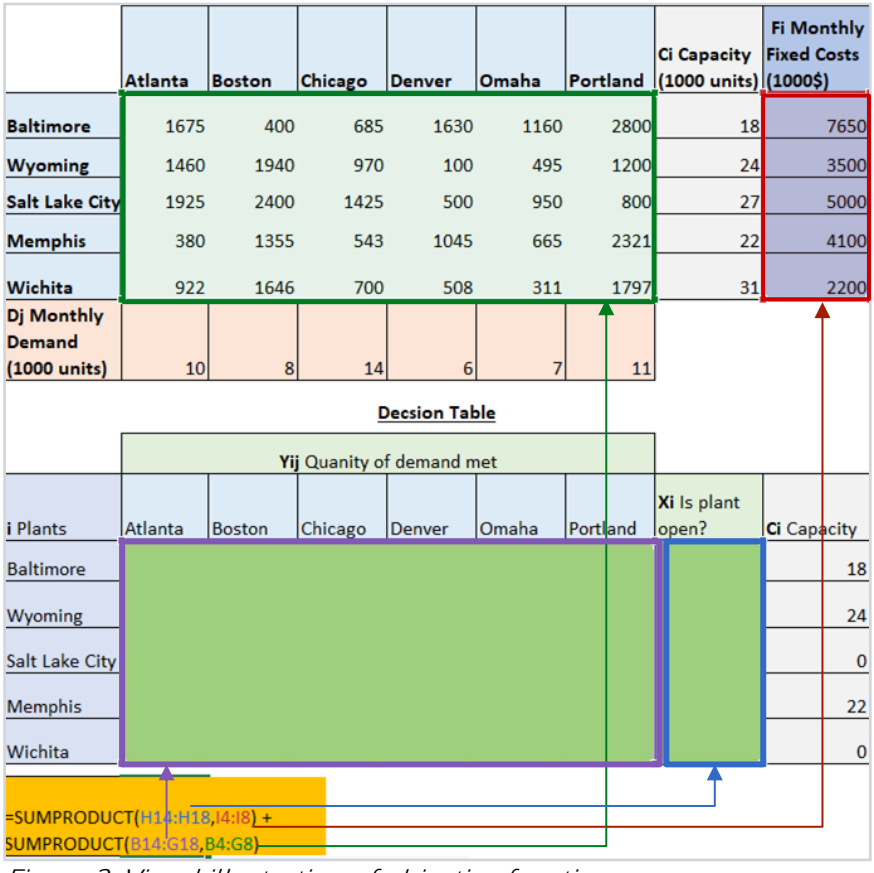

Figure 2: Visual illustration of objective function.

With objective, decision variables and constraints defined, all that's left to do to solve the problem, using the Simplex LP solver, is to enter all the information into excel solver so it can solve the problem. Refer to figure 3.

