Assign5_1

.lp

```
// Objective Function
max: 14000 u1 + 3500 u2;

/* Constraints */
14000 u1 + 3500 u2 - 150 v1 - 0.2 v2 <= 0;
14000 u1 + 21000 u2 - 400 v1 - 0.7 v2 <= 0;
42000 u1 + 10500 u2 - 320 v1 - 1.2 v2 <= 0;
28000 u1 + 42000 u2 - 520 v1 - 2.0 v2 <= 0;
19000 u1 + 25000 u2 - 350 v1 - 1.2 v2 <= 0;
14000 u1 + 15000 u2 - 320 v1 - 0.7 v2 <= 0;
150 v1 + 0.2 V2= 1;
```

This problem will have 6 different LP formulations for each DMU or facility. We will here see the formulation for the first facility.

// Objective Function max: 14000 u1 + 3500 u2;

/* Constraints */ 14000 u1 + 3500 u2 - 150 v1 - 0.2 v2 <= 0; 14000 u1 + 21000 u2 - 400 v1 - 0.7 v2 <= 0; 42000 u1 + 10500 u2 - 320 v1 - 1.2 v2 <= 0; 28000 u1 + 42000 u2 - 520 v1 - 2.0 v2 <= 0; 19000 u1 + 25000 u2 - 350 v1 - 1.2 v2 <= 0; 14000 u1 + 15000 u2 - 320 v1 - 0.7 v2 <= 0; 150 v1 + 0.2 V2= 1; u1>=0; u2>=0; v1>=0; v2>=0;

Likewise, we can have another 5 LP formulations for the other 5 facilities.

