The Potential Deployment Of Set Covering And Location-Assignment Model: The Case Of Locating Trauma Centers At The Midwest Region

Raida Abuizam, Purdue University Calumet, USA

ABSTRACT

The Midwest Trauma centers case illustrates how the application of set covering can be used in locating trauma centers in the Midwest region. It shows the students how to develop a linear programming spreadsheet model with binary variables to find the minimum number of trauma centers locations that can cover the major cities in the Midwest. Students completing the case will be able to develop a model which decides the locations of trauma centers that will maximize the total number of people covered within a certain distance. This case will present a linear programming model that will solve a set covering and location assignment problem. The application of Excel Solver and Solver Table will help students answer many what if questions. This case will also enrich students' knowledge on how to build the model entirely throughout the spreadsheet without the need to formulate the model algebraically.

Keywords: Linear Programming; Binary Variables; Integer Variables; Set Covering; Optimization

INTRODUCTION

*L*inear programming is a great quantitative technique that helps managers find optimal solutions to constrained problems. These constraints involve restrictions or limitation on scarce resources such as budgets and available material. Managers' main concern is to use the company's scarce recourses in the most economical and efficient way. Linear programming can be applied to several business problems such as identifying the optimal product mix in a factory, determining optimal schedule for employees, developing shipping plans to minimize shipping cost, identifying the optimal blends of chemicals in a refinery, and it can be used in set covering and assignment models.

One particular type of linear programming location models is called a set covering model. In a set covering model, two sets must be given. Each member of a given set (set 1) must be covered by an adequate member of another set (set 2). The objective in a set covering problem is to minimize the number of members in set 2 that are needed to cover all the members in set 1. Set covering models have been applied to areas such as airline crew scheduling, airline's hub locations, truck dispatching, capital investment, and political redistricting.

The use of binary variables and the logical constraints are the keys to solve any location-assignment model. This case study will help managers develop a linear programming spreadsheet model that will find the minimum number of trauma centers locations that can cover all cities. It will also help the students develop a model that decides the locations of trauma centers which will maximize the total number of people covered within a certain distance. The case will help students build the model entirely throughout the spreadsheet without the need to develop the model algebraically. It will also enrich the students' critical thinking skills.

CASE OVERVIEW

According to U.S Department of Health and Human Services Centers for Disease control and Prevention (CDC), nearly 45 million Americans <u>DO NOT</u> have access to a level I or II trauma centers within one hour of being injured. That is equal to the populations of Arizona, New Mexico, Texas, Louisiana, Mississippi, and Alabama combined!

A trauma center is a hospital that has additional resources and equipment to help care for severely injured patients. It is a hospital that is equipped to provide comprehensive emergency medical services to patients suffering traumatic injuries. In the United States, trauma centers can be classified as level I, II, III, IV, or V. Level 1 being the highest and level V being the lowest. To classify the level of a hospital, the hospital has to meet specific criteria established by the American College of Surgeons (ACS) and passing a site review by the Verification Review Committee.

A trauma center will often have a helideck for receiving patients that have been transported by helicopter to the hospital. In most severely injured cases, people injured in remote areas and transported to a distant trauma center by helicopter can receive faster and better medical care than if they had been transported by ground ambulance to a closer hospital that is not classified as a trauma center. According to U.S Department of Health and Human Services Centers for Disease Control and Prevention (CDC), if any person is severely injured getting care at a level I trauma center can lower his or her risk of death by 25%.

The governors of the 12 states in the Midwest region realized the necessity to build level I trauma centers that cover the need for residents in the Midwest. Since the cost to build and provide these hospitals with the additional resources and equipment needed is very high, the strategic plan suggested building the minimum number of trauma centers that can satisfy the need of the 67 million people in the Midwest. The location of these centers is crucial to help many patients survive a tragic injury because a severely injured person is highly affected by any delay to reach a trauma center. Therefore, these centers must be closer as much as possible to the maximum number of people. Table 1 lists the distances between the twelve major cities in the Midwest along with the estimate of the population of each city according to U.S census for the year 2012.

Table 1: Distances Between the 12 Major Cities in the Midwest[+] and City Population[++]

	Fargo, ND	Sioux Fall, SD	Omaha, NE	Wichita, KS	Kansas City, MO	Des Moines, IA	Minneapolis, MN	Milwaukee, WI	Chicago, IL	Indy, IN	Columbus, OH	Detroit, MI	City Population
Fargo	0	245	424	724	600	477	235	571	643	826	998	924	105,549
Sioux	245	0	186	486	363	285	236	500	572	745	919	853	153,888
Omaha	424	186	0	302	188	140	383	514	472	612	786	738	432,958
Wichita	724	486	302	0	199	392	635	765	724	680	854	961	382,368
Kansas	600	363	188	199	0	193	437	567	526	482	656	763	459,787
Des Moines	477	285	140	392	193	0	244	374	333	473	647	598	203,433
Minn.	235	236	383	635	437	244	0	337	409	592	764	689	387,753
Milwau	571	500	514	765	567	374	337	0	89	270	452	370	594,833
Chicago	643	572	472	724	526	333	409	89	0	183	356	282	2,695,598
Indy	826	745	612	680	482	473	592	270	183	0	175	287	829,712
Cloum	998	919	786	854	656	647	764	452	356	175	0	204	787,033
Detroit	924	853	738	961	763	598	689	370	282	287	204	0	713,777

[+] Source: www.mapquest.com; [++]Source: www.quickfacts.census.gov

You are hired as a consultant to develop alternative plans that can satisfy the following requirements:

1) Given the information in Table 1, how many centers are needed so that residents in all cities are within <u>300</u> miles of a trauma center? In which cities should these centers be located?

