MIS 64018 - Assignment 4

Tejasvini Mavuleti

2022-10-24

Hope Valley Health Care Association

Inputs - Staffing Labor, Cost of Supplies Outputs - No of patient-days reimbursed by third party, No of patient-days reimbursed privately

```
# First we start off by calling the Benchmarking package to run the DEA analy
sis.
require(Benchmarking)

## Loading required package: Benchmarking

## Warning: package 'Benchmarking' was built under R version 4.2.1

## Loading required package: lpSolveAPI

## Warning: package 'lpSolveAPI' was built under R version 4.2.1

## Loading required package: ucminf

## Warning: package 'ucminf' was built under R version 4.2.1

## Loading required package: quadprog

##
## Loading Benchmarking version 0.30h, (Revision 244, 2022/05/05 16:31:31) ..
.

## Build 2022/05/05 16:31:40
```

Building a matrix to load the data

```
# Add the input variables to the matrix
X <- matrix(c(150, 400, 320, 520, 350, 320, 0.2, 0.7, 1.2, 2.0, 1.2, 0.7), nc
ol = 2)

# Add the output variables to the matrix
Y <- matrix(c(14000, 14000, 42000, 28000, 19000, 14000, 3500, 21000, 10500, 4
2000, 25000, 15000), ncol = 2)

# Name the columns as they were in the data set
colnames(X) <- c("Staff Hours per Day","Supplies per Day")
colnames(Y) <- c("Reimburse Patient-Days", "Privately Paid Patient-Days")
```

```
# Review the data set in the matrix form
print(X)

##      Staff Hours per Day Supplies per Day
## [1,]                 150              0.2
## [2,]                 400              0.7
## [3,]                 320              1.2
## [4,]                 520              2.0
## [5,]                 350              1.2
## [6,]                 320              0.7

print(Y)

##      Reimburse Patient-Days Privately Paid Patient-Days
## [1,]                  14000                        3500
## [2,]                  14000                       21000
## [3,]                  42000                       10500
## [4,]                  28000                       42000
## [5,]                  19000                       25000
## [6,]                  14000                       15000
```

Solving Q1 and Q2 together

Q1. - Formuulate and perform DEA analysis

Q2. - Determine the Peers and Lambdas under each of the above assumptions

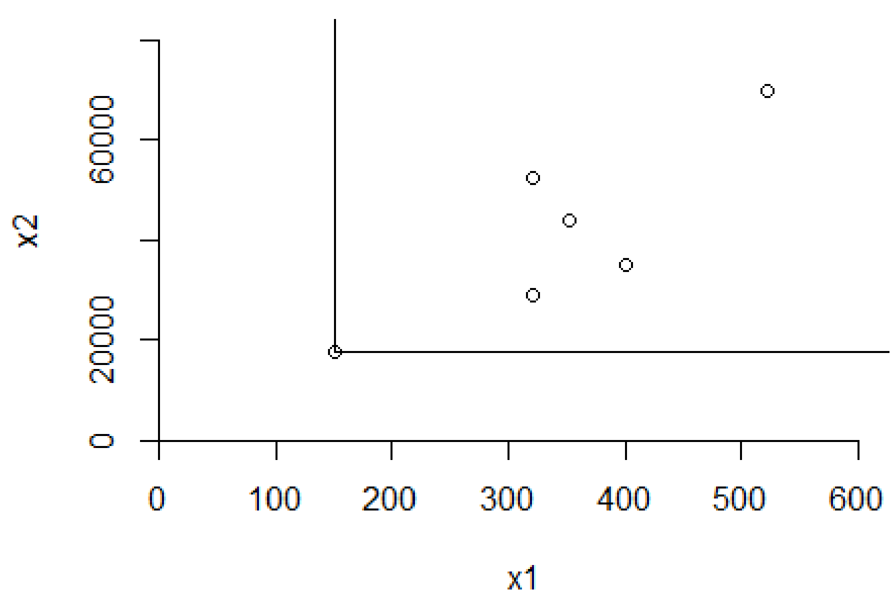
```
# Formulating DEA analysis using FDH

FDH <- rep("FDH", times = 6)
Not_Applicable <- rep(NA, times = 6)
DEA_FDH <- dea(X, Y, RTS = "FDH")
DEA_FDH_Peers <- peers(DEA_FDH)
DEA_FDH_Lambda <- lambda(DEA_FDH)

print(DEA_FDH)

## [1] 1 1 1 1 1 1

print(DEA_FDH_Peers)

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

