Assignment - Solving LP with R

Raghu Manusanipalli

2023-09-23

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.

```r
data= matrix(c('Lx1', 'Mx1', 'Sx1','Lx2', 'Mx2', 'Sx2','Lx3', 'Mx3', 'Sx3') , ncol=3, byrow=TRUE)

#specify the column names and row names of matrix
colnames(data) = c('Large','Medium','Small')
rownames(data) <- c('Plant1','Plant2','Plant3')

# assign to table
final=as.table(data)

# display
final
```

```
##        Large Medium Small
## Plant1 Lx1   Mx1    Sx1
## Plant2 Lx2   Mx2    Sx2
## Plant3 Lx3   Mx3    Sx3
```

Assume

Production of plant 1 (Large)

$$= Lx1$$

Production of plant 1 (Medium)

$$= Mx1$$

Production of plant 1 (Small)

$$= Sx1$$

Production of plant 2 (Large)

$$= Lx2$$

Production of plant 2 (Medium)

$$= Mx2$$

Production of plant 2 (Small)

$$= Sx2$$

Production of plant 3 (Large)

$$= Lx3$$

Production of plant 3 (Medium)

$$= Mx3$$

Production of plant 3 (Small)

$$= Sx3$$

(a) Decision variables are

$$= Lx1, Mx1, Sx1, Lx2, Mx2, Sx2, Lx3, Mx3 \ \ and \ \ Sx3$$

(b) LP Model is

$$Maximize \quad Z = 420Lx1 + 360Mx1 + 300Sx1 + 420Lx2 + 360Mx2 + 300Sx2 + 420Lx3 + 360Mx3 + 300Sx3$$

Such that

Storage constraint -

$$20Lx1 + 15Mx1 + 12Sx1 \leq 13000$$
$$20Lx2 + 15Mx2 + 12Sx2 \leq 12000$$
$$20Lx3 + 15Mx3 + 12Sx3 \leq 5000$$

Production Capacity constraint -

$$Lx1 + Mx1 + Sx1 \leq 750$$
$$Lx2 + Mx2 + Sx2 \leq 900$$
$$Lx3 + Mx3 + Sx3 \leq 450$$

Sales forecast constraint -

$$Lx1 + Mx1 + Sx1 \leq 900$$
$$Lx2 + Mx2 + Sx2 \leq 1200$$
$$Lx3 + Mx3 + Sx3 \leq 750$$

Percentage constraint -

Assume,

A1 = Lx1 + Mx1 + Sx1

A2 = Lx2 + Mx2 + Sx2

A3 = Lx3 + Mx3 + Sx3

$$(A1/750) * 100 = (A2/900) * 100 = (A3/450) * 100$$

Non-negativity of decision variables -

$$(Lx1, Mx1, Sx1, Lx2, Mx2, Sx2, Lx3, Mx3 \ \ and \ \ Sx3) \geq 0$$

Solving the LP model problem

```
#install.packages("lpSolve")
library(lpSolve)
```

Setting objective function

```
f.obj<-c(420,360,300,420,360,300,420,360,300)
```

Set constraint matrix

```
f.con<-matrix(c(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,
                1,1,1,0,0,0,0,0,0,
                0,0,0,1,1,1,0,0,0,
                0,0,0,0,0,0,1,1,1,
                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),ncol=9, byrow=TRUE)
f.con
```

```
##       [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
##  [1,]   20   15   12    0    0    0    0    0    0
##  [2,]    0    0    0   20   15   12    0    0    0
##  [3,]    0    0    0    0    0    0   20   15   12
##  [4,]    1    1    1    0    0    0    0    0    0
##  [5,]    0    0    0    1    1    1    0    0    0
##  [6,]    0    0    0    0    0    0    1    1    1
##  [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
```

Set inequality signs

```
f.dir<-c("<=","<=","<=","<=","<=","<=","<=","<=","<=","=","=","=")
f.dir
```

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

Set right hand side coefficients

```
f.rhs<-c(13000,12000,5000,750,900,450,900,1200,750,0,0,0)
f.rhs
```

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

Get the value of objective function

```
lp("max",f.obj,f.con,f.dir,f.rhs)
```

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

Get the value of the decision variables

```
lp("max", f.obj,f.con,f.dir,f.rhs)$solution
```

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