2) How your solution to requirement number 1 is affected by changing the mile limit? Hint: Use Solver Table and change the mile limit from 100 to 400 in 50 miles increment, and watch the total numbers of centers needed and their locations.

3) If a trauma center filled to capacity, a severely injured person needed to be transferred to another trauma center. If this is the case, how many centers are needed and in which cities should the centers be located in order to ensure that residents of all cities are within a distance of <u>300</u> miles of **two** trauma centers.

4) Given the populations of each city in Table 1, suppose that there is a budget to build <u>four</u> trauma centers in the Midwest region and the goal is to <u>maximize</u> the number of people within <u>200</u> miles of a trauma center. In which cities should the centers be located?

5) Given the information to requirement 4. How many more people will be covered if there was a budget to build five centers instead of four?

LEARNING OBJECTIVES

1. To develop the linear programming model completely through the spreadsheet without the need to mathematically formulate the problem.

2. To develop a linear programming model with binary variables to find the minimum number of trauma centers locations that can cover all cities.

3. To develop a linear programming model that decides the locations of trauma centers that will maximize the total number of people covered within a certain distance.

TEACHING NOTES: CASE REQUIREMENTS SOLUTION

Solution to Requirement 1

1) Inputs: Enter the mile limit in cell B2. Then enter the actual distance between cities from Table 1 in the shaded area as shown in Figure 1. Build a 0-1 matrix in cell B21:M32, with IF functions. The formula in cell B21 will be = IF (B4<= B2, 1, 0), then copy this cell to the rest of the range B21:M34 as shown in Figure 1.

2) Decision variables: Enter any trial values of 0's and 1's in the range used as trauma centers B17:M17 shaded in red border. These are the changing cells. We can name this range by going to the formulas tab, Define Name, and choosing Used as trauma center as a name.

3) City covered by trauma centers: To determine the number of trauma centers that covers each city, we can calculate the total number of trauma centers within 300 miles of Fargo, ND in cell C40 with the formula: SUMPRODUCT (Used as trauma center, B21:M21). These formulas will pick up the number of trauma centers that cover Fargo, ND. Then copy this to the entire array of trauma centered covered by range. Note that if the value in the Trauma covered by range is 2 or greater, this will indicate that a city is within 300 mile of multiple trauma centers.

4) Number of trauma centers: Calculate the total number of trauma centers used in cell B54 with the formula = Sum(Used as trauma centers).

5) Using Solver: Figure 2 presents Solver dialog box. The objective function is to minimize total numbers of trauma centers in cell B48. The changing cells are used as trauma center in the range B17:M17. The constraints are Used as trauma center (B17:M17) needed to be binary and trauma centers covered by range (C36:C47) should be greater than or equal the required range (E36:E47). Don't forget to click on Simplex LP for your solving method. Then click solve.

6) Requirement 1 solution's results: The spreadsheet model solved for a minimum of three trauma centers needed. Those three centers should be located in the following cities: Sioux Fall, Wichita, and Indianapolis.

398   *The Clute Institute*

Requirement 1 solution												
Mile limit	300											
	Fargo, ND	Sioux Fall, SD	Omaha, NE	Wichita, KS	Kansas City, M	Des Moines. IA	Minneapolis, MN	Milwaukee. WI	Chicago, IL	Indianapolis, IN	Colummus, OH	Detroit, MI	city populaion
Fargo, ND	0	245	424	724	600	477	235	571	643	826	998	924	105,549
Sioux Fall, SD	245	0	186	486	363	285	236	500	572	745	919	853	153,888
Omaha, NE	424	186	0	302	188	140	383	514	472	612	786	738	432,958
Wichita, KS	724	486	302	0	199	392	635	765	724	680	854	961	382,368
Kansas City, MO	600	363	188	199	0	193	437	567	526	482	656	763	459,787
Des Moines,IA	477	285	140	392	193	0	244	374	333	473	647	598	203,433
Minneapolis, MN	235	236	383	635	437	244	0	337	409	592	764	689	387,753
Milwaukee, WI	571	500	514	765	567	374	337	0	89	270	452	370	594,833
Chicago, IL	643	572	472	724	526	333	409	89	0	183	356	282	2,695,598
Indianapolis, IN	826	745	612	680	482	473	592	270	183	0	175	287	829,718
Columbus, OH	998	919	786	854	656	647	764	452	356	175	0	204	787,033
Detroit, MI	924	853	738	961	763	598	689	370	282	287	204	0	713,777
Used as trauma center?	0	1	0	1	0	0	0	0	0	1	0	0	
	Potential to have trauma center												
Fargo, ND	1	1	0	0	0	0	1	0	0	0	0	0	
Sioux Fall, SD	1	1	1	0	0	1	1	0	0	0	0	0	
Omaha, NE	0	1	1	0	1	1	0	0	0	0	0	0	
Wichita, KS	0	0	0	1	1	0	0	0	0	0	0	0	
Kansas City, MO	0	0	1	1	1	1	0	0	0	0	0	0	
Des Moines,IA	0	1	1	0	1	1	1	0	0	0	0	0	
Minneapolis, MN	1	1	0	0	0	1	1	0	0	0	0	0	
Milwaukee, WI	0	0	0	0	0	0	0	1	1	1	0	0	
Chicago, IL	0	0	0	0	0	0	0	1	1	1	0	1	
Indianapolis, IN	0	0	0	0	0	0	0	1	1	1	1	1	
Columbus, OH	0	0	0	0	0	0	0	0	0	1	1	1	
Detroit, MI	0	0	0	0	0	0	0	0	1	1	1	1	
Constraints that each city must be covered by at least one trauma center													
	Trauma centers covered by		Required										
Fargo, ND		1	>=	1									
Sioux Fall, SD		1	>=	1									
Omaha, NE		1	>=	1									
Wichita, KS		1	>=	1									
Kansas City, MO		1	>=	1									
Des Moines,IA		1	>=	1									
Minneapolis, MN		1	>=	1									
Milwaukee, WI		1	>=	1									
Chicago, IL		1	>=	1									
Indianapolis, IN		1	>=	1									
Columbus, OH		1	>=	1									
Detroit, MI		1	>=	1									
Total number of trauma cente	3	objective to minimize											