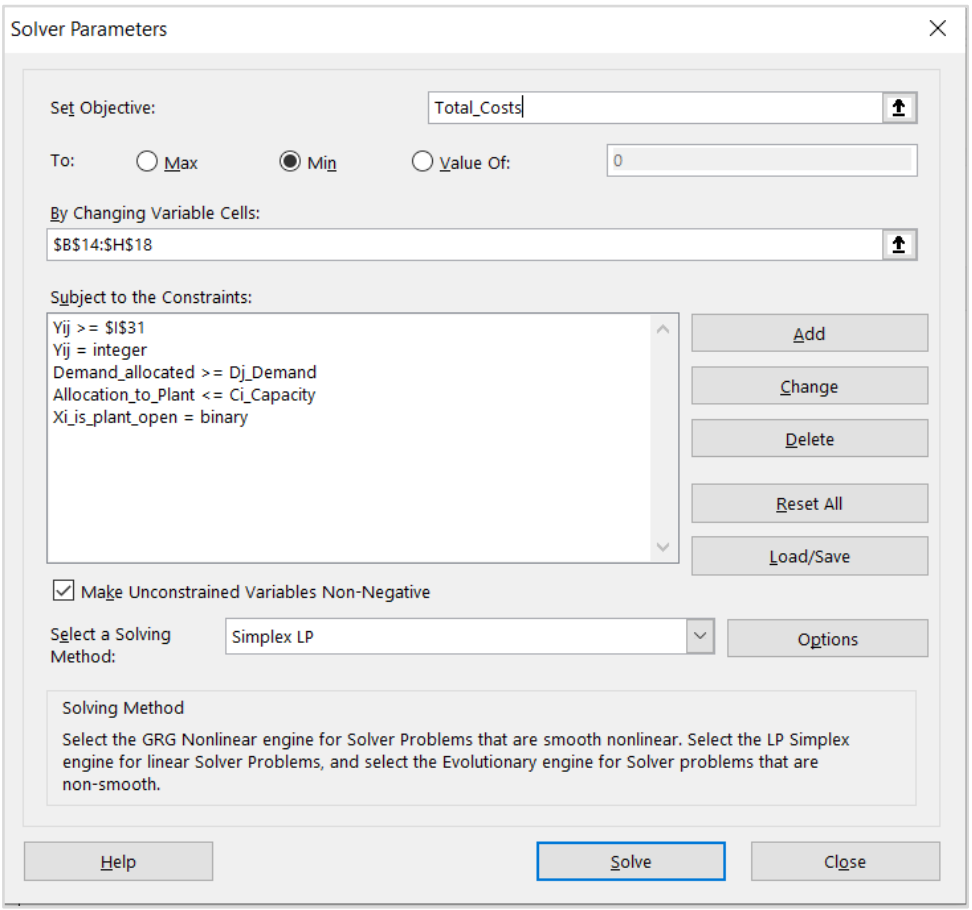

Figure 3: Inputs in Solver.

The optimal solutions for the two scenarios have been reached using the Simplex linear programming method and an answer report has been generated, as shown in the following section of the report. It was not possible to generate a sensitivity report due to the nature of the constraints involving integer and binary decision variables. Sensitivity analysis is only available for models that use continuous variables.

3.0 Solution - Part 1

The optimal combination of plants in operation and allocation of demand can be found in figure 4.

Table of Data Given

	Vij Production, Inventory and Transportation Costs (1000 $)							
	Atlanta	**Boston**	**Chicago**	**Denver**	**Omaha**	**Portland**	**Ci Capacity (1000 units)**	**Fi Monthly Fixed Costs (1000$)**
Baltimore	1675	400	685	1630	1160	2800	18	7650
Wyoming	1460	1940	970	100	495	1200	24	3500
Salt Lake City	1925	2400	1425	500	950	800	27	5000
Memphis	380	1355	543	1045	665	2321	22	4100
Wichita	922	1646	700	508	311	1797	31	2200
Dj Monthly Demand (1000 units)	10	8	14	6	7	11		

Decsion Table

	Yij Quanity of demand met							
i Plants	Atlanta	Boston	Chicago	Denver	Omaha	Portland	**Xi** Is plant open?	**Ci** Capacity
Baltimore	0	8	2	0	0	0	1	18
Wyoming	0	0	0	6	7	11	1	24
Salt Lake City	0	0	0	0	0	0	0	0
Memphis	10	0	12	0	0	0	1	22
Wichita	0	0	0	0	0	0	0	0

Minimise total cost (1000 $):	47401

Constraints

Capacity			
Baltimore	10	<=	18
Wyoming	24	<=	24
Salt Lake C	0	<=	0
Memphis	22	<=	22
Wichita	0	<=	0

Demand			
Atlanta	10	=	10
Boston	8	=	8
Chicago	14	=	14
Denver	6	=	6
Omaha	7	=	7
Portland	11	=	11

Binary Constraints		
1	=	1 or 0
1	=	1 or 0
0	=	1 or 0
1	=	1 or 0
0	=	1 or 0

Non-negativity Constraints		
Yij	>=	0

Figure 4: Solution for question 1.

The solution suggests the Salt Lake City and Wichita plants should be closed, and results in a minimised cost of $47,402,000.

4.0 Solution - Part 2

For question 2, historical data that suggests the demand requirement at Atlanta and Boston may change to 16000 and 10000 units, instead of 10000 and 8000 units respectively. The solution for this second scenario is given in figure 5 below.

