Module 4 - Solve LP Model Using R Programming

MadhusudhanMasineni

2022-09-23

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:

#install packages ("lpSolveAPI") and load libraries

```
#install.packages('lpSolveAPI')
#install.packages('lpSolve')
```

```
library(lpSolveAPI)
library(lpSolve)
```

#Objective function and constraints.

The objective function $Max\ Z = 420(L_1 + L_2 + L_3) + 360(M_1 + M_2 + M_3) + 300(S_1 + S_2 + S_3)$

Objective function also written as $Z = 420L_1 + 420L_2 + 420L_3 + 360M_1 + 360M_2 + 360M_3 + 300S_1 + 300S_2 + 300S_3$

#Capacity constraints

$$L_1 + M_1 + S_1 \leq 750$$

$$L_2 + M_2 + S_2 \leq 900$$

$$L_3 + M_3 + S_3 \leq 450$$

The Storage constraints

$$20L_1 + 15M_1 + 12S_1 \leq 13000$$

$$20L_2 + 15M_2 + 12S_2 \leq 12000$$

$$20L_3 + 15M_3 + 12S_3 \leq 5000$$

The Sales constraints

$$L_1 + L_2 + L_3 \leq 900$$

$$M_1 + M_2 + M_3 \leq 1200$$

$$S_1 + S_2 + S_3 \leq 750$$

#Percentage production

$$L_1 + M_1 + S_1)/(L_2 + M_2 + S_2)/(L_3 + M_3 + S_3) = 750 : 900 : 450$$

#Fianlly we can writeto

$$(L_1 + M_1 + S_1)/(L_2 + M_2 + S_2) = 750 : 900$$
$$(L_2 + M_2 + S_2)/(L_3 + M_3 + S_3) = 900 : 450$$

#The equation can be

$$900L_1 + 900M_1 + 900S_1 - 750L_2 - 750M_2 - 750S_2 = 0$$
$$450L_2 + 450M_2 + 450S_2 - 900L_3 - 900M_3 - 900S_3 = 0$$

Second equation

$$L_2 + M_2 + S_2 - 2L_3 - 2M_3 - 2S_3 = 0$$

#Non-negativity constraints

$$L_1, L_2, L_3, M_1, M_2, M_3, S_1, S_2, S_3 \geq 0$$

11 constraints equation

$$L_1 + 0L_2 + 0L_3 + M_1 + 0M_2 + 0M_3 + S_1 + 0S_2 + 0S_3 \leq 750$$
$$0L_1 + L_2 + 0L_3 + 0M_1 + M_2 + 0M_3 + 0S_1 + S_2 + 0S_3 \leq 900$$
$$0L_1 + 0L_2 + L_3 + 0M_1 + 0M_2 + M_3 + 0S_1 + 0S_2 + S_3 \leq 450$$
$$20L_1 + 0L_2 + 0L_3 + 15M_1 + 0M_2 + 0M_3 + 12S_1 + 0S_2 + 0S_3 \leq 13000$$
$$0L_1 + 20L_2 + 0L_3 + 0M_1 + 15M_2 + 0M_3 + 0S_1 + 12S_2 + 0S_3 \leq 12000$$
$$0L_1 + 0L_2 + 20L_3 + 0M_1 + 0M_2 + 15M_3 + 0S_1 + 0S_2 + 12S_3 \leq 5000$$
$$L_1 + L_2 + L_3 + 0M_1 + 0M_2 + 0M_3 + 0S_1 + 0S_2 + 0S_3 \leq 900$$
$$0L_1 + 0L_2 + 0L_3 + M_1 + M_2 + M_3 + 0S_1 + 0S_2 + 0S_3 \leq 1200$$
$$0L_1 + 0L_2 + 0L_3 + 0M_1 + 0M_2 + 0M_3 + S_1 + S_2 + S_3 \leq 750$$
$$900L_1 + 900M_1 + 900S_1 - 750L_2 - 750M_2 - 750S_2 = 0$$
$$L_2 + M_2 + S_2 - 2L_3 - 2M_3 - 2S_3 = 0$$

#There are 9 constraints,

```r
#Objective function var
f.objective <- c(420,420,420,360,360,360,300,300,300)

#contraint var
f.constraints <- matrix(c(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,
                   20,0,0,15,0,0,12,0,0,
                   0,20,0,0,15,0,0,12,0,
                   0,0,20,0,0,15,0,0,12,
                   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), nrow = 9, byrow = TRUE)
#inquality assign to var
f.inq <- c("<=", "<=", "<=", "<=", "<=", "<=", "<=", "<=", "<=")

#coefficient var
f.rhscoeff <- c(750, 900, 450, 13000, 12000, 5000, 900, 1200, 750)

# Z max output
lp("max", f.objective, f.constraints,f.inq,f.rhscoeff)
```