Figure 1: Excel Spreadsheet Solution for Requirement 1

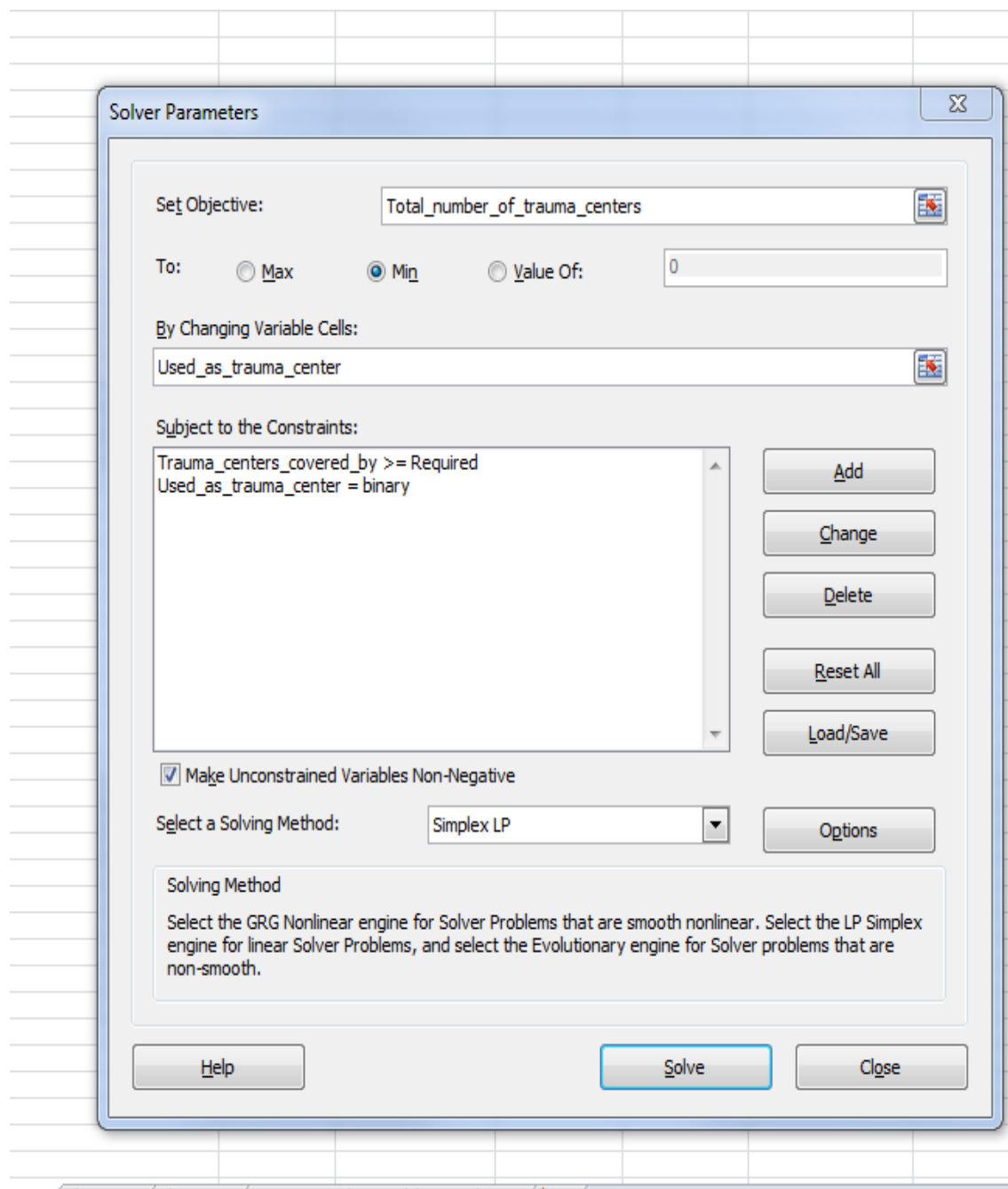   *The Clute Institute*

Figure 2: Solver Dialog Box

Solution to Requirement 2

To be able to run sensitivity analysis on the miles limit, we can use Solver Table. You need to download Solver Table by visiting (http://kelley.iu.edu/albrightbooks/Free_downloads.htm). Dr. S. Christian Albright has developed an **Excel add-Ins** called Solver Table. Solver Table allows us to ask sensitivity analysis questions about any of the input variables, not just coefficients of the objective functions and right side of the constraints and it provides straightforward answers.

