Excercise_1

2025-01-26

Step 0: Load Required Libraries

```
## This is restriktor 0.6-10

## Please report any bugs to info@restriktor.org
```

Step 1: Load the Dataset

Step 2: Summarize the Dataset

```
## 'data.frame':    112 obs. of  14 variables:
##  $ obs   : int  601 602 603 604 605 606 607 610 611 612 ...
##  $ maxO3 : int  87 82 92 114 94 80 79 79 101 106 ...
##  $ T9    : num  15.6 17 15.3 16.2 17.4 17.7 16.8 14.9 16.1 18.3 ...
##  $ T12   : num  18.5 18.4 17.6 19.7 20.5 19.8 15.6 17.5 19.6 21.9 ...
##  $ T15   : num  18.4 17.7 19.5 22.5 20.4 18.3 14.9 18.9 21.4 22.9 ...
##  $ Ne9   : int  4 5 2 1 8 6 7 5 2 5 ...
##  $ Ne12  : int  4 5 5 1 8 6 8 5 4 6 ...
##  $ Ne15  : int  8 7 4 0 7 7 8 4 4 8 ...
##  $ Vx9   : num  0.695 -4.33 2.954 0.985 -0.5 ...
##  $ Vx12  : num  -1.71 -4 1.879 0.347 -2.954 ...
##  $ Vx15  : num  -0.695 -3 0.521 -0.174 -4.33 ...
##  $ maxO3v: int  84 87 82 92 114 94 80 99 79 101 ...
##  $ vent  : chr  "Nord" "Nord" "Est" "Nord" ...
##  $ pluie : chr  "Sec" "Sec" "Sec" "Sec" ...

##       obs             maxO3              T9             T12       
##  Min.   :601.0   Min.   : 42.00   Min.   :11.30   Min.   :14.00  
##  1st Qu.:701.8   1st Qu.: 70.75   1st Qu.:16.20   1st Qu.:18.60  
##  Median :729.5   Median : 81.50   Median :17.80   Median :20.55  
##  Mean   :763.2   Mean   : 90.30   Mean   :18.36   Mean   :21.53  
##  3rd Qu.:829.2   3rd Qu.:106.00   3rd Qu.:19.93   3rd Qu.:23.55  
##  Max.   :930.0   Max.   :166.00   Max.   :27.00   Max.   :33.50  
##       T15              Ne9             Ne12            Ne15      
##  Min.   :14.90   Min.   :0.000   Min.   :0.000   Min.   :0.00  
##  1st Qu.:19.27   1st Qu.:3.000   1st Qu.:4.000   1st Qu.:3.00  
##  Median :22.05   Median :6.000   Median :5.000   Median :5.00  
##  Mean   :22.63   Mean   :4.929   Mean   :5.018   Mean   :4.83  
##  3rd Qu.:25.40   3rd Qu.:7.000   3rd Qu.:7.000   3rd Qu.:7.00  
##  Max.   :35.50   Max.   :8.000   Max.   :8.000   Max.   :8.00  
##       Vx9               Vx12             Vx15            maxO3v      
```

```
##  Min.   :-7.8785   Min.   :-7.878   Min.   :-9.000   Min.   : 42.00
##  1st Qu.:-3.2765   1st Qu.:-3.565   1st Qu.:-3.939   1st Qu.: 71.00
##  Median :-0.8660   Median :-1.879   Median :-1.550   Median : 82.50
##  Mean   :-1.2143   Mean   :-1.611   Mean   :-1.691   Mean   : 90.57
##  3rd Qu.: 0.6946   3rd Qu.: 0.000   3rd Qu.: 0.000   3rd Qu.:106.00
##  Max.   : 5.1962   Max.   : 6.578   Max.   : 5.000   Max.   :166.00
##      vent              pluie
##  Length:112         Length:112
##  Class :character   Class :character
##  Mode  :character   Mode  :character
##
##
##
```

Step 3: Check for Missing Values

```
##    obs  maxO3     T9    T12    T15    Ne9   Ne12   Ne15    Vx9   Vx12   Vx15
##      0      0      0      0      0      0      0      0      0      0      0
## maxO3v   vent  pluie
##      0      0      0
```

Step 4: Clean the Dataset

Step 5: Fit Unconstrained Model

```
##
## Call:
## lm(formula = maxO3 ~ ., data = ozone_clean)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.566  -8.727  -0.403   7.599  39.458
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 12.24442   13.47190   0.909   0.3656
## T9          -0.01901    1.12515  -0.017   0.9866
## T12          2.22115    1.43294   1.550   0.1243
## T15          0.55853    1.14464   0.488   0.6266
## Ne9         -2.18909    0.93824  -2.333   0.0216 *
## Ne12        -0.42102    1.36766  -0.308   0.7588
## Ne15         0.18373    1.00279   0.183   0.8550
## Vx9          0.94791    0.91228   1.039   0.3013
## Vx12         0.03120    1.05523   0.030   0.9765
## Vx15         0.41859    0.91568   0.457   0.6486
## maxO3v       0.35198    0.06289   5.597 1.88e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.36 on 101 degrees of freedom
```

```
## Multiple R-squared:  0.7638, Adjusted R-squared:  0.7405
## F-statistic: 32.67 on 10 and 101 DF,  p-value: < 2.2e-16
```

Step 6: Fit Constrained Model

```
##
## Call:
## conLM.lm(object = object, constraints = constraints)
##
## Restriktor: restricted linear model:
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -63.5015  -9.2064  -0.7102   8.8056  43.4884
##
## Coefficients:
##              Estimate Std. Error t value  Pr(>|t|)
## (Intercept) 56.443309  10.302499  5.4786 3.155e-07 ***
## T9          -2.551360   1.072558 -2.3788  0.019250 *
## T12          1.681563   1.562201  1.0764  0.284310
## T15          0.869797   1.249908  0.6959  0.488097
## Ne9         -3.328210   0.989748 -3.3627  0.001091 **
## Ne12        -1.086056   1.487654 -0.7300  0.467052
## Ne15         0.507342   1.094229  0.4637  0.643894
## Vx9          0.702988   0.996224  0.7057  0.482028
## Vx12         0.072475   1.154263  0.0628  0.950059
## Vx15         0.148640   0.999582  0.1487  0.882085
## maxO3v       0.501803   0.058793  8.5351 1.484e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.708 on 101 degrees of freedom
## Standard errors: standard
## Multiple R-squared reduced from 0.764 to 0.715
##
## Generalized order-restricted information criterion:
##  Loglik Penalty   goric
## -462.15   11.00  946.31

##
```

Step 7: Compare coefficients

```
##             Unconstrained Constrained
## (Intercept)   12.24441987 56.44330907
## T9            -0.01901425 -2.55136002
## T12            2.22115189  1.68156276
## T15            0.55853087  0.86979726
## Ne9           -2.18909215 -3.32820968
## Ne12          -0.42101517 -1.08605648
## Ne15           0.18373097  0.50734236
```

```
## Vx9            0.94790917  0.70298836
## Vx12           0.03119824  0.07247503
## Vx15           0.41859252  0.14863956
## maxO3v         0.35197646  0.50180286
```

Step 8: Compare models

```
## Model Comparison Results:

## --------------------------------

## Unconstrained Model RSS: 20827.23

## Constrained Model RSS:    25168.66

## F-statistic (Improvement Ratio): 21.053

## p-value: < 0.001

## Conclusion: Reject H  - Constraining coefficients significantly worsens model fit (p = 1.29e-05 )
```