WineQuality

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10/7/2020

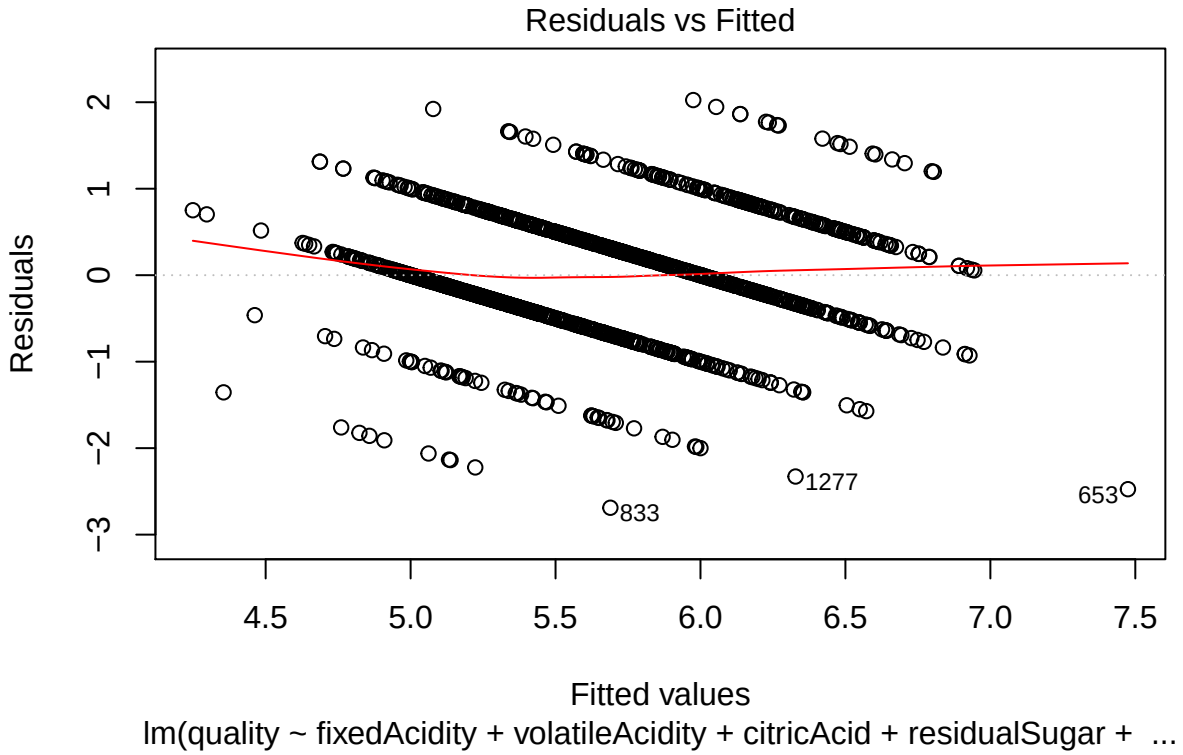
Quality is the Response Variable and is measured between 1 and 10.