400

To set up one way Solver Table, we need to have an existing Solver in the model to build on it. Click on the Solver Table Tab, and then click on run Solver. Click on the yes button that you already have an existing Solver in the model. Click OK on the one way Solver Table. To set up the parameters for Solver Table, you need to do the following: in the input cell click on the mile limit in cell B2. Set the minimum input value at 100, the maximum input value at 400, and the increment to 50. In the output cell(s), you need to highlight use as trauma centers in the range B17:M17 and total numbers of trauma centers in cell B48 as shown in Figure 3. The results of the Solver Table analysis will be posted on a different sheet on your Excel work book. Figure 4 exhibits Solver Table results.

To comment on these results: if we want the mile limit to be 100 miles instead of 300, we need to build 11 trauma centers. A center is needed to be built in all the cities except in Chicago. If we want to increase the mile limit to 200 miles, then we need to build 7 centers in the following cities: Fargo, Omaha, Kansas City, Minneapolis, Chicago, Indianapolis, and Detroit as shown in Figure 4. Figure 5 displays the sensitivity analysis chart of the number of trauma centers needed versus the mile limit input.
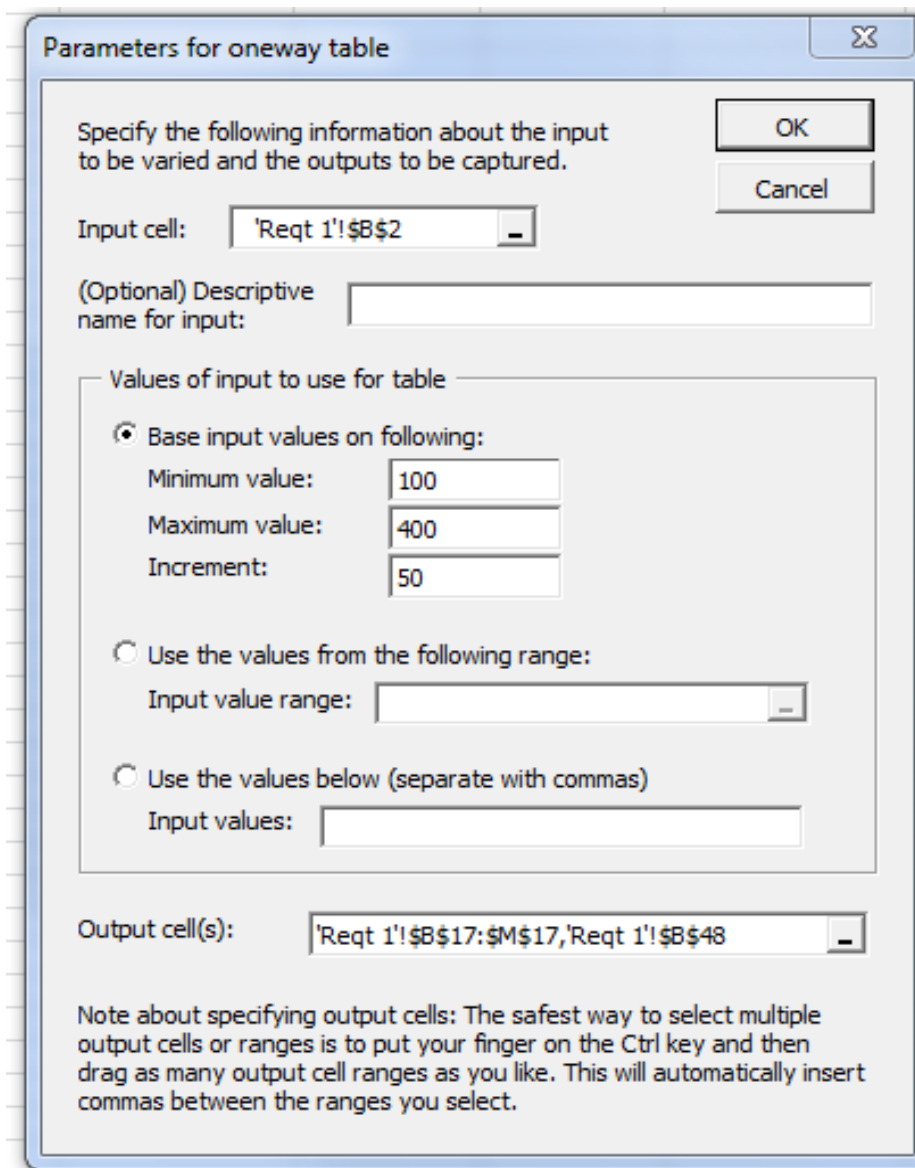

Figure 3: One Way Solver Table Parameters

Oneway analysis for Solver model in Sheet1 worksheet

Fargo, I | Sioux F | Omaha | Wichit | Kansas (| Des N | Minnea | Milwa | Chicag | Indiana | Columr | Detroit, MI