1) Formulate and perform DEA analysis under all DEA assumptions of FDH, CRS, VRS,IRS, DRS, and FRH.
2) Determine the Peers and Lambdas under each of the above assumptions.

```r
#Clear the Workspace
rm(list = ls())

library(Benchmarking)

## Loading required package: lpSolveAPI

## Loading required package: ucminf

## Loading required package: quadprog

# Lets capture Inputs into variable x and outputs into variable y

x <- matrix(c(150,400,320,520,350,320,0.2,0.7,1.2,2.0,1.2,0.7),ncol = 2)
y <-
matrix(c(14000,14000,42000,28000,19000,14000,3500,21000,10500,42000,25000,150
00), ncol=2)


# FDH: All units are efficient as per the model

ef <- dea(x,y,RTS = "fdh" , ORIENTATION = "in")
ef

## [1] 1 1 1 1 1 1

peers(ef)

##      peer1
## [1,]     1
## [2,]     2
## [3,]     3
## [4,]     4
## [5,]     5
## [6,]     6

lambda(ef)

##      L1 L2 L3 L4 L5 L6
## [1,]  1  0  0  0  0  0
## [2,]  0  1  0  0  0  0
## [3,]  0  0  1  0  0  0
## [4,]  0  0  0  1  0  0
## [5,]  0  0  0  0  1  0
## [6,]  0  0  0  0  0  1

# CRS: As per the model all except 5&6 (97.75% and 86.75% efficiency rate)
are efficient. Peers are 1,2 and 4.
# Lambda gives the weights(shadow prices) to the benchmark DMUs (in this case
1,2 4). Therefore, for 5, they are 0.20,0.08 and 0.53 and for 6 , they are
0.34, 0.39 and 0.13.
```

```r
ec <- dea(x,y,RTS = "crs", ORIENTATION = "in")
ec

## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675

peers(ec)

##      peer1 peer2 peer3
## [1,]     1    NA    NA
## [2,]     2    NA    NA
## [3,]     3    NA    NA
## [4,]     4    NA    NA
## [5,]     1     2     4
## [6,]     1     2     4

lambda(ec)

##             L1         L2 L3        L4
## [1,] 1.0000000 0.00000000  0 0.0000000
## [2,] 0.0000000 1.00000000  0 0.0000000
## [3,] 0.0000000 0.00000000  1 0.0000000
## [4,] 0.0000000 0.00000000  0 1.0000000
## [5,] 0.2000000 0.08048142  0 0.5383307
## [6,] 0.3428571 0.39499264  0 0.1310751

# VRS: All units are efficient except 6 with an efficiency ratio of 89.63%
#Peers for 6 are 1,2 and 5 with weights of 0.40,0.34 and 0.25

ev <- dea(x,y,RTS = "vrs" , ORIENTATION = "in")
ev

## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963

peers(ev)

##      peer1 peer2 peer3
## [1,]     1    NA    NA
## [2,]     2    NA    NA
## [3,]     3    NA    NA
## [4,]     4    NA    NA
## [5,]     5    NA    NA
## [6,]     1     2     5

lambda(ev)

##             L1        L2 L3 L4        L5
## [1,] 1.0000000 0.0000000  0  0 0.0000000
## [2,] 0.0000000 1.0000000  0  0 0.0000000
## [3,] 0.0000000 0.0000000  1  0 0.0000000
## [4,] 0.0000000 0.0000000  0  1 0.0000000
```

```
## [5,] 0.0000000 0.0000000  0  0 1.0000000
## [6,] 0.4014399 0.3422606  0  0 0.2562995

# IRS: All units are efficient except 6 with an efficiency ratio of 89.63%
#Peers for 6 are 1,2 and 5 with weights of 0.40,0.34 and 0.25

ei <- dea(x,y,RTS = "irs" , ORIENTATION = "in")
ei

## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963

peers(ei)

##      peer1 peer2 peer3
## [1,]     1    NA    NA
## [2,]     2    NA    NA
## [3,]     3    NA    NA
## [4,]     4    NA    NA
## [5,]     5    NA    NA
## [6,]     1     2     5

lambda(ei)

##             L1        L2 L3 L4        L5
## [1,] 1.0000000 0.0000000  0  0 0.0000000
## [2,] 0.0000000 1.0000000  0  0 0.0000000
## [3,] 0.0000000 0.0000000  1  0 0.0000000
## [4,] 0.0000000 0.0000000  0  1 0.0000000
## [5,] 0.0000000 0.0000000  0  0 1.0000000
## [6,] 0.4014399 0.3422606  0  0 0.2562995

# DRS: All units are efficient except 5&6 with an efficiency ratio of 97.75%
and 86.75% respectively
# Peers are 1,2 and 4 and the weights for 5 are 0.20,0.08 and 0.53 . For 6
weights are  0.34, 0.39 and 0.13.
ed <- dea(x,y,RTS = "drs" , ORIENTATION = "in")
ed

## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675

peers(ed)

##      peer1 peer2 peer3
## [1,]     1    NA    NA
## [2,]     2    NA    NA
## [3,]     3    NA    NA
## [4,]     4    NA    NA
## [5,]     1     2     4
## [6,]     1     2     4

lambda(ed)
```

```
##               L1          L2 L3        L4
## [1,] 1.0000000 0.00000000  0 0.0000000
## [2,] 0.0000000 1.00000000  0 0.0000000
## [3,] 0.0000000 0.00000000  1 0.0000000
## [4,] 0.0000000 0.00000000  0 1.0000000
## [5,] 0.2000000 0.08048142  0 0.5383307
## [6,] 0.3428571 0.39499264  0 0.1310751
```

```
# FRH: All units are efficient

ea <- dea(x,y,RTS = "add" , ORIENTATION = "in")
ea
```

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

```
peers(ea)
```

```
##      peer1
## [1,]     1
## [2,]     2
## [3,]     3
## [4,]     4
## [5,]     5
## [6,]     6
```

```
lambda(ea)
```

```
##      L1 L2 L3 L4 L5 L6
## [1,]  1  0  0  0  0  0
## [2,]  0  1  0  0  0  0
## [3,]  0  0  1  0  0  0
## [4,]  0  0  0  1  0  0
## [5,]  0  0  0  0  1  0
## [6,]  0  0  0  0  0  1
```