```
## [5,]     5
## [6,]     6
```

```
print(DEA_FDH_Lambda)
```

```
##      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
```

```
dea.plot.isoquant(X, Y, RTS= "FDH")
```




```
# Plot and summarize the results for the FDH assumption

DEA_FDH_Peers <- cbind(DEA_FDH_Peers, Not_Applicable, Not_Applicable)
FDH_Summary <- cbind(FDH, DEA_FDH$eff, DEA_FDH_Peers, DEA_FDH_Lambda)
colnames(FDH_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
print(FDH_Summary)
```

```
##      Method Eff P1  P2 P3 L1  L2  L3  L4  L5  L6
## [1,] "FDH"  "1" "1" NA NA "1" "0" "0" "0" "0" "0"
## [2,] "FDH"  "1" "2" NA NA "0" "1" "0" "0" "0" "0"
## [3,] "FDH"  "1" "3" NA NA "0" "0" "1" "0" "0" "0"
## [4,] "FDH"  "1" "4" NA NA "0" "0" "0" "1" "0" "0"
```

```
## [5,] "FDH"  "1" "5" NA NA "0" "0" "0" "0" "1" "0"
## [6,] "FDH"  "1" "6" NA NA "0" "0" "0" "0" "0" "1"
```

```r
# Formulating DEA analysis using CRS
CRS <- rep("CRS", times = 6)
DEA_CRS <- dea(X, Y, RTS = "CRS")
DEA_CRS_Peers <- peers(DEA_CRS)
DEA_CRS_Lambda <- lambda(DEA_CRS)


print(DEA_CRS)
```

```
## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675
```

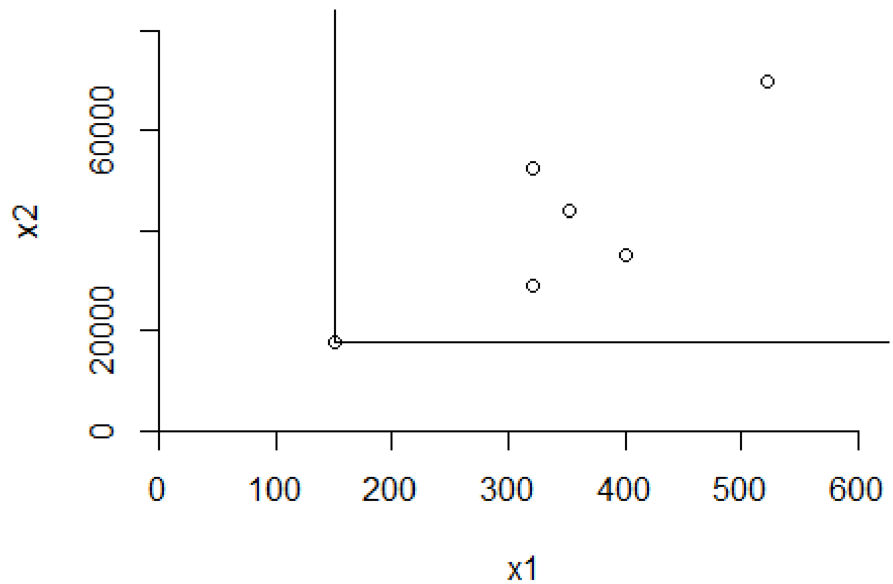
```r
print(DEA_CRS_Peers)
```