Input (cell B2) values along side, output cell(s) along top

	Used_as_trauma_center_1	Used_as_trauma_center_2	Used_as_trauma_center_3	Used_as_trauma_center_4	Used_as_trauma_center_5	Used_as_trauma_center_6	Used_as_trauma_center_7	Used_as_trauma_center_8	Used_as_trauma_center_9	Used_as_trauma_center_10	Used_as_trauma_center_11	Used_as_trauma_center_12	Total_number_of_trauma_centers
100	1	1	1	1	1	1	1	1	0	1	1	1	11
150	1	1	1	1	1	0	1	1	0	1	1	1	10
200	1	0	1	0	1	0	1	0	1	1	0	1	7
250	0	1	0	0	1	0	0	0	1	0	1	0	4
300	0	1	0	1	0	0	0	0	0	1	0	0	3
350	0	1	1	0	0	0	0	0	0	1	0	0	3
400	0	1	0	0	0	1	0	0	1	0	0	0	3

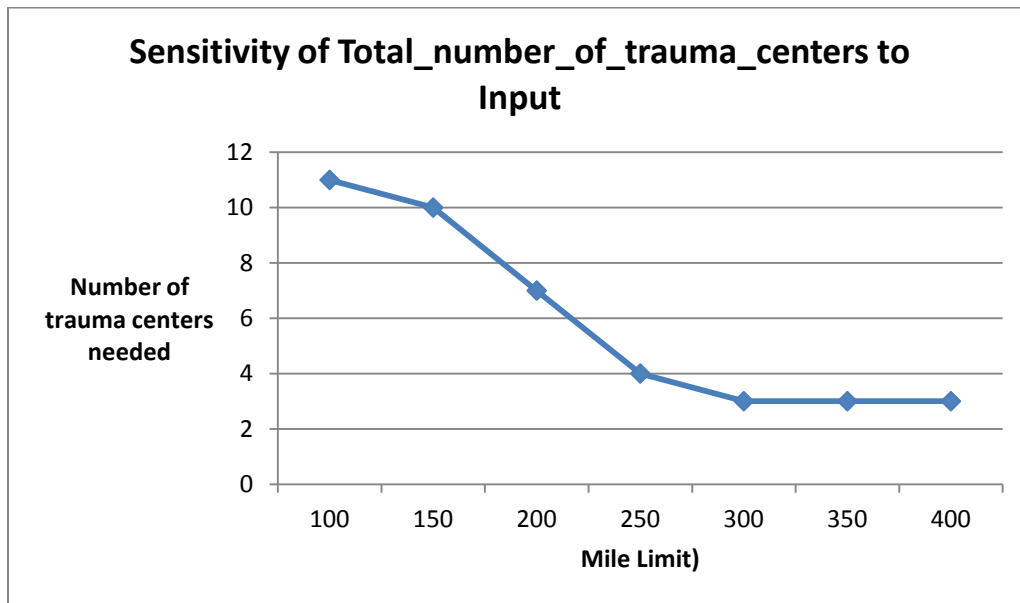**Figure 4: Solver Table Results**

Figure 5: Sensitivity Analysis Chart

Solution to Requirement 3

To solve requirement 3, we need to build on requirement 1. Requirement 3 is similar to requirement 1 except we need to change the constraint of trauma centers covered by range in cell C34:C45 to be greater than or equal the required range of 2 not 1 in the range E34:E45 as shown in Figure 6. Then open Solver and click Solve. The spreadsheet solution solved for total number of trauma centers to be 7. The location of these trauma centers will be in the following cities: Fargo, Sioux Fall, Wichita, Kansas City, Chicago, Indianapolis, and Detroit.

Requirement 3 solution													
Mile limit	300												
	Fargo, ND	Sioux Fall,	Omaha, N	Wichita,	Kansas City	Des Moin	Minneapol	Milwaukee	Chicago, IL	Indianapolis	Colummus	Detroit,	city populaion	Population 20
Fargo, ND	0	245	424	724	600	477	235	571	643	826	998	924	105,549	699,628
Sioux Fall, SD	245	0	186	486	363	285	236	500	572	745	919	853	153,888	833,354
Omaha, NE	424	186	0	302	188	140	383	514	472	612	786	738	432,958	1,855,525
Wichita, KS	724	486	302	0	199	392	635	765	724	680	854	961	382,368	2,885,905
Kansas City, MO	600	363	188	199	0	193	437	567	526	482	656	763	459,787	5,379,139
Des Moines,IA	477	285	140	392	193	0	244	374	333	473	647	598	203,433	3,074,186
Minneapolis, MN	235	236	383	635	437	244	0	337	409	592	764	689	387,753	6,021,988
Milwaukee, WI	571	500	514	765	567	374	337	0	89	270	452	370	594,833	5,726,398
Chicago, IL	643	572	472	724	526	333	409	89	0	183	356	282	2,695,598	12,875,255
Indianapolis, IN	826	745	612	680	482	473	592	270	183	0	175	287	829,718	6,537,334
Columbus, OH	998	919	786	854	656	647	764	452	356	175	0	204	787,033	11,544,225
Detroit, MI	924	853	738	961	763	598	689	370	282	287	204	0	713,777	9,883,360
														67,316,297
Used as trauma center?	1	1	0	1	1	0	0	0	1	1	0	1		
Potential to have trauma center														
Fargo, ND	1	1	0	0	0	0	1	0	0	0	0	0		
Sioux Fall, SD	1	1	1	0	0	1	1	0	0	0	0	0		
Omaha, NE	0	1	1	0	1	1	0	0	0	0	0	0		
Wichita, KS	0	0	0	1	1	0	0	0	0	0	0	0		
Kansas City, MO	0	0	1	1	1	1	0	0	0	0	0	0		
Des Moines,IA	0	1	1	0	1	1	1	0	0	0	0	0		
Minneapolis, MN	1	1	0	0	0	1	1	0	0	0	0	0		
Milwaukee, WI	0	0	0	0	0	0	0	1	1	1	0	0		
Chicago, IL	0	0	0	0	0	0	0	1	1	1	0	1		
Indianapolis, IN	0	0	0	0	0	0	0	1	1	1	1	1		
Columbus, OH	0	0	0	0	0	0	0	0	0	1	1	1		
Detroit, MI	0	0	0	0	0	0	0	0	1	1	1	1		

