---

title: “sjain15_Assignment_3” author: “Sargam Jain” date: “10/16/2022” output: pdf_document: default word_document: default

Objective Function Minimize TC = 622x11+614x12+630x13+641x21+645x22+649x23 These are subject to following constraints x11+x12+x13 >= 100 x21+x22+x23 >= 120 These are supply constraints

x11+x21 >= 80 x12+x22 >= 60 x13+x23 >= 70 These are demand constraints

These are all subject to non-negativity where xij>=0 where i=1,2 and j= 1,2,3

```
library(Matrix)
library(tinytex)
library("lpSolve")

display <- matrix(c(22,14,30,600,100,
                    16,20,24,625,120,
                    80,60,70,"-","210/220"),ncol=5,nrow=3,byrow=TRUE)
 colnames(display) <- c("Warehouse1","Warehouse2","Warehouse3","Production
Cost","Production Capacity")
 rownames(display) <- c("PlantA","PlantB","Monthly Demand")
 display <- as.table(display)
 display

##                Warehouse1 Warehouse2 Warehouse3 Production Cost
## PlantA         22         14         30         600
## PlantB         16         20         24         625
## Monthly Demand 80         60         70         -
##                Production Capacity
## PlantA         100
## PlantB         120
## Monthly Demand 210/220

  display1 <- matrix(c(622,614,630,0,100,
                    641,645,649,0,120,
                    80,60,70,10,220),ncol=5,nrow=3,byrow=TRUE)
 colnames(display1) <-
c("Warehouse1","Warehouse2","Warehouse3","Dummy","Production Capacity")
 rownames(display1) <- c("PlantA","PlantB","Monthly Demand")
 display1 <- as.table(display1)
 display1

##                Warehouse1 Warehouse2 Warehouse3 Dummy Production Capacity
## PlantA                622        614        630     0                 100
## PlantB                641        645        649     0                 120
## Monthly Demand         80         60         70    10                 220
```

#This table will satisfy the need for balanced problem. We have made total costs matrix below

```
totalcosts <- matrix(c(622,614,630,0,
                       641,645,649,0),nrow=2, byrow = TRUE)
```

#Identifying production capacity in the row of the matrix

```
row.rhs <- c(100,120)
 row.signs <- rep("<=", 2)
```

#Identifying the monthly demand with double variable 10 at the end.

```
col.rhs <- c(80,60,70,10)
 col.signs <- rep(">=", 4)
```

#Ready to run LP Transport command

```
lp.transport(totalcosts,"min",row.signs,row.rhs,col.signs,col.rhs)

## Success: the objective function is 132790
```

#Here is the solution matrix

```
lp.transport(totalcosts, "min", row.signs, row.rhs, col.signs,
col.rhs)$solution

##      [,1] [,2] [,3] [,4]
## [1,]    0   60   40    0
## [2,]   80    0   30   10
```

This gives us the following that Z = $132790. This gives us the following results for each of the variables: 60x12 which is the Warehouse 2 from plant A. 40x13 which is the Warehouse 3 from plant A. 80x21 which is the Warehouse 1 from plant B. 30x23 which is the Warehouse 3 from plant B. and because “10” shows up in the 4th Variable 10x24 is a “throw away variable”. This would complete the answer for Question 1.

Qyestion 2) We know that the number of variables in primal is equal to the number of constants in dual. The first question is the primal of the LP. Since we took the minimization in the primal we will maximize in the dual. let’s use the variables “m” & “n” for the dual problem

```
display2 <- matrix(c(622,614,630,100,"m_1",
                     641,645,649,120,"m_2",
                     80,60,70,220,"-",
                     "n_1","n_2","n_3","-","-"),ncol=5,nrow=4,byrow=TRUE)
 colnames(display2) <- c("W1","W2","W3","Prod Cap","Supply (Dual)")
 rownames(display2) <- c("PlantA","PlantB","Monthly Demand","Demand (Dual)")
 display2 <- as.table(display2)
 display2

##                W1  W2  W3  Prod Cap Supply (Dual)
## PlantA         622 614 630 100      m_1
## PlantB         641 645 649 120      m_2
```

```
## Monthly Demand 80  60  70  220      -
## Demand (Dual)  n_1 n_2 n_3 -        -
```

From here we are going to create our objective function based on the constraints from the primal. Then use the objective function from the primal to find the constants of the dual.

