R4 - Optimization

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```
library(tidyverse)
library(lpSolveAPI)
```

a.

A small farmer can produce two types of crops, A and B, which will generate profits of $30 and $25 per bushel (35 liters). The crops vary in the units of resources required and available, as shown in the following table:

Resource	Crop A	Crop B	Units available
Land	2	3	60
Water	5	2	80
Fertilizer	3	2	60
Labor	1	2	40

For example, one bushel of crop A, requires 2 units of land, 5 units of water, and so on.

- What's the maximum profit and how much of each crop should be produced?
- What allocation of resources will maximize the farmer's profit?
- Use shadow price analysis to determine what additional resources the farmer should seek?

```
#model with 0 constraints and 2 decision
lpmodel <- make.lp(0,2)
obj <-  c(30, 25)
set.objfn(lpmodel, c(obj[1], obj[2]))
# constraint coefficients
con <-  matrix(c(2, 3,
                 5, 2,
                 3, 2,
                 1, 2),
               nrow=4,ncol=2, byrow = T)
add.constraint(lpmodel, c(con[1,1], con[1,2]), "<=", 60)
add.constraint(lpmodel, c(con[2,1], con[2,2]), "<=", 80)
add.constraint(lpmodel, c(con[3,1], con[3,2]), "<=", 60)
add.constraint(lpmodel, c(con[4,1], con[4,2]), "<=", 40)
#set objective direction and hide the output
invisible(lp.control(lpmodel,sense = 'max'))
print(lpmodel)
```

```
## Model name:
##             C1    C2
## Maximize    30    25
## R1           2     3  <=  60
## R2           5     2  <=  80
## R3           3     2  <=  60
## R4           1     2  <=  40
## Kind       Std   Std
## Type      Real  Real
## Upper      Inf   Inf
## Lower        0     0
```

```
solve(lpmodel)
```

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

Maximum profit

```
p <-  get.objective(lpmodel)
print(paste0('Profit: $',round(p[1],2)), quote = F)
```

```
## [1] Profit: $645.45
```

```
v <-  get.variables(lpmodel)
print(paste0('Bushels of crop A: ', round(v[1],2)), quote = F)
```

```
## [1] Bushels of crop A: 10.91
```

```
print(paste0('Bushels of crop B: ', round(v[2],2)), quote = F)
```

```
## [1] Bushels of crop B: 12.73
```

Resource allocation

```
print(paste('Units of land: ', round((con[1,1]*v[1] + con[1,2]*v[2]),2)), quote = F)
```

```
## [1] Units of land:  60
```

```
print(paste('Units of water ', round((con[2,1]*v[1] + con[2,2]*v[2]),2)), quote = F)
```

```
## [1] Units of water  80
```

```
print(paste('Units of fertilizer: ', round((con[3,1]*v[1] + con[3,2]*v[2]),2)), quote = F)
```

```
## [1] Units of fertilizer:  58.18
```

```
print(paste('Units of Labor: ', round((con[4,1]*v[1] + con[4,2]*v[2]),2)), quote = F)
```

```
## [1] Units of Labor:  36.36
```

Shadow price analysis

```
d <-  get.dual.solution(lpmodel)
print(paste('One more unit of land will increase profit by: ', round(d[2],2)), quote = F)
```

```
## [1] One more unit of land will increase profit by:  5.91
```

```
print(paste('One more unit of water will increase profit by: ', round(d[3],2)), quote = F)
```

```
## [1] One more unit of water will increase profit by:  3.64
```

```
print(paste('One more unit of fertilizer will increase profit by: ', round(d[4],2)), quote = F)
```

```
## [1] One more unit of fertilizer will increase profit by:  0
```

```
print(paste('One more unit of labor will increase profit by: ', round(d[4],2)), quote = F)
```

```
## [1] One more unit of labor will increase profit by:  0
```

b.

A pizza chain in Athens has three locations, and in the last five minutes has received orders for pizzas to be delivered to five addresses in Athens. Assuming ordering is centrally managed, which store should assigned the making of the five orders to minimize delivery distance? What is the shortest route in miles?

Pizza chain locations

- 700 E. Broad St.
- 1591 S. Lumpkin St
- 120 Alps Rd

Delivery locations

- 170 River Rd
- 100 Kentucky Circle
- 558 West Broad St
- 125 Greek Park Circle
- 1084 Prince Ave.