Constraints that each city must be covered by at least one trauma center

|	Trauma centers covered by		Required	
Fargo, ND	2	>=	2	
Sioux Fall, SD	2	>=	2	
Omaha, NE	2	>=	2	
Wichita, KS	2	>=	2	
Kansas City, MO	2	>=	2	
Des Moines,IA	2	>=	2	
Minneapolis, MN	2	>=	2	
Milwaukee, WI	2	>=	2	
Chicago, IL	3	>=	2	
Indianapolis, IN	3	>=	2	
Columbus, OH	2	>=	2	
Detroit, MI	3	>=	2	
Total number of trauma cer	7	tive to minimize		

Figure 6: Requirement 3 Solution

Solution to Requirement 4

1)   Inputs: Enter the mile limit of 200 in cell B2. Then enter the actual distance between cities from Table 1 along with the city's populations in the shaded area as shown in Figure 7. Build a 0-1 matrix in cell B20:M31, with IF functions. The formula in cell B20 will be = IF (B4<= B2, 1, 0), then copy this cell to the rest of the range B20:M31 as shown in Figure 7.

Requirement 4 solution

Mile limit	200												
	Fargo, ND	Sioux Fall, SD	Omaha, NE	Wichita, KS	Kansas City, MO	Des Moines, IA	Minneapolis, MN	Milwaukee, WI	Chicago, IL	Indianapolis, IN	Colummus, OH	Detroit, MI	city populaion
Fargo, ND	0	245	424	724	600	477	235	571	643	826	998	924	105,549
Sioux Fall, SD	245	0	186	486	363	285	236	500	572	745	919	853	153,888
Omaha, NE	424	186	0	302	188	140	383	514	472	612	786	738	432,958
Wichita, KS	724	486	302	0	199	392	635	765	724	680	854	961	382,368
Kansas City, MO	600	363	188	199	0	193	437	567	526	482	656	763	459,787
Des Moines,IA	477	285	140	392	193	0	244	374	333	473	647	598	203,433
Minneapolis, MN	235	236	383	635	437	244	0	337	409	592	764	689	387,753
Milwaukee, WI	571	500	514	765	567	374	337	0	89	270	452	370	594,833
Chicago, IL	643	572	472	724	526	333	409	89	0	183	356	282	2,695,598
Indianapolis, IN	826	745	612	680	482	473	592	270	183	0	175	287	829,718
Columbus, OH	998	919	786	854	656	647	764	452	356	175	0	204	787,033
Detroit, MI	924	853	738	961	763	598	689	370	282	287	204	0	713,777
Used as trauma cen	0	0	0	0	1	0	0	0	1	1	0	1	4 = 4

Potential to have trauma center												
Fargo, ND	1	0	0	0	0	0	0	0	0	0	0	0
Sioux Fall, SD	0	1	1	0	0	0	0	0	0	0	0	0
Omaha, NE	0	1	1	0	1	1	0	0	0	0	0	0
Wichita, KS	0	0	0	1	1	0	0	0	0	0	0	0
Kansas City, MO	0	0	1	1	1	1	0	0	0	0	0	0
Des Moines,IA	0	0	1	0	1	1	0	0	0	0	0	0
Minneapolis, MN	0	0	0	0	0	0	1	0	0	0	0	0
Milwaukee, WI	0	0	0	0	0	0	0	1	1	0	0	0
Chicago, IL	0	0	0	0	0	0	0	1	1	1	0	0
Indianapolis, IN	0	0	0	0	0	0	0	0	1	1	1	0
Columbus, OH	0	0	0	0	0	0	0	0	0	1	1	0
Detroit, MI	0	0	0	0	0	0	0	0	0	0	0	1

Constraints that each city must be covered by at least one trauma center

	Trauma centers covered by		Covered?
Fargo, ND	0	>=	0
Sioux Fall, SD	0	>=	0
Omaha, NE	1	>=	1
Wichita, KS	1	>=	1
Kansas City, MO	1	>=	1
Des Moines,IA	1	>=	1
Minneapolis, MN	0	>=	0
Milwaukee, WI	1	>=	1
Chicago, IL	2	>=	1
Indianapolis, IN	2	>=	1
Columbus, OH	1	>=	1
Detroit, MI	1	>=	1
Total number of pe	7,099,505	objective to maximize	

Figure 7: Excel Spreadsheet Solution for Requirement 4

2)   Decision variables: Enter any trial values of 0's and 1's in the range used as trauma centers B17:M17 shaded in red border, and enter any trial values of 0's and 1's in the range Covered located in cells E34:E45 shaded in red border. These are the changing cells.

3)   Name the following range B17:M17 by going to the formulas tab, Define Name, and choosing Used as trauma center as a name. You can repeat this process by naming the following ranges: E34:E45(Covered?), N4:N15 (City Population), N17(Total), O17(required), C34:C45 (Trauma centers covered by), and B46 (Total number of people covered).