---

3) Summarize your results in a tabular format

```
#Summarizing facilities and efficiency
efficiency <-
data.frame(FDH=round(ef$eff,4),CRS=round(ec$eff,4),VRS=round(ev$eff,4),IRS=ro
und(ei$eff,4),DRS=round(ed$eff,4),FRH=round(ea$eff,4))
row.names(efficiency) = c("F1","F2","F3","F4","F5","F6") #F represents
Facility
efficiency
```

```
##    FDH    CRS    VRS    IRS    DRS  FRH
## F1   1 1.0000 1.0000 1.0000 1.0000    1
## F2   1 1.0000 1.0000 1.0000 1.0000    1
## F3   1 1.0000 1.0000 1.0000 1.0000    1
## F4   1 1.0000 1.0000 1.0000 1.0000    1
```

```
## F5   1 0.9775 1.0000 1.0000 0.9775   1
## F6   1 0.8675 0.8963 0.8963 0.8675   1
```

```
# Summarizing Facilities vs efficiency ratio VS lambda values
# We will ignore the models FDH and FRH , as all facilities under those
models are efficient

# Summary under CRS

summc = cbind(round(ec$eff,4),round(ec$lambda,4))
row.names(summc) = c("F1","F2","F3","F4","F5","F6") #F represents Facility
colnames(summc) = c("Efficiency_CRS", row.names(summc)) #F represents
Facility
summc
```

```
##    Efficiency_CRS     F1     F2 F3     F4 F5 F6
## F1         1.0000 1.0000 0.0000  0 0.0000  0  0
## F2         1.0000 0.0000 1.0000  0 0.0000  0  0
## F3         1.0000 0.0000 0.0000  1 0.0000  0  0
## F4         1.0000 0.0000 0.0000  0 1.0000  0  0
## F5         0.9775 0.2000 0.0805  0 0.5383  0  0
## F6         0.8675 0.3429 0.3950  0 0.1311  0  0
```

```
# Summary under VRS

summv = cbind(round(ev$eff,4),round(ev$lambda,4))
row.names(summv) = c("F1","F2","F3","F4","F5","F6") #F represents Facility
colnames(summv) = c("Efficiency_VRS", row.names(summv)) #F represents
Facility
summv
```

```
##    Efficiency_VRS     F1     F2 F3 F4     F5 F6
## F1         1.0000 1.0000 0.0000  0  0 0.0000  0
## F2         1.0000 0.0000 1.0000  0  0 0.0000  0
## F3         1.0000 0.0000 0.0000  1  0 0.0000  0
## F4         1.0000 0.0000 0.0000  0  1 0.0000  0
## F5         1.0000 0.0000 0.0000  0  0 1.0000  0
## F6         0.8963 0.4014 0.3423  0  0 0.2563  0
```

```
# Summary under IRS

summi = cbind(round(ei$eff,4),round(ei$lambda,4))
row.names(summi) = c("F1","F2","F3","F4","F5","F6") #F represents Facility
colnames(summi) = c("Efficiency_IRS", row.names(summi)) #F represents
Facility
summi
```

```
##    Efficiency_IRS     F1     F2 F3 F4     F5 F6
## F1         1.0000 1.0000 0.0000  0  0 0.0000  0
## F2         1.0000 0.0000 1.0000  0  0 0.0000  0
## F3         1.0000 0.0000 0.0000  1  0 0.0000  0
```

```
## F4         1.0000 0.0000 0.0000  0  1 0.0000  0
## F5         1.0000 0.0000 0.0000  0  0 1.0000  0
## F6         0.8963 0.4014 0.3423  0  0 0.2563  0
```

```
# Summary under DRS

summd = cbind(round(ed$eff,4),round(ed$lambda,4))
row.names(summd) = c("F1","F2","F3","F4","F5","F6") #F represents Facility
colnames(summd) = c("Efficiency_DRS", row.names(summd)) #F represents
Facility
summd
```

```
##    Efficiency_DRS     F1     F2 F3     F4 F5 F6
## F1         1.0000 1.0000 0.0000  0 0.0000  0  0
## F2         1.0000 0.0000 1.0000  0 0.0000  0  0
## F3         1.0000 0.0000 0.0000  1 0.0000  0  0
## F4         1.0000 0.0000 0.0000  0 1.0000  0  0
## F5         0.9775 0.2000 0.0805  0 0.5383  0  0
## F6         0.8675 0.3429 0.3950  0 0.1311  0  0
```

---

4) Compare and contrast the above results

1. All he facilities under FDH and FRH are efficient, as such effiency ratio for all the units is 1 and no lamdas and in a strict sense no peers or they themselves are peers.

