QMM ASSIGNMENT2

2023-09-24

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.

Linear Programming Model This Problem

Let us set up the Weigelt Corporation problem. Note that we have 9 decision variables and 11 constraints.
In the first formulation, we will directly create the objective function and constraints.

a. **Decision Variables**

$$H_1 = Total\ production\ of\ large\ units\ per\ day\ at\ Plant\ 1$$

$$H_2 = Total\ production\ of\ medium\ units\ per\ day\ at\ Plant\ 1$$

$$H_3 = Total\ production\ of\ small\ units\ per\ day\ at\ Plant\ 1$$

$$H_4 = Total\ production\ of\ large\ units\ per\ day\ at\ Plant\ 2$$

$$H_5 = Total\ production\ of\ medium\ units\ per\ day\ at\ Plant\ 2$$

$$H_6 = Total\ production\ of\ small\ units\ per\ day\ at\ Plant\ 2$$

$$H_7 = Total\ production\ of\ large\ units\ per\ day\ at\ Plant\ 3$$

$$H_8 = Total\ production\ of\ medium\ units\ per\ day\ at\ Plant\ 3$$

$$H_9 = Total\ production\ of\ small\ units\ per\ day\ at\ Plant\ 3$$

b. Formulate an LP model for this problem.

$$Max\ Z = 420H_1 + 360H_2 + 300H_3 + 420H_4 + 360H_5 + 300H_6 + 420H_7 + 360H_8 + 300\ H_9$$

$$ST:$$

$$H_1 + H_2 + H_3 \leq 750$$

$$H_4 + H_5 + H_6 \leq 900$$

$$H_7 + H_8 + H_9 \leq 450$$

$$20H_1 + 15H_2 + 12H_3 \leq 13{,}000$$

$$20H_4 + 15H_5 + 12H_6 \leq 12{,}000$$

$$20H_7 + 15H_8 + 12H_9 \leq 5{,}000$$

$$H_1 + H_4 + H_7 \leq 900$$

$$H_2 + H_5 + H_8 \leq 1{,}200$$

$$H_3 + H_6 + H_9 \leq 750$$

$$\frac{1}{750}(H_1 + H_2 + H_3) - \frac{1}{900}(H_4 + H_5 + H_6) = 0$$

$$\frac{1}{750}(H_1 + H_2 + H_3) - \frac{1}{450}(H_7 + H_8 + H_9) = 0$$

$$and, \quad Hij \geq 0\ (H_1 \geq 0, H_2 \geq 0, H_3 \geq 0, H_4 \geq 0, H_5 \geq 0, H_6 \geq 0, H_7 \geq 0, H_8 \geq 0, H_9 \geq 0)$$

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```r
#IMPORT THE lpSolve package
library(lpSolveAPI)
library(lpSolve)

#WE NEED TO CREATE AN LP OBJECT NAME LPPOINT WITH 0 CONSTRAINTS NAD 9
DECISIONS VARAIBLES
lppoint <- make.lp(0,9)

#NOW WE NEED TO SET RHE OBJECTIVE FUNCTION WHERE WE NEED TO SET THE PROBLEM
TO MAXIMIZE SINCE THE DEFAULT PROBLEM IS IN MINIMIZE
set.objfn(lppoint, c(420, 420, 420,
                     360, 360, 360,
                     300, 300, 300))

#WE NEED TO CHANGE OUR PROBLEM TO MAXIMIZATION
lp.control(lppoint, sense='max')

