Assignment_3

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1) Formulate and solve this transportation problem using R

```
library(lpSolve)
```

```
## Warning: package 'lpSolve' was built under R version 4.1.3
```

```
library(lpSolveAPI)
```

```
## Warning: package 'lpSolveAPI' was built under R version 4.1.3
```

```
library(tinytex)
```

```
#set the matrix and creating a table
AEDs <- matrix(c(22,14,30,600,100,
                 16,20,24,625,120,
                 80,60,70,"-","-"),ncol=5,byrow=TRUE)

colnames(AEDs) <- c("Warehouse1", "Warehouse2", "Warehouse3","Production cost","Production Capacity")
rownames(AEDs) <- c("Plant A", "Plant B", "Monthly Demand")
AEDs <- as.table(AEDs)
AEDs
```

```
##                Warehouse1 Warehouse2 Warehouse3 Production cost
## Plant A        22         14         30         600
## Plant B        16         20         24         625
## Monthly Demand 80         60         70         -
##                Production Capacity
## Plant A        100
## Plant B        120
## Monthly Demand -
```

objective Function:

The above transportation problem can be formulated in the LP format as below:

Miminize $TC = 622x_{A1} + 614x_{A2} + 630x_{A3} + 0x_{A4} + 641x_{B1} + 645x_{B2} + 649x_{B3} + 0x_{B4}$

Subject to:

Supply constraints

$$x_{A1} + x_{A2} + x_{A3} + x_{A4} \leq 100$$

$$x_{B1} + x_{B2} + x_{B3} + x_{B4} \leq 120$$

Demand Constraints:

$$x_{A1} + x_{B1} \geq 80$$
$$x_{A2} + x_{B2} \geq 60$$
$$x_{A3} + x_{B3} \geq 70$$
$$x_{A4} + x_{B4} \geq 10$$

Non-negativity of the variables:

$$x_{ij} \geq 0$$

$$Xij$$

-

$$where represents the number of AEDs shipped from plant i to warehouse j.$$

$$i = A, B$$

and

$$j = 1, 2, 3, 4$$

I have used R programming language to solve the above transportation cost minimization problem. This transportation problem is unbalanced one (demand is not equal to supply), that is demand is less than supply by 10, so I create a dummy variable in column 4 with transportation cost zero and demand 10.

```
#Creating a matrix for the given objective function
AEDs_Costs <- matrix(c(622,614,630,0,
                       641,645,649,0),ncol = 4,byrow=TRUE)
## Set the names of the rows (constraints) and columns (decision variables)
colnames(AEDs_Costs) <- c("Warehouse1", "Warehouse2", "Warehouse3","Dummy")
rownames(AEDs_Costs) <- c("Plant A", "Plant B")
AEDs_Costs
```

```
##         Warehouse1 Warehouse2 Warehouse3 Dummy
## Plant A        622        614        630     0
## Plant B        641        645        649     0
```

```r
#setting up constraint signs and right-hand sides(supply side)
row.signs <- rep("<=",2)
row.rhs <- c(100,120)
#Supply function cannot be greater than the specified units

#Demand side constraints#
col.signs <- rep(">=",4)
col.rhs <- c(80,60,70,10)
#Demand function can be greater than the specified units
```

```r
#solve the model
lptrans <- lp.transport(AEDs_Costs, "min", row.signs, row.rhs, col.signs, col.rhs)
```

```r
#Getting the objective value
lptrans$objval
```

```
## [1] 132790
```

The minimum combined shipping and production costs will be 132,790 dollars based on the given information and constrain

Next, we will return the values of the decision variables to decide how many units should be produced and shipped from eac

```r
## Get the optimum decision variables (6)values
lptrans$solution
```

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

Observations:

Plant A Units Shipped to Warehouse 2: ***60 units***

Plant A Units Shipped to Warehouse 3: ***40 units***

Plant B Units Shipped to Warehouse 1: ***80 units***

Plant B Units Shipped to Warehouse 3: ***30 units***

and "10" shows up in the 4th variable it is a "throw-away variable"(dummy).

2)Formulate the dual of this transportation problem

Besides reducing transportation costs, a secondary goal would be to increase value added (VA).

$$Maximize \;\; VA = \; 80W_1 + 60W_2 + 70W_3 - 100P_A - 120P_B$$

Subject to the following constraints:

$$Total\ \ Payment\ \ Constraints$$
$$W_1 - P_A >= 622$$
$$W_2 - P_A >= 614$$
$$W_3 - P_A >= 630$$
$$W_1 - P_B >= 641$$
$$W_2 - P_B >= 645$$
$$W_3 - P_B >= 649$$

$$Where\ \ W_1 = Warehouse\ \ 1$$
$$W_2 = Warehouse\ \ 2$$
$$W_3 = Warehouse\ \ 3$$
$$P_A = Plant\ \ 1$$
$$P_B = Plant\ \ 2$$

3)Make an economic interpretation of the dual

$$W_1 \leq 622 + P_A$$
$$W_2 \leq 614 + P_A$$
$$W_3 \leq 630 + P_A$$
$$W_1 \leq 641 + P_B$$
$$W_2 \leq 645 + P_B$$
$$W_3 \leq 649 + P_B$$

$$From\ \ the\ \ above\ \ we\ \ can\ \ see\ \ that\ \ W_1 - P_A \geq 622$$

$$that\ \ can\ \ also\ \ be\ \ expressed\ \ as\ \ W_1 \leq 622 + P_A$$

$$Here\ \ W_1\ \ is\ \ considered\ \ as\ \ the\ \ price\ \ payments\ \ being\ \ received\ \ at\ \ the\ \ origin\ \ which\ \ is\ \ nothing\ \ else,$$
$$but\ \ the\ \ revenue,\ \ whereas\ \ P_A + 622\ \ is\ \ the\ \ money\ \ paid\ \ at\ \ the\ \ origin\ \ at\ \ Plant_A$$

$$Therefore\ \ here\ \ the\ \ equation\ \ will\ \ be\ \ MR_1 >= MC_1.$$

$$we\ \ know\ \ that, For\ \ a\ \ profit\ \ maximization,\ \ The\ \ Marginal\ \ Revenue(MR)\ \ should\ \ be\ \ equal\ \ to\ \ Marginal\ \ Costs(MC$$

$$Therefore, \quad MR_1 = MC_1$$

$$From\ the\ above\ interpretation,\ we\ can\ Observe\ that,$$
$$The\ Profit\ maximization\ takes\ place\ if\ MC\ is\ equal\ to\ MR\ (MC = MR).$$

If MR < MC, We have to lower plant costs in order to obtain the Marginal Revenue (MR).

If MR > MC, We have to boost manufacturing supply if we want to reach the Marginal Revenue (MR).