```
##      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
```

```r
print(DEA_CRS_Lambda)
```

```
##             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
```

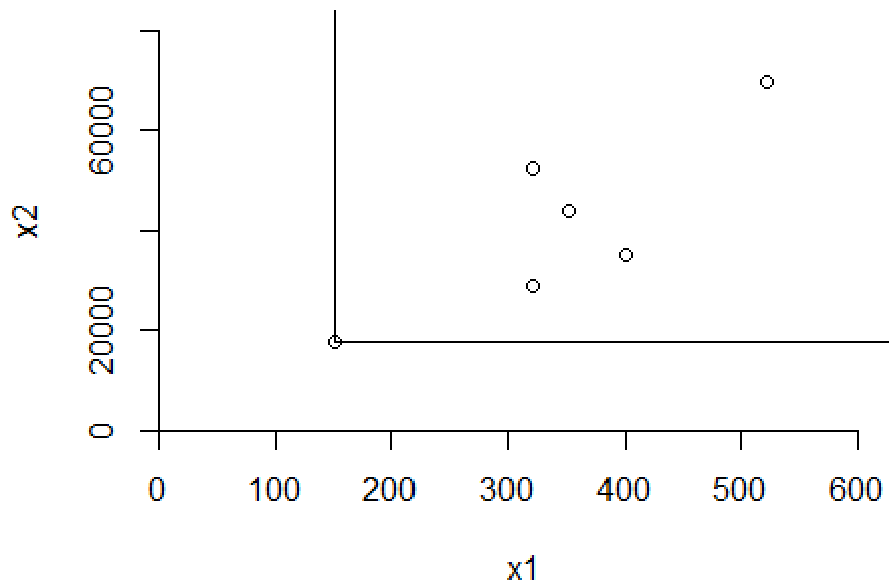
```r
dea.plot.isoquant(X, Y, RTS= "CRS")
```




```
#Plot and summarize the results for the CRS assumption

DEA_CRS_Lambda <- cbind(DEA_CRS_Lambda, Not_Applicable, Not_Applicable)
CRS_Summary <- cbind(CRS, DEA_CRS$eff, DEA_CRS_Peers, DEA_CRS_Lambda)
colnames(CRS_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
CRS_Summary <- as.data.frame(CRS_Summary)
CRS_Summary
```

```
##   Method               Eff P1   P2   P3                L1
L2 L3
## 1    CRS                 1  1 <NA> <NA>                 1
0  0
## 2    CRS                 1  2 <NA> <NA>                 0
1  0
## 3    CRS                 1  3 <NA> <NA>                 0
0  1
## 4    CRS                 1  4 <NA> <NA>                 0
0  0
## 5    CRS 0.977498691784406  1    2    4               0.2 0.08048142333856
61  0
## 6    CRS 0.867452135493373  1    2    4 0.342857142857143   0.394992636229
75  0
##                  L4   L5   L6
## 1                 0 <NA> <NA>
## 2                 0 <NA> <NA>
## 3                 0 <NA> <NA>
```

```
## 4                  1 <NA> <NA>
## 5 0.538330716902146 <NA> <NA>
## 6 0.131075110456554 <NA> <NA>

# Formulating DEA analysis using VRS
VRS <- rep("VRS", times = 6)
DEA_VRS <- dea(X, Y, RTS = "VRS")
DEA_VRS_Peers <- peers(DEA_VRS)
DEA_VRS_Lambda <- lambda(DEA_VRS)

print(DEA_VRS)

## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963

print(DEA_VRS_Peers)

##      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

print(DEA_VRS_Lambda)

##             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

dea.plot.isoquant(X, Y, RTS= "VRS")
```




```
# Plot and summarize the results for the VRS assumption

DEA_VRS_Lambda <- cbind(DEA_VRS_Lambda, Not_Applicable)
VRS_Summary <- cbind(VRS, DEA_VRS$eff, DEA_VRS_Peers, DEA_VRS_Lambda)
colnames(VRS_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
VRS_Summary <- as.data.frame(VRS_Summary)
VRS_Summary