Maximize Z = 100m1+120m2+80n1+60n2+70n3

This objective function is subject to following constraints:

m1+n1 <= 622 m1+n2 <= 614 m1+n3 <= 630 m2+n1 <= 641 m2+n2 <= 645 m2+n3 <= 649

These constants are taken from the transposed matrix of the primal of the linear programming function. An easy way to check is to transpose the f.con into the matrix and match to the constants above in the primal. These are unrestricted where mk, nl where m=1,2 & n=1,2,3

#Constants of the primal are now the objective function variables.

```
 f.obj <- c(100,120,80,60,70)
 #transposed from the constraints matrix in the primal
 f.con <- matrix(c(1,0,1,0,0,
                   1,0,0,1,0,
                   1,0,0,0,1,
                   0,1,1,0,0,
                   0,1,0,1,0,
                   0,1,0,0,1),nrow=6, byrow = TRUE)
 #these change because we are MAX the dual not min
 f.dir <- c("<=",
 "<=",
 "<=",
 "<=",
"<=", "<=")
 f.rhs <- c(622,614,630,641,645,649)
 lp ("max", f.obj, f.con, f.dir, f.rhs)

## Success: the objective function is 139120

lp ("max", f.obj, f.con, f.dir, f.rhs)$solution

## [1] 614 633   8   0  16
```

So Z=139,120 dollars and variables are: m1 = 614 which represents plant A m2 = 633 which represents Plant B n1 = 8 which represents Warehouse 1 n3 = 16 which represents Warehouse 3

OBSERVATION

The minimal Z=132790 (Primal) and the maximum Z=139120(Dual). What are we trying to max/min in this problem. We found that we should not be shipping from Plant(A/B) to all three Warehouses. We should be shipping from:

60x12 which is 60 Units from Plant A to Warehouse 2. 40x13 which is 40 Units from Plant A to Warehouse 3. 80x21 which is 60 Units from Plant B to Warehouse 1. 30x23 which is 60 Units from Plant B to Warehouse 3. Now we want to Max the profits from each distribution in respect to capacity.

Question 3)

m1 - n1 <= 622

then we subtract n1 to the other side to get m1 <= 622 - n1

To compute that value it would be $614<=(-8+622) which is true. We would continue to evaluate these equations:

m1 <= 622-n1===614<=622-8=614 = TRUE m1 <= 614-n2===614<=614-0=614 = TRUE m1 <= 630-n3===614<=630-16=614 = TRUE m2 <= 641-n1===633<=641-8=633 = TRUE m2 <= 645−n2===633<=645-0=645 = NOT TRUE m2 <= 649-n3===633<=649-16=633 = TRUE

#Also learning from the Duality-and-Sensitivity we can test for the shadow price by updating each of the column. We change the 100 to 101 and 120 to 121 in our LP Transport.

```
row.rhs1 <- c(101,120)
 row.signs1 <- rep("<=", 2)
 col.rhs1 <- c(80,60,70,10)
 col.signs1 <- rep(">=", 4)
 row.rhs2 <- c(100,121)
 row.signs2 <- rep("<=", 2)
 col.rhs2 <- c(80,60,70,10)
 col.signs2 <- rep(">=", 4)
 lp.transport(totalcosts,"min",row.signs,row.rhs,col.signs,col.rhs)
```

```
## Success: the objective function is 132790
```

```
 lp.transport(totalcosts,"min",row.signs1,row.rhs1,col.signs1,col.rhs1)
```

```
## Success: the objective function is 132771
```

```
lp.transport(totalcosts,"min",row.signs2,row.rhs2,col.signs2,col.rhs2)
```

```
## Success: the objective function is 132790
```

Since we are taking the min of this specific function seeing the number go down by 19 means the shadow price is 19, that was found from the primal and adding 1 to each of the Plants. However with Plant B does not have a shadow price. We also found that the dual variable n2 where Marginal Revenue (MR) <= Marginal Cost (MC). Recalling the equation which was m2 <= 645 -n2===633<=645-0=645 = NOT TRUE which was found by using m1-n1 <= 622

```
lp ("max", f.obj, f.con, f.dir, f.rhs)$solution
```

```
## [1] 614 633   8   0  16
```

n_2 was = 0.

CONCLUSION: from the primal: 60x12 which is 60 Units from Plant A to Warehouse 2. 40x13 which is 40 Units from Plant A to Warehouse 3. 80x21 which is 60 Units from Plant B to Warehouse 1. 30x23 which is 60 Units from Plant B to Warehouse 3. from the dual We want the MR=MC. Five of the six MR<=MC. The only equation that does not satisfy this requirement is Plant B to Warehouse 2. We can see that from the primal that we will not be shipping any AED device there.