Module 8 - DEA

Avinash Ravipudi

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#Installing required packages

#install.packages("Benchmarking")  
library(Benchmarking)

## Loading required package: lpSolveAPI

## Loading required package: ucminf

## Loading required package: quadprog

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

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

library(lpSolveAPI)  
DEA <- read.lp("DEA.lp")  
DEA

## Model name:   
## u1 u2 v1 v2   
## Maximize 14000 3500 0 0   
## R1 14000 3500 -150 -0.2 <= 0  
## R2 14000 21000 -400 -0.7 <= 0  
## R3 42000 10500 -320 -1.2 <= 0  
## R4 28000 42000 -520 -2 <= 0  
## R5 19000 25000 -350 -1.2 <= 0  
## R6 14000 15000 -320 -0.7 <= 0  
## R7 0 0 150 0.2 = 1  
## Kind Std Std Std Std   
## Type Real Real Real Real   
## Upper Inf Inf Inf Inf   
## Lower 0 0 0 0

#Formulate models for DEA.

#To obtain the weight for DEA, formulate the issue as lp.  
solve(DEA)

## [1] 0

get.objective(DEA) #to maximize DEA efficiency

## [1] 1

get.variables(DEA) #Weights for inputs and outputs advocated for optimal efficiency

## [1] 7.142857e-05 0.000000e+00 5.172414e-03 1.120690e+00

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(14000,14000,42000,28000,19000,14000,3500,21000,10500,42000,25000,15000),ncol = 2)  
  
colnames(y) <- c("Reimbursed Patient\_Days","Privately Paid Patient\_Days")  
colnames(x) <- c("Staff\_Hours", "Supplies")  
  
  
print(x) #Print the values of 'X'

## Staff\_Hours Supplies  
## [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) #Print the values of 'Y'

## Reimbursed Patient\_Days Privately Paid Patient\_Days  
## [1,] 14000 3500  
## [2,] 14000 21000  
## [3,] 42000 10500  
## [4,] 28000 42000  
## [5,] 19000 25000  
## [6,] 14000 15000

Table<- cbind(x,y)  
row.names(Table) = c("Facility1", "Facility2", "Facility3", "Facility4", "Facility5", "Facility6")  
Table

## Staff\_Hours Supplies Reimbursed Patient\_Days  
## Facility1 150 0.2 14000  
## Facility2 400 0.7 14000  
## Facility3 320 1.2 42000  
## Facility4 520 2.0 28000  
## Facility5 350 1.2 19000  
## Facility6 320 0.7 14000  
## Privately Paid Patient\_Days  
## Facility1 3500  
## Facility2 21000  
## Facility3 10500  
## Facility4 42000  
## Facility5 25000  
## Facility6 15000

#Following that, we conduct DEA Analysis under all DEA assumptions (FDH, CRS, VRS, IRS, DRS, and FRH)

#Convexity, free disposability, and constant returns to scale  
CRS <- dea(x,y, RTS = "crs") # provide the input and output The results demonstrate that Facilities 1, 2, 3, 4, and 5 are efficient, with efficiency rates of 98% and 87%, respectively.  
print(CRS)

## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675

peers(CRS) # determine the peers For facilities 5,6, the peer units are 1,2,4.

## 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

CRS\_Weights <- lambda(CRS) #Determine the relative weights assigned to the peers. For facility 4, the weights are 0.20, 0.08, and 0.54. The facility 6 weights are 0.34, 0.39, and 0.13.  
  
  
#hull for free disposal  
FDH <- dea(x,y, RTS= "fdh")  
FDH #All amenities are effective.

## [1] 1 1 1 1 1 1

peers(FDH) #Each facility's peer is itself

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

FDH\_Weights <- lambda(FDH)  
  
  
#Convexity, free disposability, and variable returns to scale  
VRS <- dea(x,y, RTS = "vrs")  
VRS #Except for facility 6, all facilities are effective.

## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963

peers(VRS) #peers for facility 6 are 1,2,5

## 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

VRS\_Weights <- lambda(VRS)  
  
  
#Increasing returns to scale (up-scaling but not down-scaling), convexity, and free disposability  
IRS <- dea(x,y, RTS= "irs")  
IRS #Reduced scale returns, convexity, downscaling, and free disposability

## [1] 1.0000 1.0000 1.0000 1.0000 1.0000 0.8963

peers(IRS) #peers for facility 6 are 1,2,5

## 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

IRS\_Weights <- lambda(IRS)  
  
  
#Reduced returns to scale, convexity, downscaling, and free disposability  
DRS <- dea(x,y, RTS= "drs") #DRS produced the same findings as CRS.  
DRS #Except for facility 5,6, all facilities are efficient.

## [1] 1.0000 1.0000 1.0000 1.0000 0.9775 0.8675

peers(DRS) # For facilities 5,6, the peer units are 1,2,4.

## 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

DRS\_Weights <- lambda(DRS)  
   
  
  
FRH <- dea(x,y, RTS= "add")  
FRH #Every facility is effective.

## [1] 1 1 1 1 1 1

peers(FRH) #Each facility's peer unit is itself.