##   Method                Eff P1   P2   P3               L1                L
2 L3
## 1    VRS                  1  1 <NA> <NA>                1
0  0
## 2    VRS                  1  2 <NA> <NA>                0
1  0
## 3    VRS                  1  3 <NA> <NA>                0
0  1
## 4    VRS                  1  4 <NA> <NA>                0
0  0
## 5    VRS                  1  5 <NA> <NA>                0
0  0
## 6    VRS 0.896328293736501  1    2    5 0.401439884809215 0.34226061915046
8  0
##   L4                L5   L6
## 1  0                 0 <NA>
## 2  0                 0 <NA>
## 3  0                 0 <NA>
```

```
## 4  1                 0 <NA>
## 5  0                 1 <NA>
## 6  0 0.256299496040317 <NA>
```

```
# Formulating DEA analysis using IRS
IRS <- rep("IRS", times = 6)
DEA_IRS <- dea(X, Y, RTS = "IRS")
DEA_IRS_Peers <- peers(DEA_IRS)
DEA_IRS_Lambda <- lambda(DEA_IRS)

print(DEA_IRS)
```

```
## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963
```

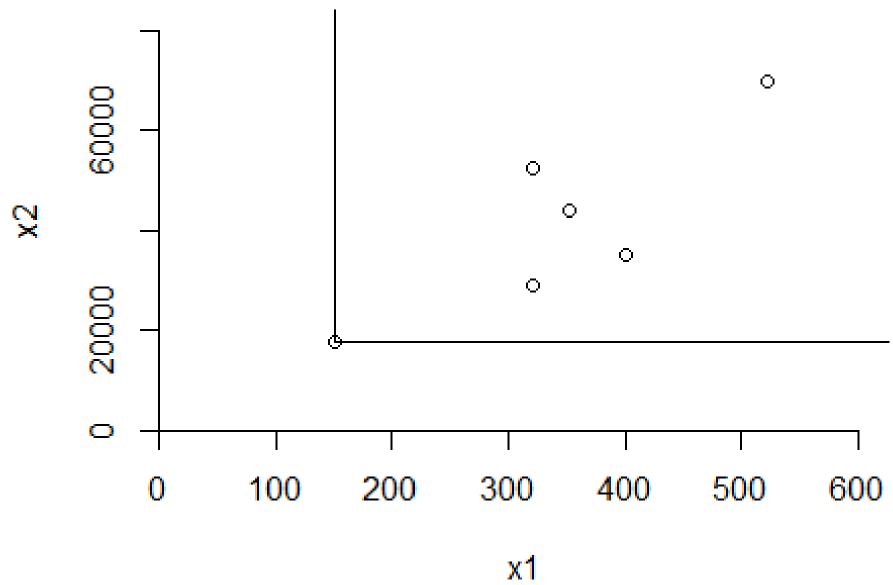
```
print(DEA_IRS_Peers)
```

```
##      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
```

```
print(DEA_IRS_Lambda)
```

```
##             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
```

```
dea.plot.isoquant(X, Y, RTS= "IRS")
```




```
# Plot and summarize the results for the IRS assumption

DEA_IRS_Lambda <- cbind(DEA_IRS_Lambda, Not_Applicable)
IRS_Summary <- cbind(IRS, DEA_IRS$eff, DEA_IRS_Peers, DEA_IRS_Lambda)
colnames(IRS_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
IRS_Summary <- as.data.frame(IRS_Summary)
IRS_Summary
```

```
##   Method                Eff P1   P2   P3                L1                 L
2 L3
## 1    IRS                  1  1 <NA> <NA>                 1
0  0
## 2    IRS                  1  2 <NA> <NA>                 0
1  0
## 3    IRS                  1  3 <NA> <NA>                 0
0  1
## 4    IRS                  1  4 <NA> <NA>                 0
0  0
## 5    IRS                  1  5 <NA> <NA>                 0
0  0
## 6    IRS 0.896328293736501  1    2    5 0.401439884809215 0.34226061915046
8  0
##   L4                L5   L6
## 1  0                 0 <NA>
## 2  0                 0 <NA>
## 3  0                 0 <NA>
```

