

8. a. Let $x_i = \begin{cases} 1 & \text{if investment alternative } i \text{ is selected} \\ 0 & \text{otherwise} \end{cases}$

$$\begin{aligned}
 &\max \quad 4000x_1 + 6000x_2 + 10500x_3 + 4000x_4 + 8000x_5 + 3000x_6 \\
 &\text{s.t.} \\
 &\quad 3000x_1 + 2500x_2 + 6000x_3 + 2000x_4 + 5000x_5 + 1000x_6 \leq 10,500 \\
 &\quad 1000x_1 + 3500x_2 + 4000x_3 + 1500x_4 + 1000x_5 + 500x_6 \leq 7,000 \\
 &\quad 4000x_1 + 3500x_2 + 5000x_3 + 1800x_4 + 4000x_5 + 900x_6 \leq 8,750 \\
 &\quad x_1, x_2, x_3, x_4, x_5, x_6 = 0, 1
 \end{aligned}$$

The optimal solution is

$$\begin{aligned}
 x_3 &= 1 \\
 x_4 &= 1 \\
 x_6 &= 1
 \end{aligned}$$

Value = 17,500

- b. The following mutually exclusive constraint must be added to the model.

$$x_1 + x_2 \leq 1 \quad \text{No change in optimal solution.}$$

- c. The following co-requisite constraint must be added to the model in b.

$$x_3 - x_4 = 0. \quad \text{No change in optimal solution.}$$

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15. a. Let $x_i = \begin{cases} 1 & \text{if a principal place of business in county } i \\ 0 & \text{otherwise} \end{cases}$

$$y_i = \begin{cases} 1 & \text{if county } i \text{ is not served} \\ 0 & \text{if county } i \text{ is served} \end{cases}$$

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The objective function for an integer programming model calls for minimizing the population not served.

$$\min 195y_1 + 96y_2 + \dots + 173y_{15}$$

There are 13 constraints needed; each is written so that y_i will be forced to equal one whenever it is not possible to do business in county i .

$$\text{Constraint 1: } x_1 + x_2 + x_3 + y_1 \geq 1$$

$$\text{Constraint 2: } x_1 + x_2 + x_3 + x_4 + x_6 + x_7 + y_2 \geq 1$$

$$\begin{array}{ccccccc} \bullet & & & & \bullet & & \bullet \\ \bullet & & & & \bullet & & \bullet \\ \bullet & & & & \bullet & & \bullet \end{array}$$

$$\text{Constraint 13: } x_{11} + x_{12} + x_{13} + y_{13} \geq 1$$

One more constraint must be added to reflect the requirement that only one principal place of business may be established.

$$x_1 + x_2 + \dots + x_{13} = 1$$

The optimal solution has a principal place of business in County 11 with an optimal value of 739,000. A population of 739,000 cannot be served by this solution. Counties 1-5 and 10 will not be served.

- b. The only change necessary in the integer programming model for part a is that the right-hand side of the last constraint is increased from 1 to 2.

$$x_1 + x_2 + \dots + x_{13} = 2.$$

The optimal solution has principal places of business in counties 3 and 11 with an optimal value of 76,000. Only County 10 with a population of 76,000 is not served.

- c. It is not the best location if only one principal place of business can be established; 1,058,000 customers in the region cannot be served. However, 642,000 can be served and if there is no opportunity to obtain a principal place of business in County 11, this may be a good start. Perhaps later there will be an opportunity in County 11.

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