#WE NEED TO ADD THE 12 CONSTRAINTS BASED ON THE PLANT'S NUMBER AND THE
PRODUCTS MADE ON THOSE PLANTS.
add.constraint(lppoint, c(1, 0, 0, 1, 0, 0, 1, 0, 0), "<=", 750)
add.constraint(lppoint, c(0, 1, 0, 0, 1, 0, 0, 1, 0), "<=", 900)
add.constraint(lppoint, c(0, 0, 1, 0, 0, 1, 0, 0, 1), "<=", 450)

add.constraint(lppoint, c(20, 0, 0, 15, 0, 0, 12, 0, 0), "<=", 13000)
add.constraint(lppoint, c (0, 20, 0, 0, 15, 0, 0, 12, 0), "<=", 12000)
add.constraint(lppoint, c(0, 0, 20, 0, 0, 15, 0, 0, 12), "<=", 5000)

add.constraint(lppoint, c(1, 1, 1, 0, 0, 0, 0, 0, 0), "<=", 900)
add.constraint(lppoint, c(0, 0, 0, 1, 1, 1, 0, 0, 0), "<=", 1200)
add.constraint(lppoint, c(0, 0, 0, 0, 0, 0, 1, 1, 1), "<=", 750)

add.constraint(lppoint, c(900, -750, 0, 900, -750, 0, 900, -750, 0), "=", 0)
add.constraint(lppoint, c(0, 450, -900, 0, 450, -900, 0, 450, -900), "=", 0)
add.constraint(lppoint, c(450, 0, -750, 450, 0, -750, 450, 0, -750), "=", 0)
```

```r
#REMEMBER THAT ALL VARIABLES HAD TO BE NON-NEGATIVE.
set.bounds(lppoint, lower = c(0, 0, 0, 0, 0, 0, 0, 0, 0),
```

```r
           columns = c(1:9))


#TO IDENTIFY THE VARAIBLES AND CONSTRAINTS, WE NEED TO SET THE NAMES FOR
VARIABLES AND CONSTRAINTS
row.names<- c("ProductionCapacityPlant1", "ProductionCapacityPlant2",
"ProductionCapacityPlant3",
              "StorageCapacityPlant1", "StorageCapacityPlant2",
"StorageCapacityPlant3",
              "SalesForecastLarge","SalesForecastMedium",
"SalesForecastSmall",
              "PctCapacityPlant1_2", "PctCapacityPlant2_3",
"PctCapacityPlant1_3")
colnames<- c("Plant1Large", "Plant2Large", "Plant3Large",
               "Plant1Medium", "Plant2Medium", "Plant3Medium",
               "Plant1Small", "Plant2Small", "Plant3Small")

dimnames(lppoint) <- list(row.names, colnames)

#PRINTING THE MODEL
lppoint

## Model name:
##   a linear program with 9 decision variables and 12 constraints

#NOW LETS SOLVE THE LP PROBLEM PRESENTED STRUCTURED ABOVE
solve(lppoint)

## [1] 0

#FROM THE RESULT ABOVE WE CAN SEE THAT THE RESULT IS "0" AND IT IS SOLVED.
##OUTPUT OF OBJECTIVE FUNCTIONS AND VARIABLE
get.objective(lppoint)

## [1] 696000

#THEREFORE, IT GAVE US THE OPTIMAL NUMBER OF SIZE PRODUCTS THAT HAS TO BE
MADE ON EACH PRODUCTION PLANT
get.variables(lppoint)

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

#THEREFORE, WE CAN SAY THAT IN ORDER TO OBTAIN THE SAME PERCENTAGE OF PLANT'S
EXCESS CAPACITY TO PRODUCE NEW PRODUCTS IN THREE SIZES(LARGE, MEDIUM AND
SMALL) ON EACH PLANT (PLANT1, PLANT2, PLANT3) SHOULD USE 92.59% OF ITS
CAPACITY
##FROM ABOVE OUTPUT, WE CAN SAY THAT EACH PLANT SHOULD PROUDUCE,
### 516.6667 OF LARGE PRODUCTS AND 177.778 OF MEDIUM PRODUCTS IN PLANT1
```

```
### 666.6667 OF MEDIUM PRODUCTS AND 166.6667 OF SMALL PRODUCTS IN PLANT2
### AND, 416.6667 OF SMALL PRODUCTS IN PLANT3
```