Qmm_Assignment_1

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#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.

#a. Define the decision variables

#The decision variables are the number of units of the new product, regardless its size, that should be produced on each plant to maximize the company's profit.

#Note:

#X_i = means the number of units produced on each plant, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3)

#L, M, and S = means the product's size, where L = large, M = medium, and S = small.

#The decision variables are:

#X_iL = number of large items produced on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#X_iM = number of medium items produced on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#X_iS = number of small items produced on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#b. Formulate a linear programming model for this problem.

#Let

#X_iL = number of large items produced on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#X_iM = number of medium items produced on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#X_iS = number of small items produced on on plant i, where i= 1 (Plant 1), 2 (Plant 2), and 3 (Plant 3).

#Maximize profit

#$Z = 420\ (X_1L + X_2L + X_3L) + 360\ (X_1M + X_2M + X_3M) + 300\ (X_1S + X_2S + X_3S)$ #Constraints:

#Total number of size's units produced regardless the plant:

#$L = X_1L + X_2L + X_3L$

#$M = X_1M + X_2M + X_3M$

#$S = X_1S + X_2S + X_3S$ #Production capacity per unit by plant each day:

#Plant $1 = X_1L + X_1M + X_1S$ 750

#Plant $2 = X_2L + X_2M + X_2S$ 900

#Plant $3 = X_3L + X_3M + X_3S$ 450 #Storage capacity per unit by plant each day: #Plant $1 = 20X_1L + 15X_1M + 12X_1S$ 13000

#Plant $2 = 20X_2L + 15X_2M + 12X_2S$ 12000

#Plant $3 = 20X_3L + 15X_3M + 12X_3S$ 5000

#Sales forecast per day:

#$L = X_1L + X_2L + X_3L$ 900

#$M = X_1M + X_2M + X_3M$ 1200

#$S = X_1S + X_2S + X_3S$ 750 #The plants should use the same percentage of their excess capacity to produce the new product.

#$\frac{X_1L + X_1M + X_1S}{750} = \frac{X_2L + X_2M + X_2S}{900} = \frac{X_3L + X_3M + X_3S}{450}$

#It can be simplified as: #a) $900(X_1L + X_1M + X_1S) - 750(X_2L + X_2M + X_2S) = 0$

#b) $450(X_2L + X_2M + X_2S) - 900(X_3L + X_3M + X_3S) = 0$

#c) $450(X_1L + X_1M + X_1S) - 750(X_3L + X_3M + X_3S) = 0$

#All values must be greater or equal to zero

#L, M, and $S \geq 0$

#X_iL, X_iM, and $X_iS \geq 0$

#——————SOLUTION USING R————————

```r
# Import the lpSolve package.
library(lpSolve)
```

```
## Warning: package 'lpSolve' was built under R version 4.1.3
```

```r
# Setting coefficients of the objective function assignment_objfunc
assignment_objfunc <- c(420, 420, 420,
                360, 360, 360,
                300, 300, 300)
# Setting the left hand side of the problem's constraints as assignment_leftconst
assignment_leftconst <- 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,
```

```r
                        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)
# Setting the right hand side of the problem's constraints as assignment_rightconst
assignment_rightconst <- c(750,
                 900,
                 450,
                 13000,
                 12000,
                 5000,
                 900,
                 1200,
                 750,
                 0,
                 0,
                 0)


# Setting the unequality signs as assignment_uneqsigns
assignment_uneqsigns <- c("<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "<=",
              "=",
              "=",
              "=")
# Set up the final lp problem
lp("max", assignment_objfunc, assignment_leftconst, assignment_uneqsigns, assignment_rightconst)
```

```
## Success: the objective function is 716666.7
```

```r
# To get the solution of the lp problem
lp("max", assignment_objfunc, assignment_leftconst, assignment_uneqsigns, assignment_rightconst)$soluti
```

```
## [1]   0.0000 694.4444   0.0000   0.0000 500.0000 333.3333   0.0000   0.0000
## [9] 416.6667
```