```
## 4  1                  0 <NA>
## 5  0                  1 <NA>
## 6  0 0.256299496040317 <NA>
```

```
# Formulating DEA analysis using DRS
DRS <- rep("DRS", times = 6)
DEA_DRS <- dea(X, Y, RTS = "DRS")
DEA_DRS_Peers <- peers(DEA_DRS)
DEA_DRS_Lambda <- lambda(DEA_DRS)

print(DEA_DRS)
```

```
## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675
```

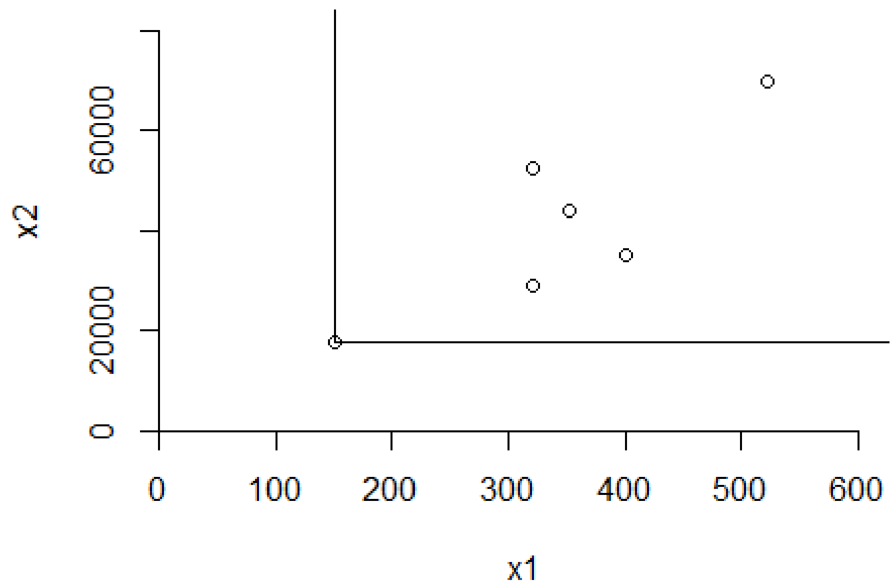
```
print(DEA_DRS_Peers)
```

```
##      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
```

```
print(DEA_DRS_Lambda)
```

```
##             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
```

```
dea.plot.isoquant(X, Y, RTS= "DRS")
```




```
# Plot and summarize the results for the DRS assumption

DEA_DRS_Lambda <- cbind(DEA_DRS_Lambda, Not_Applicable, Not_Applicable)
DRS_Summary <- cbind(DRS, DEA_DRS$eff, DEA_DRS_Peers, DEA_DRS_Lambda)
colnames(DRS_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
DRS_Summary <- as.data.frame(DRS_Summary)
DRS_Summary

##   Method                Eff P1   P2   P3                L1
L2 L3
## 1    DRS                  1  1 <NA> <NA>                 1
0  0
## 2    DRS                  1  2 <NA> <NA>                 0
1  0
## 3    DRS                  1  3 <NA> <NA>                 0
0  1
## 4    DRS                  1  4 <NA> <NA>                 0
0  0
## 5    DRS 0.977498691784406  1    2    4               0.2 0.08048142333856
55  0
## 6    DRS 0.867452135493373  1    2    4 0.342857142857143  0.3949926362297
49  0
##                 L4   L5   L6
## 1                0 <NA> <NA>
## 2                0 <NA> <NA>
## 3                0 <NA> <NA>
```

```
## 4                  1 <NA> <NA>
## 5 0.538330716902146 <NA> <NA>
## 6 0.131075110456554 <NA> <NA>

# Formulating DEA analysis using FRH or also called as ADD
ADD <- rep("ADD", times = 6)
DEA_ADD <- dea(X, Y, RTS = "ADD")
DEA_ADD_Peers <- peers(DEA_ADD)
DEA_ADD_Lambda <- lambda(DEA_ADD)

print(DEA_ADD)