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

FRH\_Weights <- lambda(FRH)

as.data.frame(Table)

## Staff\_Hours Supplies Reimbursed Patient\_Days  
## Facility1 150 0.2 14000  
## Facility2 400 0.7 14000  
## Facility3 320 1.2 42000  
## Facility4 520 2.0 28000  
## Facility5 350 1.2 19000  
## Facility6 320 0.7 14000  
## Privately Paid Patient\_Days  
## Facility1 3500  
## Facility2 21000  
## Facility3 10500  
## Facility4 42000  
## Facility5 25000  
## Facility6 15000

Df <-data.frame (CRS = c(1.0000, 1.0000, 1.0000, 1.0000, 0.9775, 0.8675),  
FDH= c(1,1,1,1,1,1), VRS= c(1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 0.8963),IRS =c( 1.0000, 1.0000, 1.0000, 1.0000, 1.0000 ,0.8963), DRS= c(1.0000 ,1.0000 ,1.0000, 1.0000, 0.9775, 0.8675), FRH= c(1,1,1,1,1,1))  
Df

## CRS FDH VRS IRS DRS FRH  
## 1 1.0000 1 1.0000 1.0000 1.0000 1  
## 2 1.0000 1 1.0000 1.0000 1.0000 1  
## 3 1.0000 1 1.0000 1.0000 1.0000 1  
## 4 1.0000 1 1.0000 1.0000 1.0000 1  
## 5 0.9775 1 1.0000 1.0000 0.9775 1  
## 6 0.8675 1 0.8963 0.8963 0.8675 1

#We now examine the efficiency outcomes at each facility in each DEA scenario. CRS and DRS produce the same findings, as do FDH and FRH, and both VRS and IRS produce the same results.  
Results <- cbind(Table,Df)  
Results[,-c(1:4)]

## CRS FDH VRS IRS DRS FRH  
## Facility1 1.0000 1 1.0000 1.0000 1.0000 1  
## Facility2 1.0000 1 1.0000 1.0000 1.0000 1  
## Facility3 1.0000 1 1.0000 1.0000 1.0000 1  
## Facility4 1.0000 1 1.0000 1.0000 1.0000 1  
## Facility5 0.9775 1 1.0000 1.0000 0.9775 1  
## Facility6 0.8675 1 0.8963 0.8963 0.8675 1

#A list of the weights allocated to each facility in each DEA assumption.  
Weights\_tbl <- cbind(FDH\_Weights, CRS\_Weights, VRS\_Weights, IRS\_Weights, DRS\_Weights, FRH\_Weights)  
row.names(Weights\_tbl) = c("Fac1", "Fac2", "Fac3", "Fac4", "Fac5", "Fac6")  
  
colnames(Weights\_tbl) <- c("FDH","FDH", "FDH", "FDH","FDH","FDH", "CRS", "CRS", "CRS", "CRS", "VRS", "VRS", "VRS","VRS", "VRS", "IRS", "IRS", "IRS", "IRS","IRS", "DRS", "DRS", "DRS", "DRS", "FRH", "FRH", "FRH", "FRH", "FRH","FRH")   
as.data.frame(Weights\_tbl) #The table summarizes the input and output weights for each facility under each DEA assumption.

## FDH FDH FDH FDH FDH FDH CRS CRS CRS CRS VRS  
## Fac1 1 0 0 0 0 0 1.0000000 0.00000000 0 0.0000000 1.0000000  
## Fac2 0 1 0 0 0 0 0.0000000 1.00000000 0 0.0000000 0.0000000  
## Fac3 0 0 1 0 0 0 0.0000000 0.00000000 1 0.0000000 0.0000000  
## Fac4 0 0 0 1 0 0 0.0000000 0.00000000 0 1.0000000 0.0000000  
## Fac5 0 0 0 0 1 0 0.2000000 0.08048142 0 0.5383307 0.0000000  
## Fac6 0 0 0 0 0 1 0.3428571 0.39499264 0 0.1310751 0.4014399  
## VRS VRS VRS VRS IRS IRS IRS IRS IRS  
## Fac1 0.0000000 0 0 0.0000000 1.0000000 0.0000000 0 0 0.0000000  
## Fac2 1.0000000 0 0 0.0000000 0.0000000 1.0000000 0 0 0.0000000  
## Fac3 0.0000000 1 0 0.0000000 0.0000000 0.0000000 1 0 0.0000000  
## Fac4 0.0000000 0 1 0.0000000 0.0000000 0.0000000 0 1 0.0000000  
## Fac5 0.0000000 0 0 1.0000000 0.0000000 0.0000000 0 0 1.0000000  
## Fac6 0.3422606 0 0 0.2562995 0.4014399 0.3422606 0 0 0.2562995  
## DRS DRS DRS DRS FRH FRH FRH FRH FRH FRH  
## Fac1 1.0000000 0.00000000 0 0.0000000 1 0 0 0 0 0  
## Fac2 0.0000000 1.00000000 0 0.0000000 0 1 0 0 0 0  
## Fac3 0.0000000 0.00000000 1 0.0000000 0 0 1 0 0 0  
## Fac4 0.0000000 0.00000000 0 1.0000000 0 0 0 1 0 0  
## Fac5 0.2000000 0.08048142 0 0.5383307 0 0 0 0 1 0  
## Fac6 0.3428571 0.39499264 0 0.1310751 0 0 0 0 0 1

###DEA Analysis Summary for Hope Valley Health Care Association: All facilities are efficient under FDH and FRH; all facilities are efficient under CRS and DRS except Facility 5,6. Except for facility 6, all were efficient under VRS and IRS assumptions. They are the peer units for efficient facilities. The VRS and IRS assumptions for inefficient facilities were 1, 2, and 5. The peer units under CRS and DRS were 1, 2, and 4.