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

```r
# Variables final values
lp("max", f.objective, f.constraints,f.inq,f.rhscoeff)$solution
```

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

If we take 11 constraints into the consideration

```r
lpwc <- make.lp(0,9)  #start with 0 constraint and 9 variables

#objective function
set.objfn(lpwc, c(420, 420, 420, 360, 360, 360, 300, 300, 300))
lp.control(lpwc, sense = 'max')  # this is a maximization problem
```

```
## $anti.degen
## [1] "fixedvars" "stalling"
##
## $basis.crash
## [1] "none"
##
## $bb.depthlimit
## [1] -50
##
## $bb.floorfirst
## [1] "automatic"
##
## $bb.rule
## [1] "pseudononint" "greedy"       "dynamic"      "rcostfixing"
##
## $break.at.first
## [1] FALSE
##
## $break.at.value
## [1] 1e+30
##
## $epsilon
##       epsb       epsd      epsel     epsint epsperturb   epspivot
##      1e-10      1e-09      1e-12      1e-07      1e-05      2e-07
##
## $improve
## [1] "dualfeas" "thetagap"
##
## $infinite
## [1] 1e+30
##
## $maxpivot
## [1] 250
##
## $mip.gap
## absolute relative
##    1e-11    1e-11
```

```
##
## $negrange
## [1] -1e+06
##
## $obj.in.basis
## [1] TRUE
##
## $pivoting
## [1] "devex"    "adaptive"
##
## $presolve
## [1] "none"
##
## $scalelimit
## [1] 5
##
## $scaling
## [1] "geometric"   "equilibrate" "integers"
##
## $sense
## [1] "maximize"
##
## $simplextype
## [1] "dual"   "primal"
##
## $timeout
## [1] 0
##
## $verbose
## [1] "neutral"
```

```
#Add the constraints
add.constraint(lpwc, c(1,0,0,1,0,0,1,0,0), "<=", 750)
add.constraint(lpwc, c(0,1,0,0,1,0,0,1,0), "<=", 900)
add.constraint(lpwc, c(0,0,1,0,0,1,0,0,1), "<=", 450)
add.constraint(lpwc, c(20,0,0,15,0,0,12,0,0),"<=",13000)
add.constraint(lpwc, c(0,20,0,0,15,0,0,12,0), "<=", 12000)
add.constraint(lpwc, c(0,0,20,0,0,15,0,0,12),"<=", 5000)
add.constraint(lpwc,c(1,1,1,0,0,0,0,0,0), "<=", 900)
add.constraint(lpwc, c(0,0,0,1,1,1,0,0,0), "<=",1200)
add.constraint(lpwc, c(0,0,0,0,0,0,1,1,1), "<=", 750)
add.constraint(lpwc, c(900,-750,0, 900,-750,0,900,-750,0),"=",0)
add.constraint(lpwc, c(0,450,-900,0,450,-900,0,450,-900),"=",0)
#set variable names and name the constraints
RowNames <- c("Capacity1", "Capacity2", "Capacity3", "Storage1","Storage2",
              "Storage3","Sale1","Sale2","Sale3","Perc1","Perc2")
ColNames <- c("L1", "L2", "L3","M1","M2","M3", "S1","S2","S3")
dimnames(lpwc) <- list(RowNames, ColNames)
```

```
solve(lpwc)
```

```
## [1] 0
```

The objective function is ::

```r
get.objective(lpwc)
```

```
## [1] 696000
```

```r
get.variables(lpwc)
```

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

The 9 variables are 516.6667, 0, 0, 177.7778, 666.6667, 0,0, 166.6667, 416.6667

In conclusion if considering first 9 constraints: The optimal output is 708000 and 9 variables are 350.0000 0.0000 0.0000 400.0000 400.0000 133.3333 0.0000 500.0000 250.0000 Plant1 produces 350 large and 400 medium products Plant2 produces 400 medium and 500 small products Plant3 produces 133.3333 medium and 250 small products

If considering all 11 constraints,the optimal max profit is 696,000 Plant1 produces 516.6667 large and 177.7778 medium products, Plant2 produces 666.6667 medium and 166.6667 small products Plant3 produces 416.6667 small products. If the number of products are integers, we will take a neighboring set of the optimal that can satisfy the percentage constraint approx (not 100%). Plant1 can produce 516 large and 177 medium products. Plant 2 should produce 666 medium and 166 small products while Plant 3 should produce 416 small products to reach a max profit of 696,000

$$Z = 420 * 516 + 360 * (177 + 666) + 300 * (166 + 416) = 696,000$$