## [1] 1 1 1 1 1 1

print(DEA_ADD_Peers)

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

print(DEA_ADD_Lambda)

##      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

# Plot and summarize the results for the FRH/ADD assumption

DEA_ADD_Peers <- cbind(DEA_ADD_Peers, Not_Applicable, Not_Applicable)
ADD_Summary <- cbind(ADD, DEA_ADD$eff, DEA_ADD_Peers, DEA_ADD_Lambda)
colnames(ADD_Summary) <- c("Method","Eff", "P1", "P2", "P3", "L1", "L2", "L3"
, "L4", "L5", "L6")
ADD_Summary <- as.data.frame(ADD_Summary)
ADD_Summary

##   Method Eff P1   P2   P3 L1 L2 L3 L4 L5 L6
## 1    ADD   1  1 <NA> <NA>  1  0  0  0  0  0
## 2    ADD   1  2 <NA> <NA>  0  1  0  0  0  0
## 3    ADD   1  3 <NA> <NA>  0  0  1  0  0  0
## 4    ADD   1  4 <NA> <NA>  0  0  0  1  0  0
## 5    ADD   1  5 <NA> <NA>  0  0  0  0  1  0
## 6    ADD   1  6 <NA> <NA>  0  0  0  0  0  1
```

Q3. Summarize your results in a tabular format

```
# Summarizing all the results from every DEA assumption in a tabular form
summary_table <- rbind(FDH_Summary, CRS_Summary, VRS_Summary, IRS_Summary, DR
S_Summary, ADD_Summary)
print(summary_table)

##    Method                Eff P1   P2   P3                L1
L2
## 1     FDH                  1  1 <NA> <NA>                 1
0
## 2     FDH                  1  2 <NA> <NA>                 0
1
## 3     FDH                  1  3 <NA> <NA>                 0
0
## 4     FDH                  1  4 <NA> <NA>                 0
0
## 5     FDH                  1  5 <NA> <NA>                 0
0
## 6     FDH                  1  6 <NA> <NA>                 0
0
## 7     CRS                  1  1 <NA> <NA>                 1
0
## 8     CRS                  1  2 <NA> <NA>                 0
1
## 9     CRS                  1  3 <NA> <NA>                 0
0
## 10    CRS                  1  4 <NA> <NA>                 0
0
## 11    CRS 0.977498691784406  1    2    4               0.2 0.0804814233385
661
## 12    CRS 0.867452135493373  1    2    4 0.342857142857143   0.39499263622
975
## 13    VRS                  1  1 <NA> <NA>                 1
0
## 14    VRS                  1  2 <NA> <NA>                 0
1
## 15    VRS                  1  3 <NA> <NA>                 0
0
## 16    VRS                  1  4 <NA> <NA>                 0
0
## 17    VRS                  1  5 <NA> <NA>                 0
0
## 18    VRS 0.896328293736501  1    2    5 0.401439884809215  0.342260619150
468
## 19    IRS                  1  1 <NA> <NA>                 1
0
## 20    IRS                  1  2 <NA> <NA>                 0
1
## 21    IRS                  1  3 <NA> <NA>                 0
0
```