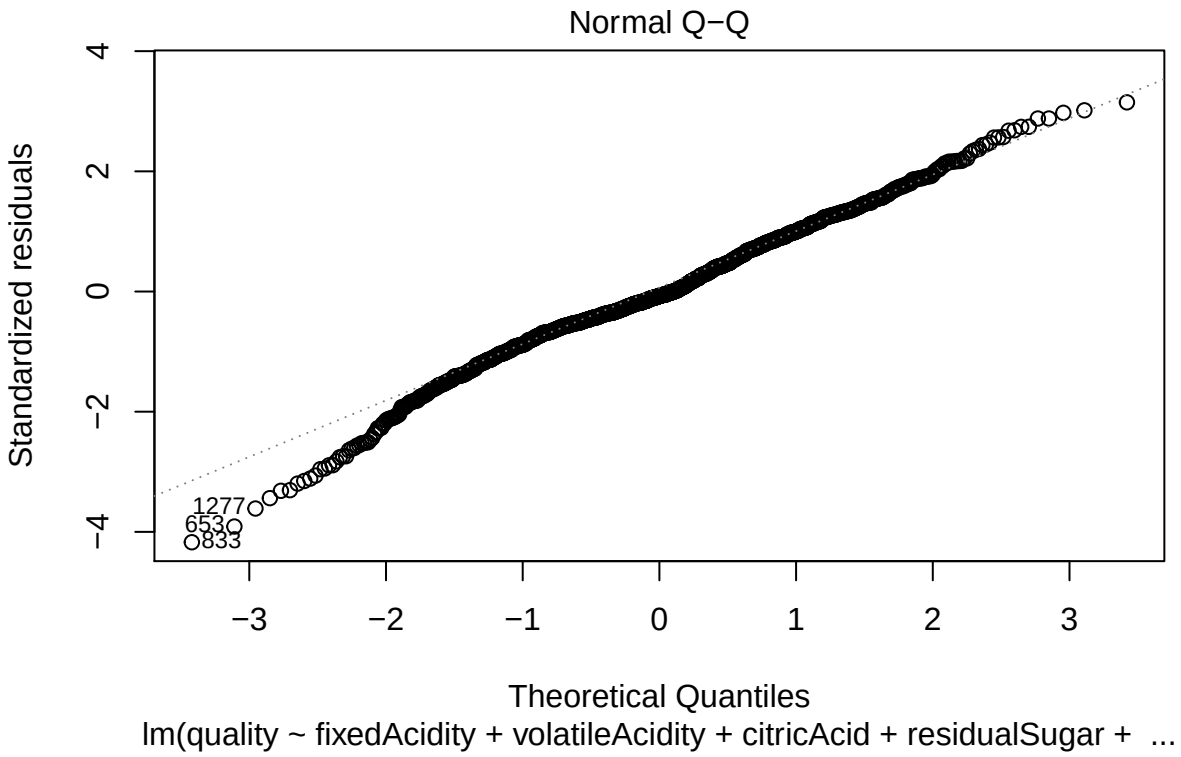
```
wine_red <- read.csv("~/Data 467/winequality-red.csv",sep = ';')
fixedAcidity = wine_red$fixed.acidity
volatileAcidity = wine_red$volatile.acidity
citricAcid = wine_red$citric.acid
residualSugar = wine_red$residual.sugar
chlorides = wine_red$chlorides
freeSulfurDioxide = wine_red$free.sulfur.dioxide
totalSulfurDioxide = wine_red$total.sulfur.dioxide
densityRed = wine_red$density
pH = wine_red$pH
sulphates = wine_red$sulphates
alcohol = wine_red$alcohol
quality = wine_red$quality

redWine.lm <-lm(quality~fixedAcidity+volatileAcidity+citricAcid+residualSugar+
                  chlorides+freeSulfurDioxide+totalSulfurDioxide+densityRed+pH+sulphates+alcohol)
summary(redWine.lm)
```

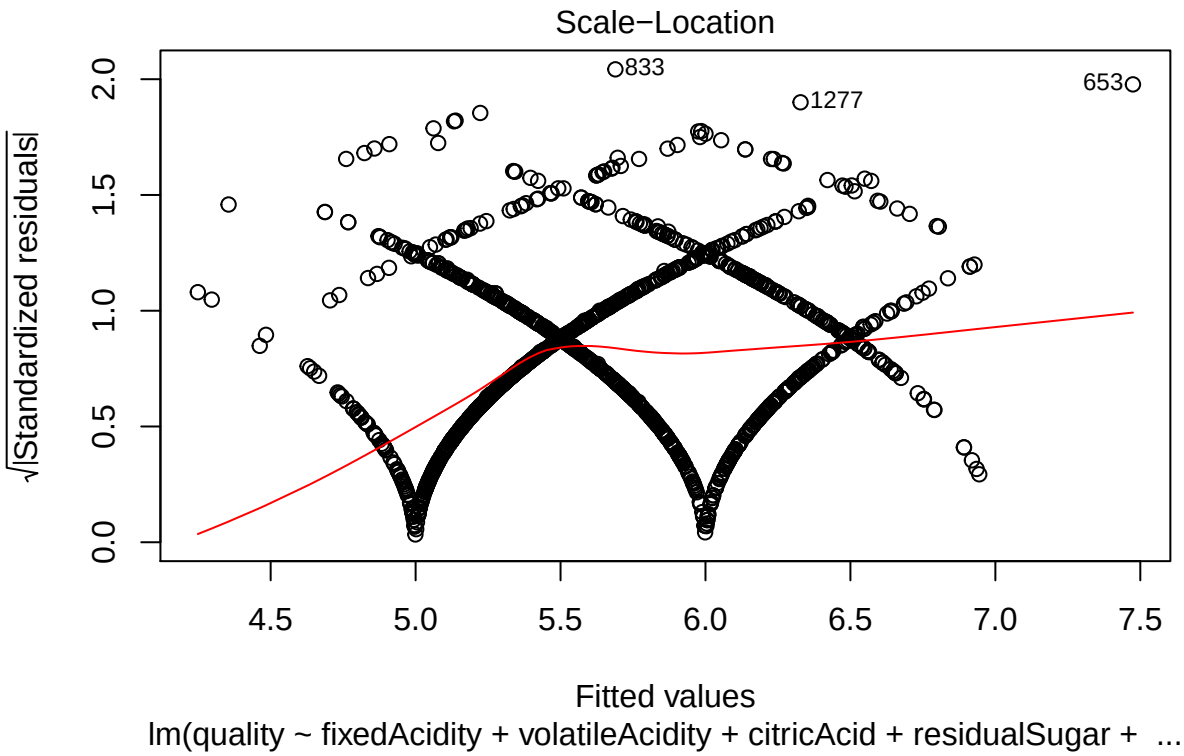
```
##
## Call:
## lm(formula = quality ~ fixedAcidity + volatileAcidity + citricAcid +
##     residualSugar + chlorides + freeSulfurDioxide + totalSulfurDioxide +
##     densityRed + pH + sulphates + alcohol)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.68911 -0.36652 -0.04699  0.45202  2.02498
##
## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
## (Intercept)          2.197e+01  2.119e+01   1.036   0.3002
## fixedAcidity         2.499e-02  2.595e-02   0.963   0.3357
## volatileAcidity     -1.084e+00  1.211e-01  -8.948  < 2e-16 ***
## citricAcid          -1.826e-01  1.472e-01  -1.240   0.2150
## residualSugar        1.633e-02  1.500e-02   1.089   0.2765
## chlorides           -1.874e+00  4.193e-01  -4.470 8.37e-06 ***
## freeSulfurDioxide    4.361e-03  2.171e-03   2.009   0.0447 *
## totalSulfurDioxide -3.265e-03  7.287e-04  -4.480 8.00e-06 ***
## densityRed          -1.788e+01  2.163e+01  -0.827   0.4086
```

