Assignment 1 QMM

2023-09-22

R Markdown

This notebook contains the code for Assignment 1

Summary

1. Maximum revenue = $1780 by making 40 of artisanal truffles, 12 of handcrafted chocolate nuggets and 4 of Premium Gourmet Chocolate Bars.
2. Cacao Butter, dairy cream and honey are constraints.
3. Cacao Butter constraint: Shadow price = $2, Range of feasibility = 475 to 600 Pounds.
4. Dairy cream constraint: Shadow price = $30, Range of feasibility = 300 to 520 Pounds.
5. Honey constraint: Shadow price = $6, Range of feasibility = 250 to 500 Pounds.
6. Range of optimality: Artisanal truffles = $20.00 to $38.00, Handcrafted chocolate nuggets = $22.50 to $26.66667 & Premium gourmet chocolate bars = $18.75 to $35.00. ***

```
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 define the following:

- Decision Variables: Let *x1* be the number of cup of butter used,*x2* be the number of cup of honey used and *x3* be the number of cup of cream used.
- The Objective is to *Max 35x1 + 25x2 + 20x3*. The constraints are
    - *Butter: 1x1 + 0.5x2 + 1x3 <= 50;*
    - *Honey : 1x1 + 0.66x2 + 0.5x3 <= 50;*
    - *Cream : 0.5x1 + 0.66x2 + 0.5x3 <= 30;*
    - *"z" >= 10
    - *Max >= 0

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] 1782.927
```

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

The solution shows that the revenue is 1782.93, with the first variable value equal to 40, and the second variable value equal to 12.2.

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 Chardonnay and then Blanc.

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 *A1.lp* file. In RStudio, you can double click on the file in the Files list on the right pane.

```
x <- read.lp("A1.lp") # create an lp object x
x                           # display x
```

```
## Model name:
##            artisinal    truffle    Nuggets       Bars
## Maximize          35          1         25         20
## Butter             1          1        0.5          1  <=  50
## Cream              1          1       0.66        0.5  <=  50
## Honey            0.5          1       0.66        0.5  <=  30
## Kind             Std        Std        Std        Std
## Type            Real       Real       Real       Real
## Upper            Inf        Inf        Inf        Inf
## Lower              0          0          0          0
```

Solve the lp model

```
solve(x)
```

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

```
get.objective(x)        # get objective value
```

```
## [1] 1782.927
```

```
get.variables(x)        # get values of decision variables
```

```
## [1] 40.000000  0.000000 12.195122  3.902439
```

```
get.constraints(x)      # get constraint RHS values
```

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

If you run all the chunks above, you can display the text, code, and output in an html file. This is achieved by *knitting* your file. To start,

1. Save your file
2. Click on *Knit to HTML* from the drop down menu (it might say Preview)

You can also get the output in word, or pdf form by knitting the output. Use the Knit Document option from the File menu, or use the drop down menu from the Preview option above.

Extensions - Post Optimality Analysis

This is called post-optimality analysis

```
get.sensitivity.rhs(x)  # get shadow prices
```

```
## $duals
## [1]   1.707317  30.000000   6.585366   0.000000 -37.292683   0.000000   0.000000
##
## $dualsfrom
## [1]  4.757576e+01  3.000000e+01  2.500000e+01 -1.000000e+30 -1.000000e+30
## [6] -1.000000e+30 -1.000000e+30
##
## $dualstill
## [1] 6.000000e+01 5.195122e+01 5.000000e+01 1.000000e+30 1.000000e+01
## [6] 1.000000e+30 1.000000e+30
```

```
get.sensitivity.obj(x)  # get reduced cost
```

```
## $objfrom
## [1]  2.000000e+01 -1.000000e+30  2.230000e+01  1.893939e+01
##
## $objtill
## [1] 38.29268 38.29268 26.40000 35.00000
```