SADS-Problem-7 **13-03-2024**

In the first phase of a study of the cost of transporting milk from farms to dairy plants, a survey was taken of firms engaged in milk transportations. Cost data on X_1 = fuel, X_2 = repair and X_3=capital, all measured on a per mile basis, are presented in below table for n_1=20 gasoline and n_2=15 diesel trucks.

Table-1: Milk Transportation Cost Data

Gasoline Trucks			Diesel Trucks		
X_1	X_2	X_3	X_1	X_2	X_3
16	12	11	8	12	9
7	3	4	7	5	17
10	2	10	10	3	11
4	6	8	10	15	6
11	5	11	13	4	29
14	6	10	10	13	11
13	11	11	6	9	19
13	14	9	11	10	14
29	15	3	9	3	14
13	8	10	10	5	21
7	6	8	11	18	35
10	4	9	12	12	17
10	5	10	9	13	21
11	6	8	8	10	17
12	14	14	8	6	16
10	3	6			
10	6	12			
9	3	12			
12	8	11			
8	14	12			

Test whether mean cost vectors for Gasoline Trucks and Diesel Trucks are same or not at $\alpha = 0.01$ level of significance [$F_{3,31}(0.01) = 4.48$].

Solution:

```
rm(list=ls())
x11=c(16,7,10,4,11,14,13,13,29,13,7,10,10,11,12,10,10,9,12,8)
x21=c(12,3,2,6,5,6,11,14,15,8,6,4,5,6,14,3,6,3,8,14)
x31=c(11,4,10,8,11,10,11,9,3,10,8,9,10,8,14,6,12,12,11,12)
x=c(x11,x21,x31)
X1=matrix(x,ncol=3,byrow=F)
X1
      [,1] [,2] [,3]
 [1,]   16   12   11
 [2,]    7    3    4
 [3,]   10    2   10
 [4,]    4    6    8
 [5,]   11    5   11
 [6,]   14    6   10
```

```
 [7,]   13   11   11
 [8,]   13   14    9
 [9,]   29   15    3
[10,]   13    8   10
[11,]    7    6    8
[12,]   10    4    9
[13,]   10    5   10
[14,]   11    6    8
[15,]   12   14   14
[16,]   10    3    6
[17,]   10    6   12
[18,]    9    3   12
[19,]   12    8   11
[20,]    8   14   12
```

```
n1=20
x12=c(8,7,10,10,13,10,6,11,9,10,11,12,9,8,8)
x22=c(12,5,3,15,4,13,9,10,3,5,18,12,13,10,6)
x32=c(9,17,11,6,29,11,19,14,14,21,35,17,21,17,16)
y=c(x12,x22,x32)
X2=matrix(y,ncol=3,byrow=F)
X2
```

```
      [,1] [,2] [,3]
 [1,]    8   12    9
 [2,]    7    5   17
 [3,]   10    3   11
 [4,]   10   15    6
 [5,]   13    4   29
 [6,]   10   13   11
 [7,]    6    9   19
 [8,]   11   10   14
 [9,]    9    3   14
[10,]   10    5   21
[11,]   11   18   35
[12,]   12   12   17
[13,]    9   13   21
[14,]    8   10   17
[15,]    8    6   16
```

```
n2=15

M1=colMeans(X1)
M1

[1] 11.45  7.55  9.45

M2=colMeans(X2)
M2

[1]  9.466667  9.200000 17.133333

#mean difference
M=M1-M2
M

[1]  1.983333 -1.650000 -7.683333

X1bar=matrix(M1,nrow=20,ncol=3,byrow=T)
X1bar

       [,1] [,2] [,3]
 [1,] 11.45 7.55 9.45
 [2,] 11.45 7.55 9.45
```

```
 [3,] 11.45 7.55 9.45
 [4,] 11.45 7.55 9.45
 [5,] 11.45 7.55 9.45
 [6,] 11.45 7.55 9.45
 [7,] 11.45 7.55 9.45
 [8,] 11.45 7.55 9.45
 [9,] 11.45 7.55 9.45