2. Under CRS and DRS , all units are efficient except 5&6 with an efficiency ratio of 97.75% and 86.75% respectively.Peers are 1,2 and 4 and the weights for 5 are 0.20,0.08 and 0.53 . For 6 weights are 0.34, 0.39 and 0.13.

3. Under VRS and IRS ,all units are efficient except 6 with an efficiency ratio of 89.63%.Peers for 6 are 1,2 and 5 with weights of 0.40,0.34 and 0.25

What does this all mean ? For example, under VRS and IRS , 6 is inefficient and the peers are 1,2 and 5.

Calculations are added in the dataset variable, and thus Facility 6 need to have 36.5 less staff hours , 0.082 less supplies , 1110 more Reimbursed patient days and 210 less privately paid patient days in order to become efficient.

```
dataset = read.csv('DEA worksheet.csv')

## Warning in read.table(file = file, header = header, sep = sep, quote =
quote, :
## incomplete final line found by readTableHeader on 'DEA worksheet.csv'

dataset

##              X     F1 Lambda   Value      F2 Lambda.1  Value.1      F5
Lambda.2
## 1 staff hours   150.0    0.4   60.00   400.0     0.34  136.000   350.0
```

```
0.25
## 2    supplies     0.2    0.4    0.08     0.7     0.34    0.238     1.2
0.25
## 3     RP days 14000.0    0.4 5600.00 14000.0     0.34 4760.000 19000.0
0.25
## 4     PP days  3500.0    0.4 1400.00 21000.0     0.34 7140.000 25000.0
0.25
##   Value.2     Total F6.Totals Difference
## 1    87.5   283.500     320.0     36.500
## 2     0.3     0.618       0.7      0.082
## 3  4750.0 15110.000   14000.0  -1110.000
## 4  6250.0 14790.000   15000.0    210.000
```

Assign5_2_Emax

.lp

// Objective function

max : 20x1 + 15x2 + 25x3 - 6y1p - 6y1m - 3 y2m;

// Constraints

6x1 + 4x2 + 5x3 + y1m - y1p = 50;

8x1 + 7x2 + 5x3 + y2m - y2p = 75;

```
#Clear the Workspace
rm(list = ls())
```

Let x1, x2, and x3 represent quantities of the three products. The objective is to

Maximize Z = P - 6C - 3D, where

P = total (discounted) profit over the life of the new products,

C = change (in either direction) in the current level of employment,

D = decrease (if any) in next year's earnings from the current year's level.

y1p and y1m are increase in and decrease in the current level of employment respectively (6 penalty) y2p and y2m are increase (no penalty) and decrease (3 penalty) in next year's earnings from current level of 75

```
library(lpSolveAPI)

model <- read.lp("EmaxCorp.lp")
model

## Model name:
##              x1    x2    x3   y1p   y1m   y2m   y2p
## Maximize     20    15    25    -6    -6    -3     0
```

```
## R1           6     4     5    -1     1     0     0  =  50
## R2           8     7     5     0     0     1    -1  =  75
## Kind       Std   Std   Std   Std   Std   Std   Std
## Type      Real  Real  Real  Real  Real  Real  Real
## Upper      Inf   Inf   Inf   Inf   Inf   Inf   Inf
## Lower        0     0     0     0     0     0     0
```

```
solve (model)
```

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

```
get.objective(model)
```

```
## [1] 225
```

```
get.variables(model)
```

```
## [1]  0  0 15 25  0  0  0
```

EmaxCorp would need to only produce 15 units of x3 (Product 3) , ignoring x1&x2 (Product 1 and 2), achieving a maximum profit of 225 million , however, employment will shoot up by 2500.