```
## 22    IRS                 1  4 <NA> <NA>                0
0
## 23    IRS                 1  5 <NA> <NA>                0
0
## 24    IRS 0.896328293736501  1    2    5 0.401439884809215  0.342260619150
468
## 25    DRS                 1  1 <NA> <NA>                1
0
## 26    DRS                 1  2 <NA> <NA>                0
1
## 27    DRS                 1  3 <NA> <NA>                0
0
## 28    DRS                 1  4 <NA> <NA>                0
0
## 29    DRS 0.977498691784406  1    2    4               0.2 0.0804814233385
655
## 30    DRS 0.867452135493373  1    2    4 0.342857142857143  0.394992636229
749
## 31    ADD                 1  1 <NA> <NA>                1
0
## 32    ADD                 1  2 <NA> <NA>                0
1
## 33    ADD                 1  3 <NA> <NA>                0
0
## 34    ADD                 1  4 <NA> <NA>                0
0
## 35    ADD                 1  5 <NA> <NA>                0
0
## 36    ADD                 1  6 <NA> <NA>                0
0
##    L3                L4                L5   L6
## 1   0                 0                 0    0
## 2   0                 0                 0    0
## 3   1                 0                 0    0
## 4   0                 1                 0    0
## 5   0                 0                 1    0
## 6   0                 0                 0    1
## 7   0                 0              <NA> <NA>
## 8   0                 0              <NA> <NA>
## 9   1                 0              <NA> <NA>
## 10  0                 1              <NA> <NA>
## 11  0 0.538330716902146              <NA> <NA>
## 12  0 0.131075110456554              <NA> <NA>
## 13  0                 0                 0 <NA>
## 14  0                 0                 0 <NA>
## 15  1                 0                 0 <NA>
## 16  0                 1                 0 <NA>
## 17  0                 0                 1 <NA>
## 18  0                 0 0.256299496040317 <NA>
## 19  0                 0                 0 <NA>
```

```
## 20  0                 0                 0 <NA>
## 21  1                 0                 0 <NA>
## 22  0                 1                 0 <NA>
## 23  0                 0                 1 <NA>
## 24  0                 0 0.256299496040317 <NA>
## 25  0                 0              <NA> <NA>
## 26  0                 0              <NA> <NA>
## 27  1                 0              <NA> <NA>
## 28  0                 1              <NA> <NA>
## 29  0 0.538330716902146              <NA> <NA>
## 30  0 0.131075110456554              <NA> <NA>
## 31  0                 0                 0    0
## 32  0                 0                 0    0
## 33  1                 0                 0    0
## 34  0                 1                 0    0
## 35  0                 0                 1    0
## 36  0                 0                 0    1
```

```
# creating an excel file
library(rio)

## Warning: package 'rio' was built under R version 4.2.1

library(writexl)

## Warning: package 'writexl' was built under R version 4.2.1

export(summary_table,"C:/Users/mavul/OneDrive/Documents/MIS 64018 - Assignmen
t 4/64018-A4.xlsx")
```

Q4. Compare and contrast the above results

In conclusion - All the DEA assumptions estimate the technology by using a minimum extrapolation technique. What we learn here, is that the FDH is the smallest technology set and it gives out fewer outputs (no. of patient days reimbursed by third-party sources and no. of patient days reimbursed privately) with more inputs (no. of patient days reimbursed by third-party sources and no. of patient days reimbursed privately) (staffing labor and the cost of supplies).

Key takeaways –

- From the above results we saw that the FRH and FDH assumptions gave out efficiency with the value 1.0. And in every DEA assumptions the peer and lambda values were identical.

- The other observation we found out was about the efficiency at 1.0

- In the CRS method got DMU[1:4] efficient at 1.0

VRS method had DMU[1:5] efficient at 1.0

IRS method had DMU[1:5] efficient at 1.0

DRS method had DMU{1:4} efficient at 1.0

- Most importantly all of the other less efficient DMUs had a Peer[1] and Peer [2] value of 1 and 2, but Peer[3] had a value of either 4 or 5. This was dependent on the method we used for the DEA assumption.

- The lambdas also known as relative weights for the same DMUs were extremely close to each other in every method.

What we know about every Facility –

- Facilities 1,2,3 and 4 are fully efficient for all the assumptions and Facilities 5 and 6 are not efficient.

- Facility 5 is fully efficient for FDH,VRS,IRS and FRH assumptions.

- We can see that there is 97.7% efficiency for the CRS and DRS assumptions.

- Facility 6 is fully efficient for the FDH and FRS assumptions.

- For Facility 6, CRS and DRS assumptions are 86.7% efficient

- Lastly, for Facility 6, IRS and VRS assumptions are 89.6% efficient.