```
library(tidyverse)
library(TSP)
library(measurements)
library(googleway)
k <- read_csv("~/Dropbox/R/API keys/GoogleAPIkey.txt")
```

Use a loop to find the delivery distance from each store and select the minimum as the pizza making store.

```
maker <-  c('700 E. Broad St, Athens, GA', '1591 S. Lumpkin St, Athens, GA','120 Alps Rd, Athens, GA')
mindist <-  9999999
num_makers = length(maker)
for(s in 1:num_makers) {
  locations <-  c(maker[s], "170 River Rd, Athens, GA", "100 Kentucky Circle, Athens, GA", "558 West Br
# Set a pickup store as the starting point for the tour
start_location <- 1
  l <-  length(locations) # number of locations is length of vector
  # set up distance as symmetric matrix
  distMat <-  matrix(0,l,l)
  # compute distances and enter into cells
  for(i in 1:(l-1)){
    for(j in (i+1):l){
     t <-  google_distance(locations[i],locations[j],mode=c('driving'),simplify = TRUE, key = k$key)
     tx <- t$rows$elements[[1]]$distance$value*conv_unit(1,'m','mi') # convert meters to miles
     distMat[i,j] <-  tx
      distMat[j,i] <-  tx
    }
  }
  tsp <-  TSP(distMat,locations)
  # Set store as the starting point
  solve_TSP(tsp,start = start_location)
  tour <- solve_TSP(tsp)
  labels(tour)
  as.integer(tour)
  tour_length(tour)
  print(paste0('Store: ', maker[s]), quote=F)
  print(paste0(round(tour_length(tour),2), ' miles'), quote=F)
  print(paste0('Route'), quote=F)
  print(labels(tour), quote=F)
  print('' , quote=F)
  if(tour_length(tour) < mindist) {
    mindist <-  tour_length(tour)
    mindeliver <-  s
    mintour <-  tour
  }
}
```

```
## [1] Store: 700 E. Broad St, Athens, GA
## [1] 9.49 miles
## [1] Route
```

```
## [1] 1084 Prince Ave, Athens, GA       700 E. Broad St, Athens, GA
## [3] 100 Kentucky Circle, Athens, GA   170 River Rd, Athens, GA
## [5] 125 Greek Park Circle, Athens, GA 558 West Broad St, Athens, GA
## [1]
## [1] Store: 1591 S. Lumpkin St, Athens, GA
## [1] 10.67 miles
## [1] Route
## [1] 170 River Rd, Athens, GA          125 Greek Park Circle, Athens, GA
## [3] 1591 S. Lumpkin St, Athens, GA    1084 Prince Ave, Athens, GA
## [5] 558 West Broad St, Athens, GA     100 Kentucky Circle, Athens, GA
## [1]
## [1] Store: 120 Alps Rd, Athens, GA
## [1] 11.63 miles
## [1] Route
## [1] 120 Alps Rd, Athens, GA           558 West Broad St, Athens, GA
## [3] 125 Greek Park Circle, Athens, GA 170 River Rd, Athens, GA
## [5] 100 Kentucky Circle, Athens, GA   1084 Prince Ave, Athens, GA
## [1]
```

```
print("Minimum distance store", quote=F)
```

```
## [1] Minimum distance store
```

```
print(maker[mindeliver], quote=F)
```

```
## [1] 700 E. Broad St, Athens, GA
```

```
print(paste0(round(mindist,2),' miles'), quote=F)
```

```
## [1] 9.49 miles
```