4)   City covered by trauma centers: To determine the number of trauma centers that covers each city, we can calculate the total number of trauma centers within 200 miles of Fargo, ND in cell C34 with the formula: SUMPRODUCT (Used as trauma center, B20:M20). These formulas will pick up the number of trauma centers that cover Fargo, ND. Then copy this to the entire array of Trauma centers covered by range. Note that if the value in the Trauma covered by range is 2 or greater, this will indicate that a city is within 200 mile of multiple trauma centers.

5)   Number of trauma centers: Calculate the total number of trauma centers used in cell N17 with the formula = Sum(Used as trauma centers)

6)   Calculate total number of people covered in cell B46 using this formula: = SUMPRODUCT(City Population, Covered). This cell represents the objective function cell that the model will maximize.

7)   Using Solver: Figure 8 presents Solver dialog box. The objective function is to maximize total numbers of people covered in cell B46. The changing cells are used as trauma center in the range B17:M17, and covered in the range E34:E45. The constraints are Used as trauma center (B17:M17) needed to be binary, trauma centers covered by range (C34:C45) should be greater than or equal the required range covered in (E34:E45), the sum of used as trauma center should be equal to 4, and the range covered in cells E34:E45 needed to be binary. Don't forget to click on Simplex LP for your solving method. Then click solve.
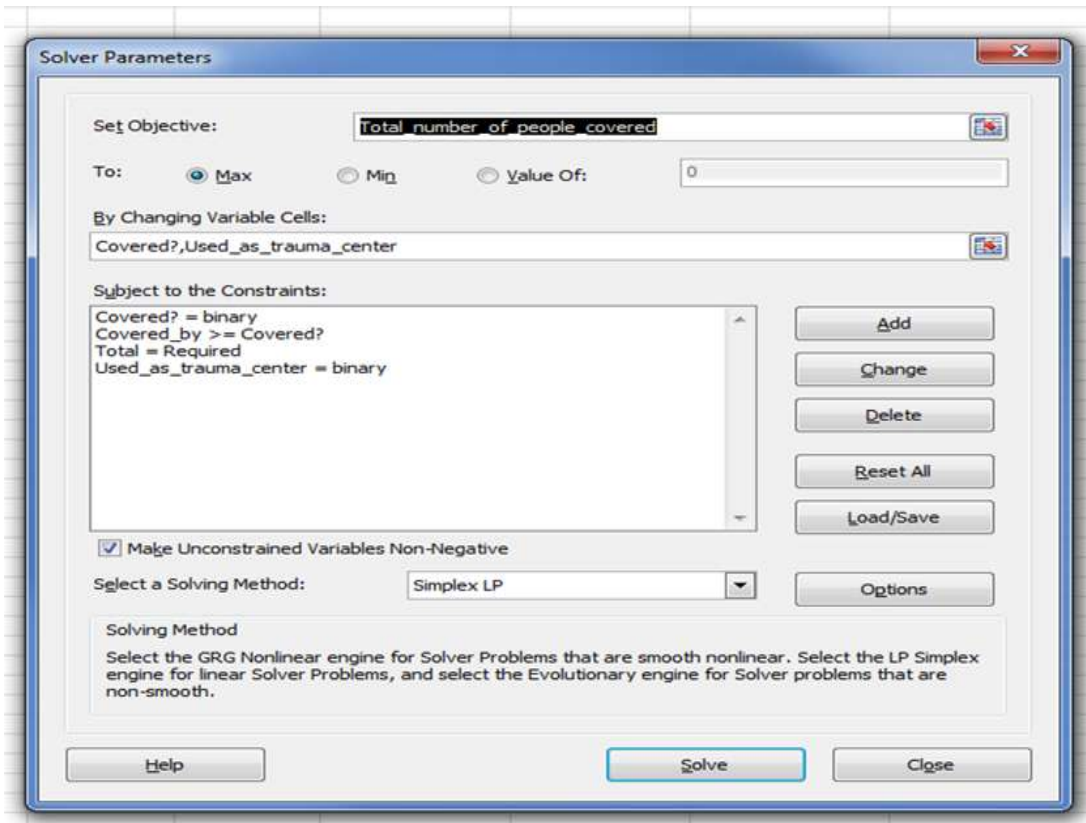
Figure 8: Solver Dialog Box for Requirement 4

405

8)   Requirement 4 solution's results: The spreadsheet model solved for a maximum of total number of peopled covered to be 7,099,505. The four centers should be located in the following cities: Kansas City, Chicago, Indianapolis, and Detroit as shown in Figure 7.

Solution to Requirement 5

We need to modify the Excel spreadsheet model in requirement 4 and change the required cell in O17 to be five. Also we need to calculate the difference in cell B47 using the formula = B46-7,099,505. Then we need to open solver keeping everything as is and click solve. The solution is shown in Figure 9. The solution stated that the location of these five centers will as follows: Kansas City, Minneapolis, Chicago, Indianapolis, and Detroit. By adding one more center this will increase the coverage by 387,753 people.

