Assignment-2 QMM

DURGA PRASAD GANDI

2023-09-24

Problem

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 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.

LP Model

Create table

```r
Industries = matrix(c(750, 13000, 900, 12000, 450, 5000), byrow = TRUE, nrow
=3)

colnames(Industries) = c("Capacity", "Square_feet")

rownames(Industries) = c("Plant1", "Plant2", "Plant3")

Result1= as.table(Industries)

Result1

##        Capacity Square_feet
## Plant1      750       13000
## Plant2      900       12000
## Plant3      450        5000
```

```
Z = matrix(c( 20, 900, "$420", 15, 1200, "$360", 12, 750, "$900"), byrow=
TRUE, nrow = 3)

colnames(Z) = c("Square_feet", "Sales", "Profit")

rownames(Z) = c("Large", "Medium", "Small")

Result2 = as.table(Z)

Result2

##        Square_feet Sales Profit
## Large  20          900   $420
## Medium 15          1200  $360
## Small  12          750   $900
```

Define the decision variables

The Weigelt Corporation has three types of plant.

The dimensions for the products are Large, Medium and Small that are produced in respective plants.

Considering that, the no.of Large size products in plant 1 = $F1_L$

Assume number of Medium size products in plant 1 = $F1_M$

Assume number of Small size products in plant 1 = $F1_S$

Assume number of Large size products in plant 2 = $F2_L$

Assume number of Medium size products in plant 2 = $F2_M$

Assume number of Small size products in plant 2 = $F2_S$

Assume number of Large size products in plant 3 = $F3_L$

Assume number of Medium size products in plant 3 = $F3_M$

Assume number of Small size products in plant 3 = $F3_S$

The Decision Variable are:

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S$$

Objective Function

The maximum quantity of each size to be produced by the individual plants to increase revenue:

$$MaxZ = 420(F1_L + F2_L + F3_L) + 360(F1_M + F2_M + F3_M) + 300(F1_S + F2_S + F3_S)$$

Constraints

Capacity Constraints:

Capacity constraint for plant1 : $F1_L + F1_M + F1_S <= 750$

Capacity constraint for plant2 : $F2_L + F2_M + F2_S <= 900$

Capacity constraint for plant3 : $F3_L + F3_M + F3_S <= 450$

Storage Constraints:

Storage constraint for plant1 : $20F1_L + 15F1_M + 12F1_S <= 13000$

Storage constraint for plant2 : $20F2_L + 15F2_M + 12F2_S <= 12000$

Storage constraint for plant3 : $20F3_L + 15F3_M + 12F3_S <= 5000$

Sales Constraint:

Sales constraint of product produced in Large size :

$$F1_L + F2_L + F3_L <= 900$$

Sales constraint of product produced in Medium size :

$$F1_M + F2_M + F3_M <= 1200$$

Sales constraint of product produced in Small size :

$$F1_S + F2_S + F3_S <= 750$$

Same capacity constraints:

To generate the new product ,the plants should utilize the same proportion of their surplus capacity according to the management:

$$F1_L + F1_M + F1_S/750 = F2_L + F2_M + F2_S/900 = F3_L + F3_M + F3_S/450$$

Non negativity of variable:

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S >= 0$$

Mathematical Model for the LP problem

Objective Function

$$MaxZ = 420(F1_L + F2_L + F3_L) + 360(F1_M + F2_M + F3_M) + 300(F1_S + F2_S + F3_S)$$

Decision variable

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S$$

Capacity Constraints

$$F1_L + F1_M + F1_S <= 750$$

$$F2_L + F2_M + F2_S <= 900$$

$$F3_L + F3_M + F3_S <= 450$$

Storage Constraints

$$20F1_L + 15F1_M + 12F1_S <= 13000$$

$$20F2_L + 15F2_M + 12F2_S <= 12000$$

$$20F3_L + 15F3_M + 12F3_S <= 5000$$

Sales Constraint

$$F1_L + F2_L + F3_L <= 900$$

$$F1_M + F2_M + F3_M <= 1200$$

$$F1_S + F2_S + F3_S <= 750$$

Same capacity constraint

$$F1_L + F1_M + F1_S/750 = F2_L + F2_M + F2_S/900 = F3_L + F3_M + F3_S/450$$

Non negativity of variable

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S >= 0$$

LP Model in R

Using Installed Library

```
library(lpSolve)
```

The maximum quantity of each size to be produced by the individual plants to increase revenue:

$$MaxZ = 420(F1_L + F2_L + F3_L) + 360(F1_M + F2_M + F3_M) + 300(F1_S + F2_S + F3_S)$$

```
v_Obj<-c(420,360,300,420,360,300,420,360,300)
```

Creating matrix for Constraints

```
v_con <-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), nrow = 9, byrow = TRUE)
```

Adding Direction values of constraints

```
v_dir <-c("<=",
          "<=",
          "<=",
          "<=",
          "<=",
          "<=",
          "<=",
          "<=",
          "<=")
```

Adding values of constraints

```
v_rhs <-c(750,
          900,
          450,
          13000,
          12000,
          5000,
          900,
          1200,
          750)
```

Objective Function

```
lp("max", v_Obj, v_con, v_dir, v_rhs)

## Success: the objective function is 708000
```

Solution

```
lp("max", v_Obj, v_con, v_dir, v_rhs)$solution

## [1] 350.0000 400.0000   0.0000   0.0000 400.0000 500.0000   0.0000
133.3333
## [9] 250.0000
```