QMM Assignment 1

THALLURU PUSHPITHA - 811250075

2023-09-24

R Markdown

#summary

1.Maximum Revenue = $1780 by making 40 Artisanal Truffles, 12 Handmade Chocolate Nuggets and 4 Chocolate Bars.

2.Artisanal Truffles, Handmade Chocolate Nuggets and Chocolate Bars constrains binding.

3.Artisanal Truffles: Shadow Price = $2, Range of Fiesability = 47.5 to 51.6 Pounds

4.Handmade Chocolate Nuggets: Shadow Price = $30, Range of Fiesability = 30 to 52 Pounds

5.Chocolate Bars: Shadow Price = $6, Range of Fiesability = 29.1 to 50 Pounds

6.Range of Optimality: Artisanal Truffles = $20 to $38, Handmade Chocolate Nuggets = $22.5 to $26.67 and Chocolate Bars = $18.75 to $35.00

#Load lpSolveAPI

```
library("lpSolveAPI")
```

Problem Statement: A renowned chocolatier, Francesco Schröeder, makes three kinds of chocolate confectionery: artisanal truffles, handcrafted chocolate nuggets, and premium gourmet chocolate bars. He uses the highest quality of cacao butter, dairy cream, and honey as the main ingredients. Francesco makes his chocolates each morning, and they are usually sold out by the early afternoon. For a pound of artisanal truffles, Francesco uses 1 cup of cacao butter, 1 cup of honey, and 1/2 cup of cream. The handcrafted nuggets are milk chocolate and take 1/2 cup of cacao, 2/3 cup of honey, and 2/3 cup of cream for each pound. Each pound of the chocolate bars uses 1 cup of cacao butter, 1/2 cup of honey, and 1/2 cup of cream. One pound of truffles, nuggets, and chocolate bars can be purchased for $35, $25, and $20,respectively. A local store places a daily order of 10 pounds of chocolate nuggets, which means that Francesco needs to make at least 10 pounds of the chocolate nuggets each day. Before sunrise each day, Francesco receives a delivery of 50 cups of cacao butter, 50 cups of honey, and 30 cups of dairy cream. 1.Formulate and solve the LP model that maximizes revenue given the constraints. How much of each chocolate product should Francesco make each morning? What is the maximum daily revenue that he can make? 2.Report the shadow price and the range of feasibility of each binding constraint. 3.If the local store increases the daily order to 25 pounds of chocolate nuggets, how much of each product should Francesco make? We will solve this problem with two approaches: First by directly encoding the variables and coefficients, and secondly, by using a .lp file

1.Formulate and solve the LP model that maximizes revenue given the constraints. How much of each chocolate product should Francesco make each morning? What is the maximum daily revenue that he can make? We define the following: Decision Variables: Let AT be the number of Artisanal Truffles produced, CN be the number of Handcrafted Chocolate Nuggets produced, and CB be the number of Chocolate Bars produced. * The Objective is to Max 35AT + 25CN + 20 CB. * The constraints are + Cacao Butter: 1AT + 0.5CN + 1CB <= 50; + Honey: 1AT + 0.67CN + 0.5CB <= 50; + Diary Cream: 0.5AT + 0.67CN + 0.5CB<=30 + Nugget Orders: CN>=10 + Non-negativity constraints

make an lp object with 0 constraints and 3 decision variables

```
lprec <- make.lp(0, 3)
```

Now create the objective function. The default is a minimization problem.

```
set.objfn(lprec, c(35, 25, 20))
```

As the default is a minimization problem, we change the direction to set maximization

```
lp.control(lprec,sense='max')
```

```
## $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 four constraints

```r
add.constraint(lprec, c(1, 1/2, 1), "<=", 50)
add.constraint(lprec, c(1, 2/3, 1/2), "<=", 50)
add.constraint(lprec, c(1/2, 2/3, 1/2), "<=", 30)
add.constraint(lprec, c(0, 1, 0), ">=", 10)
```

Set bounds for variables.

```r
set.bounds(lprec, lower = c(0, 0, 0), columns = c(1, 2, 3))
```

To identify the variables and constraints, we can

set variable names and name the constraints

```
RowNames <- c("CacaoButter", "Honey", "DiaryCream", "NUggetsOrder")
ColNames <- c("AritisanTruffel", "ChocalateNuggets", "ChocalateBars")
dimnames(lprec) <- list(RowNames, ColNames)
```

#The model can also be saved to a file

```
write.lp(lprec, filename = "nuggets.lp", type = "lp")
```

We now solve the above LP problem

```
solve(lprec)
```

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

The output above doesn't indicate that the answer is 0, but that there was a successful solution We now output the value of the objective function, and the variables

```
get.objective(lprec)
```

```
## [1] 1780
```

```
varV <- get.variables(lprec)
```

The solution shows that the revenue is 1780, with the first variable value equal to 40, and the second variable value equal to 12.One difficulty in reading the output is that lpsolveAPI will not write the variable name next to the solution. As such, you should remember that the variables values are output in the order in which it shows up in the lp formulation. In our case, it was Aritisan Truffel, Handcrafted Chocalate Nuggets and then Choclate Bars.

Before we look at other output values, let us consider using a different method to input the problem formuation. We will use the lp format by creating a text file that contains the problem formulation. We also outputted an lp file using the write.lp statement above.

Please now look at the coc.lp file. In RStudio, you can double click on the file in the Files list on the right pane.