[10,] 11.45 7.55 9.45
[11,] 11.45 7.55 9.45
[12,] 11.45 7.55 9.45
[13,] 11.45 7.55 9.45
[14,] 11.45 7.55 9.45
[15,] 11.45 7.55 9.45
[16,] 11.45 7.55 9.45
[17,] 11.45 7.55 9.45
[18,] 11.45 7.55 9.45
[19,] 11.45 7.55 9.45
[20,] 11.45 7.55 9.45
```

```
X2bar=matrix(M2,nrow=15,ncol=3,byrow=T)
X2bar
```

```
          [,1] [,2]     [,3]
 [1,] 9.466667  9.2 17.13333
 [2,] 9.466667  9.2 17.13333
 [3,] 9.466667  9.2 17.13333
 [4,] 9.466667  9.2 17.13333
 [5,] 9.466667  9.2 17.13333
 [6,] 9.466667  9.2 17.13333
 [7,] 9.466667  9.2 17.13333
 [8,] 9.466667  9.2 17.13333
 [9,] 9.466667  9.2 17.13333
[10,] 9.466667  9.2 17.13333
[11,] 9.466667  9.2 17.13333
[12,] 9.466667  9.2 17.13333
[13,] 9.466667  9.2 17.13333
[14,] 9.466667  9.2 17.13333
[15,] 9.466667  9.2 17.13333
```

```
a=(X1-X1bar)
a
```

```
       [,1]  [,2]  [,3]
 [1,]  4.55  4.45  1.55
 [2,] -4.45 -4.55 -5.45
 [3,] -1.45 -5.55  0.55
 [4,] -7.45 -1.55 -1.45
 [5,] -0.45 -2.55  1.55
 [6,]  2.55 -1.55  0.55
 [7,]  1.55  3.45  1.55
 [8,]  1.55  6.45 -0.45
 [9,] 17.55  7.45 -6.45
[10,]  1.55  0.45  0.55
[11,] -4.45 -1.55 -1.45
[12,] -1.45 -3.55 -0.45
[13,] -1.45 -2.55  0.55
[14,] -0.45 -1.55 -1.45
[15,]  0.55  6.45  4.55
[16,] -1.45 -4.55 -3.45
[17,] -1.45 -1.55  2.55
[18,] -2.45 -4.55  2.55
[19,]  0.55  0.45  1.55
[20,] -3.45  6.45  2.55
```

```
k=t(a)%*%a
k
```

```
       [,1]   [,2]   [,3]
[1,] 466.95 222.05 -72.05
[2,] 222.05 342.95  32.05
[3,] -72.05  32.05 140.95
```

```
b=X2-X2bar
b
```

```
             [,1] [,2]        [,3]
 [1,] -1.4666667  2.8  -8.1333333
 [2,] -2.4666667 -4.2  -0.1333333
 [3,]  0.5333333 -6.2  -6.1333333
 [4,]  0.5333333  5.8 -11.1333333
 [5,]  3.5333333 -5.2  11.8666667
 [6,]  0.5333333  3.8  -6.1333333
 [7,] -3.4666667 -0.2   1.8666667
 [8,]  1.5333333  0.8  -3.1333333
 [9,] -0.4666667 -6.2  -3.1333333
[10,]  0.5333333 -4.2   3.8666667
[11,]  1.5333333  8.8  17.8666667
[12,]  2.5333333  2.8  -0.1333333
[13,] -0.4666667  3.8   3.8666667
[14,] -1.4666667  0.8  -0.1333333
[15,] -1.4666667 -3.2  -1.1333333
```

```
l=t(b)%*%b
l
```

```
         [,1]  [,2]      [,3]
[1,] 49.73333  14.6  61.06667
[2,] 14.60000 306.4  41.60000
[3,] 61.06667  41.6 779.73333
```

```
#sample covariance matrix
s=(k+l)/(n1+n2-2)
s
```

```
           [,1]      [,2]       [,3]
[1,] 15.6570707  7.171212 -0.3328283
[2,]  7.1712121 19.677273  2.2318182
[3,] -0.3328283  2.231818 27.8994949
```

```
#calculate T^2
T={(n1*n2)/(n1+n2)}*t(M)%*%solve(s)%*%M
T
```

```
         [,1]
[1,] 22.01801
```

```
#calculate F
F={T/(n1+n2-2)}*{(n1+n2-2-3+1)/3}
F
```

```
         [,1]
[1,] 6.894529
```