Decision Table

	Yij Quanity of demand met							
i Plants	Atlanta	Boston	Chicago	Denver	Omaha	Portland	**Xi** Is plant c	**Ci** Capacity
Baltimore	0	10	8	0	0	0	1	18
Wyoming	0	0	0	6	7	11	1	24
Salt Lake City	0	0	0	0	0	0	0	0
Memphis	16	0	6	0	0	0	1	22
Wichita	0	0	0	0	0	0	0	0

Minimize:	51333

Constraints

Capacity				**Binary Constraints**		
Baltimore	18	<=	18	1	=	1 or 0
Wyoming	24	<=	24	1	=	1 or 0
Salt Lake City	0	<=	0	0	=	1 or 0
Memphis	22	<=	22	1	=	1 or 0
Wichita	0	<=	0	0	=	1 or 0
Demand				**Non-negativity Constraints**		
Atlanta	16	=	16	**Yij**	>=	0
Boston	10	=	10			
Chicago	14	=	14			
Denver	6	=	6			
Omaha	7	=	7			
Portland	11	=	11			

Figure 5: Solution for question 2.

The solution suggested the same plants stop operation, and the total cost while meeting all demand increases to $51,333,000.

5.0 Answer Report

The answer report is a useful tool for analysing linear programming solutions, giving further information about optimal values, constraints that are binding and information on the sensitivity of the optimal solution. See figures A1.1 - A2.2 in the appendix for full details of the answer reports.

The report shows that the results from running the simplex LP engine were obtained in 0.266 seconds for solution 1, and 0.297 for solution 2. The optimal solution for question 1 was found in only 4 iterations and 24 subproblems, indicating that the solution is robust and reliable. The solution for question 2 was found in even less steps, in 4 iterations and 12 subproblems. Inspection of the answers reports verifies that the production capacity constraint is satisfied for both solutions, and the demand of each market is met for both. This cross verifies that the solution is feasible and optimal.

6.0 Findings and Recommendations

Upon analysis of the model solution (figure4), it is recommended that TelecomOne cease operations in the Salt Lake City and Wichita plants. By doing so, the remaining plants in Baltimore, Wyoming, and Memphis can effectively fulfil the demands of the market at a cost of $46,401,000. Capacity constraints are also met, with Baltimore operating under its full capacity (see figure 6.)

Constraints

Capacity				**Binary Constraints**		
Baltimore	10	<=	18	1	=	1 or 0
Wyoming	24	<=	24	1	=	1 or 0
Salt Lake	0	<=	0	0	=	1 or 0
Memphis	22	<=	22	1	=	1 or 0
Wichita	0	<=	0	0	=	1 or 0
Demand				**Non-negativity Constraints**		
Atlanta	10	=	10	**Yij**	>=	0
Boston	8	=	8			
Chicago	14	=	14			
Denver	6	=	6			
Omaha	7	=	7			
Portland	11	=	11			

Figure 6: Constraints

Even with a potential increase in demand requirements at Atlanta and Boston (as proposed by question 2), it is still advisable for TelecomOne to proceed with closing the previously recommended plants. Comparison of figures 7 and 8 demonstrates through

reallocation of Chicago's demand from plant Memphis to plant Baltimore, and with the increase in Boston's demand allocated to the remaining Baltimore capacity, Memphis can satisfy the additional demand in Atlanta at a cost of $51,333,000. The optimal solution presented satisfies all constraints.

	Yij No. of units of demand allocated							
	j markets							
i Plants	Atlanta	Boston	Chicago	Denver	Omaha	Portland	**Xi** Is plant open?	**Ci** Capacity
Baltimore	0	8	2	0	0	0	1	18
Wyoming	0	0	0	6	7	11	1	24
Salt Lake City	0	0	0	0	0	0	0	0
Memphis	10	0	12	0	0	0	1	22
Wichita	0	0	0	0	0	0	0	0

Figure 7: Solution 1.

	Yij Quanity of demand met							
i Plants	Atlanta	Boston	Chicago	Denver	Omaha	Portland	**Xi** Is plant	**Ci** Capacity
Baltimore	0	10	8	0	0	0	1	18
Wyoming	0	0	0	6	7	11	1	24
Salt Lake City	0	0	0	0	0	0	0	0
Memphis	16	0	6	0	0	0	1	22
Wichita	0	0	0	0	0	0	0	0

Figure 8: Solution 2.

6.0.1 Final Recommendations

It is recommended that TelecomOne halt operations in the Salt Lake City and Wichita plants. The remaining plants in Baltimore, Wyoming, and Memphis can efficiently fulfil market demands while also meeting capacity constraints. In the event of a potential increase in demand requirements at Atlanta and Boston, the optimal solution would be to reallocate Chicago's demand from plant Memphis to plant Baltimore and allocate the increase in Boston's demand to the remaining Baltimore capacity. This solution satisfies all constraints and incurs a cost of $51,333,000.