Requirement 5 solution														
Mile limit	200													
	Fargo, ND	Sioux Fal	Omaha,	Wichita	Kansas C	Des Mo	Minneap	Milwauk	Chicago	Indianap	Columm	Detroit	city populaion	
Fargo, ND	0	245	424	724	600	477	235	571	643	826	998	924	105,549	
Sioux Fall, SD	245	0	186	486	363	285	236	500	572	745	919	853	153,888	
Omaha, NE	424	186	0	302	188	140	383	514	472	612	786	738	432,958	
Wichita, KS	724	486	302	0	199	392	635	765	724	680	854	961	382,368	
Kansas City, MO	600	363	188	199	0	193	437	567	526	482	656	763	459,787	
Des Moines,IA	477	285	140	392	193	0	244	374	333	473	647	598	203,433	
Minneapolis, MN	235	236	383	635	437	244	0	337	409	592	764	689	387,753	
Milwaukee, WI	571	500	514	765	567	374	337	0	89	270	452	370	594,833	
Chicago, IL	643	572	472	724	526	333	409	89	0	183	356	282	2,695,598	
Indianapolis, IN	826	745	612	680	482	473	592	270	183	0	175	287	829,718	
Columbus, OH	998	919	786	854	656	647	764	452	356	175	0	204	787,033	
Detroit, MI	924	853	738	961	763	598	689	370	282	287	204	0	713,777	
													Total	Req'd
Used as trauma ce	0	0	0	0	1	0	1	0	1	1	0	1	5	=	5
		Potential to have trauma center												
Fargo, ND	1	0	0	0	0	0	0	0	0	0	0	0		
Sioux Fall, SD	0	1	1	0	0	0	0	0	0	0	0	0		
Omaha, NE	0	1	1	0	1	1	0	0	0	0	0	0		
Wichita, KS	0	0	0	1	1	0	0	0	0	0	0	0		
Kansas City, MO	0	0	1	1	1	1	0	0	0	0	0	0		
Des Moines,IA	0	0	1	0	1	1	0	0	0	0	0	0		
Minneapolis, MN	0	0	0	0	0	0	1	0	0	0	0	0		
Milwaukee, WI	0	0	0	0	0	0	0	1	1	0	0	0		
Chicago, IL	0	0	0	0	0	0	0	1	1	1	0	0		
Indianapolis, IN	0	0	0	0	0	0	0	0	1	1	1	0		
Columbus, OH	0	0	0	0	0	0	0	0	0	1	1	0		
Detroit, MI	0	0	0	0	0	0	0	0	0	0	0	1		

Constraints that each city must be covered by at least one trauma center			
	Trauma centers covered by		Covered?
Fargo, ND	0	>=	0
Sioux Fall, SD	0	>=	0
Omaha, NE	1	>=	1
Wichita, KS	1	>=	1
Kansas City, MO	1	>=	1
Des Moines,IA	1	>=	1
Minneapolis, MN	1	>=	1
Milwaukee, WI	1	>=	1
Chicago, IL	2	>=	1
Indianapolis, IN	2	>=	1
Columbus, OH	1	>=	1
Detroit, MI	1	>=	1

objective to maximize	
people covered	7,487,258
Difference	387.753

Figure 9: Requirement 5 Spreadsheet Solution

CONCLUSION

The main objective of this case analysis is to enhance students' critical and logical thinking abilities. It also strengthen their spreadsheet modeling skills. In this case, students will apply one type of linear programming location model called set covering. The objective in a set covering problem is to minimize the number of members in set 2 that are needed to cover all the members in set 1. Set covering application can be used in several areas such as airlines industry, political redistricting, capital investments and truck dispatching. Students will also learn how to apply Excel Solver and Solver Table to answer many what if questions. This case will also enrich students' knowledge on how to build the model entirely throughout the spreadsheet without the need to formulate the model algebraically.

AUTHOR INFORMATION

Raida Abuizam is an Associate Professor of Operations Management in the Department of Management Information Systems, Finance, and Business Analytics at Purdue University Calumet, Hammond Indiana, USA. She has a Ph.D. from Illinois Institute of Technology in Management Science/Operations Management. She joined the faculty at Purdue University Calumet in the Fall of 1999. Dr. Abuizam's expertise is in the areas of quantitative methods, operations management, and management science. She is teaching the quantitative courses such as fundamental managerial statistics, operations management, business analytics, decision analytics, and supply chain management. Her academic research focuses on the area of applied management science and decision making such as forecasting, decision making under uncertainty, supply chain management, and inventory control. E-mail: abuizam@purduecal.edu

SUGGESTED REFERENCES

1. Albright, S. C., & Winston, W. L. (2009). *Practical management science.* Revised third edition. Mason, Ohio: South-Western Cengage Learning.
2. Albright, S. C., & Winston, W. L. (2009). *Spreadsheet modeling and applications.* Belmont, California: Thompson/Brooks Cole.
3. MapQuest Maps - Driving Directions - Map. (n.d.). *MapQuest maps - driving directions - map*. Retrieved October 6, 2013 from http://www.mapquest.com/#c27eeb8ec2c476d57d3f7389
4. Midwest City (city) QuickFacts from the US Census Bureau. (n.d.). *Midwest City (city) QuickFacts from the US Census Bureau*. Retrieved October 6, 2013 from http://quickfacts.census.gov/qfd/states/40/4048350.html
5. Ragsdale, T. C. (2004). *Spreadsheet modeling & decision analysis: A practical introduction to management science.* Fourth edition, Mason, Ohio: Thomson South-Western.
6. Stevenson, J. W. (2009). *Operations management*. Tenth Edition. New York, New York: McGraw-Hill Irwin.

<u>**NOTES**</u>

408