Assignment 4

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#Question

Consider the problem from a previous assignment. The Weigelt Corporation has three branch plants with excess production capacity. Fortunately, the corporation has a new product ready to begin production, and all three plants have this capability, so some of the excess capacity can be used in this way. This product can be made in three sizes–large, medium, and small–that yield a net unit profit of $420, $360, and $300, respectively. Plants 1, 2, and 3 have the excess capacity to produce 750, 900, and 450 units per day of this product, respectively, regardless of the size or combination of sizes involved. The amount of available in-process storage space also imposes a limitation on the production rates of the new product. Plants 1, 2, and 3 have 13,000, 12,000, and 5,000 square feet, respectively, of in-process storage space available for a day's production of this product. Each unit of the large, medium, and small sizes produced per day requires 20, 15, and 12 square feet, respectively. Sales forecasts indicate that if available, 900, 1,200, and 750 units of the large, medium, and small sizes, respectively, would be sold per day. At each plant, some employees will need to be laid off unless most of the plant's excess production capacity can be used to produce the new product. To avoid layoffs if possible, management has decided that the plants should use the same percentage of their excess capacity to produce the new product. Management wishes to know how much of each of the sizes should be produced by each of the plants to maximize profit. Solve the problem using lpsolve, or any other equivalent library in R.

A. Define the decision variables.

The number of units of the new product, regardless of size, that should be produced on each plant to maximize the profit of the Weigelt corporation.

Note: X= number of units produced on each plant,

i.e., i = 1 (Plant 1), 2 (Plant 2), 3 (Plant 3). L, M and S = Product's Size

Where L = large, M = medium, S = small.

Decision Variables:

Number of Large sized items produced on plant 1

$$XL_1$$

Number of Medium sized items produced on plant 2

$$XM_2$$

Number of Small sized items produced on plant 3

$$XS_3$$

B. Formulate a Linear Programming for this Problem:

Number of Large sized items produced on plant i

$$XL_i$$

Number of Medium sized items produced on plant i

$$XM_i$$

Number of Small sized items produced on plant i

$$XS_i$$

Where i = 1 (Plant 1), 2 (Plant 2), 3 (Plant 3).

Maximized Profit: z=maximized profit

$$Z = 420(XL_1 + XL_2 + XL_3) + 360(XM_1 + XM_2 + XM_3) + 300(XS_1 + XS_2 + XS_3)$$

Constraints:

Total number of size’s units produced regardless the plant:

$$L = XL_1 + XL_2 + XL_3$$

$$M = XM_1 + XM_2 + XM_3$$

$$S = XS_1 + XS_2 + XS_3$$

Production Capacity per unit by plant each day i.e.,

$$Plant1 = XL_1 + XM_1 + XS_1 \leq 750$$

$$Plant2 = XL_2 + XM_2 + XS_2 \leq 900$$

$$Plant3 = XL_3 + XM_3 + XS_3 \leq 450$$

Storage capacity per unit by plant each day:

$$Plant1 = 20XL_1 + 15XM_1 + 12XS_1 \leq 13000$$

$$Plant2 = 20XL_2 + 15XM_2 + 12XS_2 \leq 12000$$

$$Plant3 = 20XL_3 + 15XM_3 + 12XS_3 \leq 5000$$

Sales forecast per day:

$$L = XL_1 + XL_2 + XL_3 \leq 900$$

$$M = XM_1 + XM_2 + XM_3 \leq 1200$$

$$S = XS_1 + XS_2 + XS_3 \leq 750$$

The Plants always utilize the same % of their excess capacity to produce the new product.

$$XL_1 + XM_1 + XS_1/750 = XL_2 + XM_2 + XS_2/900 = XL_3 + XM_3 + XS_3/450$$

#Solving the lp problem using R

```
#Installing and Loading libraries
library(lpSolve)
library(tinytex)

# Setting up the objective function
fun_objective <- c(420, 360, 300,420, 360, 300,420, 360, 300)
fun_objective

## [1] 420 360 300 420 360 300 420 360 300

# Setting up the Left Hand Side of constraint matrix
const_matrix <- matrix(c(1, 1, 1, 0, 0, 0, 0, 0, 0,
                        0, 0, 0, 1, 1, 1, 0 ,0, 0,
                        0, 0, 0, 0, 0, 0, 1, 1, 1,
                        20, 15, 12, 0, 0, 0, 0, 0, 0,
                        0, 0, 0, 20, 15, 12, 0, 0, 0,
                        0, 0, 0, 0, 0, 0, 20, 15, 12,
                        1, 0, 0, 1, 0, 0, 1, 0, 0,
                        0, 1, 0, 0, 1, 0, 0, 1, 0,
                        0, 0, 1, 0, 0, 1, 0, 0, 1,
                        900, 900, 900, -750, -750, -750, 0, 0, 0,
                        0, 0, 0, 450, 450, 450, -900, -900, -900,
                        450, 450, 450, 0, 0, 0, -750, -750, -750), nrow = 12,
byrow = TRUE)
const_matrix

##       [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
##  [1,]    1    1    1    0    0    0    0    0    0
##  [2,]    0    0    0    1    1    1    0    0    0
##  [3,]    0    0    0    0    0    0    1    1    1
##  [4,]   20   15   12    0    0    0    0    0    0
##  [5,]    0    0    0   20   15   12    0    0    0
##  [6,]    0    0    0    0    0    0   20   15   12
##  [7,]    1    0    0    1    0    0    1    0    0
##  [8,]    0    1    0    0    1    0    0    1    0
##  [9,]    0    0    1    0    0    1    0    0    1
## [10,]  900  900  900 -750 -750 -750    0    0    0
## [11,]    0    0    0  450  450  450 -900 -900 -900
## [12,]  450  450  450    0    0    0 -750 -750 -750

#Setting up the Right Hand Side coefficients
fun_rhs <- c(750,
             900,
             450,
```

```r
                 13000,
                 12000,
                 5000,
                 900,
                 1200,
                 750,
                 0,
                 0,
                 0)
fun_rhs
```

```
##  [1]   750   900   450 13000 12000  5000   900  1200   750     0     0
0
```

```r
# Setting the unequality signs
fun_dir <- c("<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "=",
              "=",
              "=")
fun_dir
```

```
##  [1] "<=" "<=" "<=" "<=" "<=" "<=" "<=" "<=" "<=" "="  "="  "="
```

```r
# Set up the final lp problem
lp("max",fun_objective, const_matrix, fun_dir, fun_rhs)
```

```
## Success: the objective function is 696000
```

```r
# To get the solution of the lp problem
lp("max", fun_objective, const_matrix, fun_dir, fun_rhs)$solution
```

```
## [1] 516.6667 177.7778   0.0000   0.0000 666.6667 166.6667   0.0000
0.0000
## [9] 416.6667
```