6.1 Limitations

While the problem assumes that variable costs are linear and production capacity is fixed, it is important to note that real-world conditions can be much more volatile. For instance, transportation costs can fluctuate significantly due to fuel price changes, and a plant's production capacity can be affected by unforeseen factors such as work shortages. Therefore, to create a more robust model, it is recommended to analyse various scenarios to understand how the model will respond to different conditions.

Appendix

Microsoft Excel 16.0 Answer Report
Worksheet: [group_work.xlsx]Solution -Part 1
Report Created: 06/03/2023 16:16:30
Result: Solver found an integer solution within tolerance. All Constraints are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.266 Seconds.
Iterations: 4 Subproblems: 24
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$B$19	Minimize: Atlanta	47401	47401

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$13:$H$17				
$B$13	Baltimore Atlanta	0	0	Integer
$C$13	Baltimore Boston	8	8	Integer
$D$13	Baltimore Chicago	2	2	Integer
$E$13	Baltimore Denver	0	0	Integer
$F$13	Baltimore Omaha	0	0	Integer
$G$13	Baltimore Portland	0	0	Integer
$H$13	Baltimore Xi Is plant open?	1	1	Binary
$B$14	Wyoming Atlanta	0	0	Integer
$C$14	Wyoming Boston	0	0	Integer
$D$14	Wyoming Chicago	0	0	Integer
$E$14	Wyoming Denver	6	6	Integer
$F$14	Wyoming Omaha	7	7	Integer
$G$14	Wyoming Portland	11	11	Integer
$H$14	Wyoming Xi Is plant open?	1	1	Binary
$B$15	Salt Lake City Atlanta	0	0	Integer
$C$15	Salt Lake City Boston	0	0	Integer
$D$15	Salt Lake City Chicago	0	0	Integer
$E$15	Salt Lake City Denver	0	0	Integer
$F$15	Salt Lake City Omaha	0	0	Integer
$G$15	Salt Lake City Portland	0	0	Integer
$H$15	Salt Lake City Xi Is plant open?	0	0	Binary
$B$16	Memphis Atlanta	10	10	Integer
$C$16	Memphis Boston	0	0	Integer
$D$16	Memphis Chicago	12	12	Integer
$E$16	Memphis Denver	0	0	Integer
$F$16	Memphis Omaha	0	0	Integer
$G$16	Memphis Portland	0	0	Integer
$H$16	Memphis Xi Is plant open?	1	1	Binary
$B$17	Wichita Atlanta	0	0	Integer
$C$17	Wichita Boston	0	0	Integer
$D$17	Wichita Chicago	0	0	Integer
$E$17	Wichita Denver	0	0	Integer
$F$17	Wichita Omaha	0	0	Integer
$G$17	Wichita Portland	0	0	Integer
$H$17	Wichita Xi Is plant open?	0	0	Binary

Figure A1.1: Answer report 1 - part 1.

