

BA64018_Assignment2

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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 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 `lp_solve`, or any other equivalent library in R.

LP Model

This represents data in the table format.

```
data_plant = matrix(c(750,13000,
                      900,12000,
                      450,5000), ncol=2, byrow = TRUE)

colnames(data_plant) = c('Capacity', 'Square Feet')
rownames(data_plant) = c('P1', 'P2', 'P3')

final_plant = as.table(data_plant)

print(final_plant)
```

##	Capacity	Square Feet
## P1	750	13000
## P2	900	12000
## P3	450	5000

```

data_size = matrix(c(20,900,'$420',
                    15,1200,'360',
                    12,750,'$900'), ncol=3, byrow = TRUE)

colnames(data_size) = c('Square Feet', 'Sales', 'Profit')
rownames(data_size) = c('Large', 'Medium', 'Small')

final_size = as.table(data_size)

print(final_size)

```

```

##           Square Feet Sales Profit
## Large    20           900   $420
## Medium   15          1200   360
## Small    12           750   $900

```

Decision Variable

Let us assume, $p1_l$, $p1_m$, $p1_s$ for plant 1, $p2_l$, $p2_m$, $p2_s$ for plant 2, and $p3_l$, $p3_m$, $p3_s$ for plant 3.

Objective Function

Objective for Weigelt Corporation is to increase profits. So, all large units in all plants are making 420 Dollars profit, all medium units in all plants are making 360 Dollars profit, and all small units in all plants are making 300 Dollars profit

Objective function for Weigelt Corporation:

$$Z = 420(p1_l + p2_l + p3_l) + 360(p1_m + p2_m + p3_m) + 300(p1_s + p2_s + p3_s)$$

Constraints

Capacity Constraint:

Total units produced by plant 1 per week is 750, Total units produced by plant 2 per week is 900, and Total units produced by plant 3 per week is 450.

$$\text{Plant 1: } p1_l + p1_m + p1_s \leq 750$$

$$\text{Plant 2: } p2_l + p2_m + p2_s \leq 900$$

$$\text{Plant 3: } p3_l + p3_m + p3_s \leq 450$$

Storage Constraint:

Total square feet required for large per week is 20, Total square feet required for medium per week is 15, and Total square feet required for small per week is 12

Total square feet required for plant 1 is 13000, Total square feet required for plant 2 is 12000, and Total square feet required for plant 3 is 5000

$$\text{Plant 1: } 20p1_l + 15p1_m + 12p1_s \leq 13000$$

$$\text{Plant 2: } 20p2_l + 15p2_m + 12p2_s \leq 12000$$

$$\text{Plant 3: } 20p3_l + 15p3_m + 12p3_s \leq 5000$$

Salesforecast Capacity

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.

$$p1_l + p2_l + p3_l \leq 900$$

$$p1_m + p2_m + p3_m \leq 1200$$

$$p1_s + p2_s + p3_s \leq 750$$

Same Capacity Constraint:

To ensure same percentage of excess capacity does not exceed at each plant. So, we can use constraint like this

$$p1_l + p1_m + p1_s / 750 = p2_l + p2_m + p2_s / 900 = p3_l + p3_m + p3_s / 450$$

Non Negative Constraint:

$$p1_l, p1_m, p1_s, p2_l, p2_m, p2_s, p3_l, p3_m, p3_s \geq 0$$

Mathematical Formula

Decision Variable:

$$p1_l, p1_m, p1_s, p2_l, p2_m, p2_s, p3_l, p3_m, p3_s$$

Objective Function:

$$Z = 420(p1_l + p2_l + p3_l) + 360(p1_m + p2_m + p3_m) + 300(p1_s + p2_s + p3_s)$$

Constraints:

Capacity Constraint:

$$\text{Plant 1: } p1_l + p1_m + p1_s \leq 750$$

$$\text{Plant 2: } p2_l + p2_m + p2_s \leq 900$$

$$\text{Plant 3: } p3_l + p3_m + p3_s \leq 450$$

Storage Capacity:

$$\text{Plant 1: } 20p1_l + 15p1_m + 12p1_s \leq 13000$$

$$\text{Plant 2: } 20p2_l + 15p2_m + 12p2_s \leq 12000$$

$$\text{Plant 3: } 20p3_l + 15p3_m + 12p3_s \leq 5000$$

Salesforecast Capacity:

$$p1_l + p2_l + p3_l \leq 900$$

$$p1_m + p2_m + p3_m \leq 1200$$

$$p1_s + p2_s + p3_s \leq 750$$

Same Capacity Constraint:

$$p1_l + p1_m + p1_s / 750 = p2_l + p2_m + p2_s / 900 = p3_l + p3_m + p3_s / 450$$

Non Negative Constraint:

$$p1_l, p1_m, p1_s, p2_l, p2_m, p2_s, p3_l, p3_m, p3_s \geq 0$$

So, this above mathematical formulas will help Weigelt Corporation to maximize profits.

Solution in R

Calling Installed Library*

```
library(lpSolve)
```

Defining Objective Function

```
MaxZ = c(420,360,300,420,360,300,420,360,300)
```

Defining Constraints

```
constraints = 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)
```

Defining Signs used for constraints

```
signs = c("<=", "<=", "<=", "<=", "<=", "<=", "<=", "<=", "<=")
```

Defining Sign values used for constraints

```
sign_values = c(750,900,450,13000,12000,5000,900,1200,750)
```

Objective Function

```
lp_result = lp("max", MaxZ, constraints, signs, sign_values)
print(lp_result)
```

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

LP Model Solution

```
lp_result$solution
```

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