```
x <- read.lp("nuggets.lp")
x
```

```
## Model name:
##                  AritisanTruffel  ChocalateNuggets     ChocalateBars
## Maximize                      35                25                20
## CacaoButter                    1               0.5                 1  <=  50
## Honey                          1    0.666666666667               0.5  <=  50
## DiaryCream                   0.5    0.666666666667               0.5  <=  30
```

```
## NUggetsOrder                  0              1              0  >=  10
## Kind                        Std            Std            Std
## Type                       Real           Real           Real
## Upper                       Inf            Inf            Inf
## Lower                         0              0              0
```

Solve the lp model

```r
solve(lprec)
```

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

```r
get.objective(lprec)  # get objective value
```

```
## [1] 1780
```

```r
get.variables(lprec) # get values of decision variables
```

```
## [1] 40 12  4
```

```r
get.constraints(lprec) # get constraint RHS values
```

```
## [1] 50 50 30 12
```

*2.Report the shadow price and the range of feasibility of each binding constraint.

```r
get.sensitivity.rhs(lprec) # get shadow prices
```

```
## $duals
## [1]  2 30  6  0  0  0  0
##
## $dualsfrom
## [1]  4.750000e+01  3.000000e+01  2.916667e+01 -1.000000e+30 -1.000000e+30
## [6] -1.000000e+30 -1.000000e+30
##
## $dualstill
## [1] 5.166667e+01 5.200000e+01 5.000000e+01 1.000000e+30 1.000000e+30
## [6] 1.000000e+30 1.000000e+30
```

```r
get.sensitivity.obj(lprec) # get reduced cost
```

```
## $objfrom
## [1] 20.00 22.50 18.75
##
## $objtill
## [1] 38.00000 26.66667 35.00000
```

make an lp object with 0 constraints and 3 decision variables

```
lprec <- make.lp(0, 3)
```

Now create the objective function. The default is a minimization problem

```
set.objfn(lprec, c(35, 25, 20))
```

As the default is a minimization problem, we change the direction to set maximization

```
lp.control(lprec,sense='max')
```

```
## $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 four constraints

```
add.constraint(lprec, c(1, 1/2, 1), "<=", 50)
add.constraint(lprec, c(1, 2/3, 1/2), "<=", 50)
add.constraint(lprec, c(1/2, 2/3, 1/2), "<=", 30)
```

Updated constraints from 10 to 25 Pounds

```
add.constraint(lprec, c(0, 1, 0), ">=", 25)
```

Set bounds for variables.

```
set.bounds(lprec, lower = c(0, 0, 0), columns = c(1, 2, 3)) #Not really needed
```

To identify the variables and constraints, we can

set variable names and name the constraints

```
RowNames <- c("CacaoButter", "Honey", "DiaryCream", "NUggetsOrder")
ColNames <- c("AritisanTruffel", "ChocalateNuggets", "ChocalateBars")
dimnames(lprec) <- list(RowNames, ColNames)
```

#The model can also be saved to a file

```
write.lp(lprec, filename = "nuggets.lp", type = "lp")
```

```
solve(lprec)
```

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

```
get.objective(lprec)
```

```
## [1] 1558.333
```

```
varV <- get.variables(lprec)
```

```
x <- read.lp("nuggets.lp")  # create an lp object x
x                           #display
```

```
## Model name:
##                AritisanTruffel  ChocalateNuggets     ChocalateBars
## Maximize                    35                25                20
## CacaoButter                  1               0.5                 1  <=  50
## Honey                        1    0.666666666667               0.5  <=  50
## DiaryCream                 0.5    0.666666666667               0.5  <=  30
## NUggetsOrder                 0                 1                 0  >=  25
## Kind                       Std               Std               Std
## Type                      Real              Real              Real
## Upper                      Inf               Inf               Inf
## Lower                        0                 0                 0
```

```
solve(lprec)
```

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

```r
get.objective(lprec)  #get objective value
```

```
## [1] 1558.333
```

```r
get.variables(lprec) # get values of decision variables
```

```
## [1] 26.66667 25.00000  0.00000
```

```r
get.constraints(lprec) # get constraint RHS values
```

```
## [1] 39.16667 43.33333 30.00000 25.00000
```