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$C$23:$C$27 <= $E$23:$E$27					
$C$23	Baltimore Boston	10	$C$23<=$E$23	Not Binding	8
$C$24	Wyoming Boston	24	$C$24<=$E$24	Binding	0
$C$25	Salt Lake City Boston	0	$C$25<=$E$25	Binding	0
$C$26	Memphis Boston	22	$C$26<=$E$26	Binding	0
$C$27	Wichita Boston	0	$C$27<=$E$27	Binding	0
$C$30:$C$35 >= $E$30:$E$35					
$C$30	Atlanta Boston	10	$C$30>=$E$30	Binding	0
$C$31	Boston Boston	8	$C$31>=$E$31	Binding	0
$C$32	Chicago Boston	14	$C$32>=$E$32	Binding	0
$C$33	Denver Boston	6	$C$33>=$E$33	Binding	0
$C$34	Omaha Boston	7	$C$34>=$E$34	Binding	0
$C$35	Portland Boston	11	$C$35>=$E$35	Binding	0
$B$13:$G$17 >= $I$30					
$B$13	Baltimore Atlanta	0	$B$13>=$I$30	Binding	0
$C$13	Baltimore Boston	8	$C$13>=$I$30	Not Binding	8
$D$13	Baltimore Chicago	2	$D$13>=$I$30	Not Binding	2
$E$13	Baltimore Denver	0	$E$13>=$I$30	Binding	0
$F$13	Baltimore Omaha	0	$F$13>=$I$30	Binding	0
$G$13	Baltimore Portland	0	$G$13>=$I$30	Binding	0
$B$14	Wyoming Atlanta	0	$B$14>=$I$30	Binding	0
$C$14	Wyoming Boston	0	$C$14>=$I$30	Binding	0
$D$14	Wyoming Chicago	0	$D$14>=$I$30	Binding	0
$E$14	Wyoming Denver	6	$E$14>=$I$30	Not Binding	6
$F$14	Wyoming Omaha	7	$F$14>=$I$30	Not Binding	7
$G$14	Wyoming Portland	11	$G$14>=$I$30	Not Binding	11
$B$15	Salt Lake City Atlanta	0	$B$15>=$I$30	Binding	0
$C$15	Salt Lake City Boston	0	$C$15>=$I$30	Binding	0
$D$15	Salt Lake City Chicago	0	$D$15>=$I$30	Binding	0
$E$15	Salt Lake City Denver	0	$E$15>=$I$30	Binding	0
$F$15	Salt Lake City Omaha	0	$F$15>=$I$30	Binding	0
$G$15	Salt Lake City Portland	0	$G$15>=$I$30	Binding	0
$B$16	Memphis Atlanta	10	$B$16>=$I$30	Not Binding	10
$C$16	Memphis Boston	0	$C$16>=$I$30	Binding	0
$D$16	Memphis Chicago	12	$D$16>=$I$30	Not Binding	12
$E$16	Memphis Denver	0	$E$16>=$I$30	Binding	0
$F$16	Memphis Omaha	0	$F$16>=$I$30	Binding	0
$G$16	Memphis Portland	0	$G$16>=$I$30	Binding	0
$B$17	Wichita Atlanta	0	$B$17>=$I$30	Binding	0
$C$17	Wichita Boston	0	$C$17>=$I$30	Binding	0
$D$17	Wichita Chicago	0	$D$17>=$I$30	Binding	0
$E$17	Wichita Denver	0	$E$17>=$I$30	Binding	0
$F$17	Wichita Omaha	0	$F$17>=$I$30	Binding	0
$G$17	Wichita Portland	0	$G$17>=$I$30	Binding	0
$B$13:$G$17=Integer					
$H$13:$H$17=Binary					

Figure A1.2: Answer report 1 - part 2.

Microsoft Excel 16.0 Answer Report
Worksheet: [group_work.xlsx]Solution - Part 2
Report Created: 06/03/2023 16:29:32
Result: Solver found an integer solution within tolerance. All Constraints are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.297 Seconds.
Iterations: 4 Subproblems: 12
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$B$19	Minimize: Atlanta	51333	51333

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$13:$H$17				
$B$13	Baltimore Atlanta	0	0	Integer
$C$13	Baltimore Boston	10	10	Integer
$D$13	Baltimore Chicago	8	8	Integer
$E$13	Baltimore Denver	0	0	Integer
$F$13	Baltimore Omaha	0	0	Integer
$G$13	Baltimore Portland	0	0	Integer
$H$13	Baltimore Xi Is plant open?	1	1	Binary
$B$14	Wyoming Atlanta	0	0	Integer
$C$14	Wyoming Boston	0	0	Integer
$D$14	Wyoming Chicago	0	0	Integer
$E$14	Wyoming Denver	6	6	Integer
$F$14	Wyoming Omaha	7	7	Integer
$G$14	Wyoming Portland	11	11	Integer
$H$14	Wyoming Xi Is plant open?	1	1	Binary
$B$15	Salt Lake City Atlanta	0	0	Integer
$C$15	Salt Lake City Boston	0	0	Integer
$D$15	Salt Lake City Chicago	0	0	Integer
$E$15	Salt Lake City Denver	0	0	Integer
$F$15	Salt Lake City Omaha	0	0	Integer
$G$15	Salt Lake City Portland	0	0	Integer
$H$15	Salt Lake City Xi Is plant open?	0	0	Binary
$B$16	Memphis Atlanta	16	16	Integer
$C$16	Memphis Boston	0	0	Integer
$D$16	Memphis Chicago	6	6	Integer
$E$16	Memphis Denver	0	0	Integer
$F$16	Memphis Omaha	0	0	Integer
$G$16	Memphis Portland	0	0	Integer
$H$16	Memphis Xi Is plant open?	1	1	Binary
$B$17	Wichita Atlanta	0	0	Integer
$C$17	Wichita Boston	0	0	Integer
$D$17	Wichita Chicago	0	0	Integer
$E$17	Wichita Denver	0	0	Integer
$F$17	Wichita Omaha	0	0	Integer
$G$17	Wichita Portland	0	0	Integer
$H$17	Wichita Xi Is plant open?	0	0	Binary

Figure A2. 1: Answer report 2 - part 1.

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$C$23:$C$27 <= $E$23:$E$27					
$C$23	Baltimore Boston	18	$C$23<=$E$23	Binding	0
$C$24	Wyoming Boston	24	$C$24<=$E$24	Binding	0
$C$25	Salt Lake City Boston	0	$C$25<=$E$25	Binding	0
$C$26	Memphis Boston	22	$C$26<=$E$26	Binding	0
$C$27	Wichita Boston	0	$C$27<=$E$27	Binding	0
$C$30:$C$35 >= $E$30:$E$35					
$C$30	Atlanta Boston	16	$C$30>=$E$30	Binding	0
$C$31	Boston Boston	10	$C$31>=$E$31	Binding	0
$C$32	Chicago Boston	14	$C$32>=$E$32	Binding	0
$C$33	Denver Boston	6	$C$33>=$E$33	Binding	0
$C$34	Omaha Boston	7	$C$34>=$E$34	Binding	0
$C$35	Portland Boston	11	$C$35>=$E$35	Binding	0
$B$13:$G$17 >= $I$30					
$B$13	Baltimore Atlanta	0	$B$13>=$I$30	Binding	0
$C$13	Baltimore Boston	10	$C$13>=$I$30	Not Binding	10
$D$13	Baltimore Chicago	8	$D$13>=$I$30	Not Binding	8
$E$13	Baltimore Denver	0	$E$13>=$I$30	Binding	0
$F$13	Baltimore Omaha	0	$F$13>=$I$30	Binding	0
$G$13	Baltimore Portland	0	$G$13>=$I$30	Binding	0
$B$14	Wyoming Atlanta	0	$B$14>=$I$30	Binding	0
$C$14	Wyoming Boston	0	$C$14>=$I$30	Binding	0
$D$14	Wyoming Chicago	0	$D$14>=$I$30	Binding	0
$E$14	Wyoming Denver	6	$E$14>=$I$30	Not Binding	6
$F$14	Wyoming Omaha	7	$F$14>=$I$30	Not Binding	7
$G$14	Wyoming Portland	11	$G$14>=$I$30	Not Binding	11
$B$15	Salt Lake City Atlanta	0	$B$15>=$I$30	Binding	0
$C$15	Salt Lake City Boston	0	$C$15>=$I$30	Binding	0
$D$15	Salt Lake City Chicago	0	$D$15>=$I$30	Binding	0
$E$15	Salt Lake City Denver	0	$E$15>=$I$30	Binding	0
$F$15	Salt Lake City Omaha	0	$F$15>=$I$30	Binding	0
$G$15	Salt Lake City Portland	0	$G$15>=$I$30	Binding	0
$B$16	Memphis Atlanta	16	$B$16>=$I$30	Not Binding	16
$C$16	Memphis Boston	0	$C$16>=$I$30	Binding	0
$D$16	Memphis Chicago	6	$D$16>=$I$30	Not Binding	6
$E$16	Memphis Denver	0	$E$16>=$I$30	Binding	0
$F$16	Memphis Omaha	0	$F$16>=$I$30	Binding	0
$G$16	Memphis Portland	0	$G$16>=$I$30	Binding	0
$B$17	Wichita Atlanta	0	$B$17>=$I$30	Binding	0
$C$17	Wichita Boston	0	$C$17>=$I$30	Binding	0
$D$17	Wichita Chicago	0	$D$17>=$I$30	Binding	0
$E$17	Wichita Denver	0	$E$17>=$I$30	Binding	0
$F$17	Wichita Omaha	0	$F$17>=$I$30	Binding	0
$G$17	Wichita Portland	0	$G$17>=$I$30	Binding	0
$B$13:$G$17=Integer					
$H$13:$H$17=Binary					

Figure A2.2: Answer report 2 - part 2.