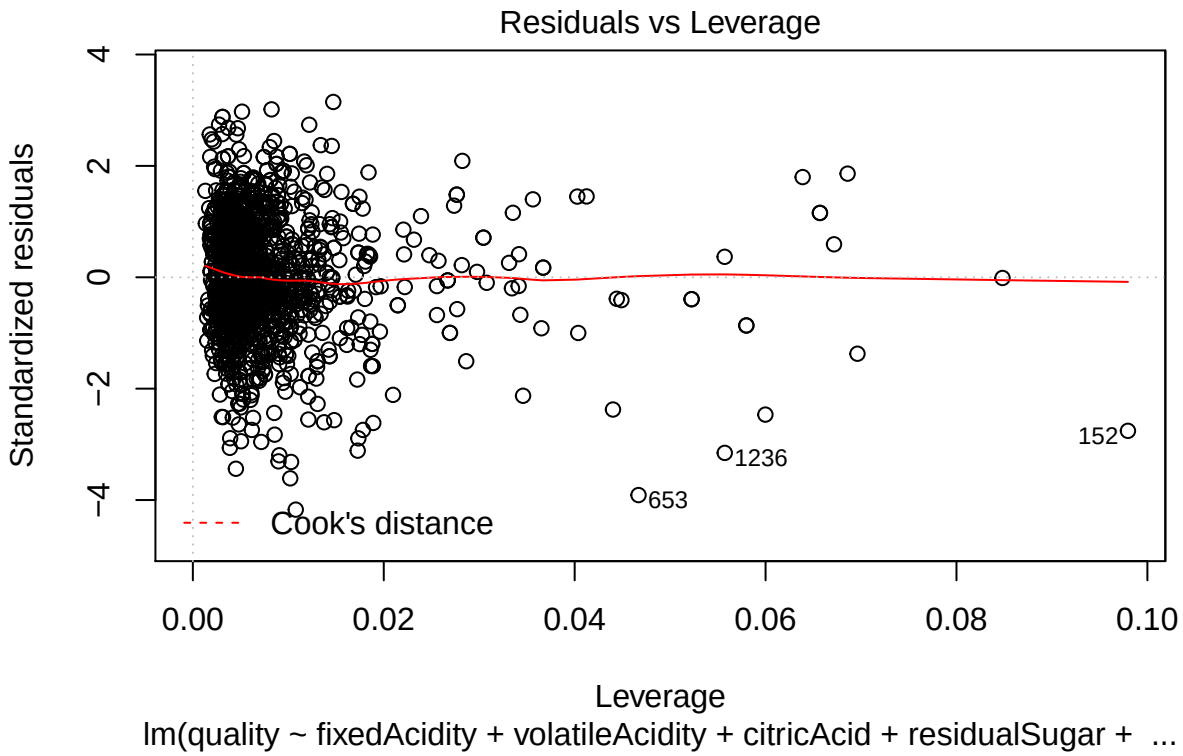
```
## pH                  -4.137e-01  1.916e-01  -2.159   0.0310 *
## sulphates            9.163e-01  1.143e-01   8.014 2.13e-15 ***
## alcohol              2.762e-01  2.648e-02  10.429  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.648 on 1587 degrees of freedom
## Multiple R-squared:  0.3606, Adjusted R-squared:  0.3561
## F-statistic: 81.35 on 11 and 1587 DF,  p-value: < 2.2e-16
```

```
plot(redWine.lm)
```




Normal Q−Q
Standardized residuals
4
2
0
−2
−4
1277
653
833
−3
−2
−1
0
1
2
3
Theoretical Quantiles
lm(quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar + ...


Scale−Location
833
1277
653
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
Fitted values
lm(quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar + ...



removing predictors with p-values > 0.05, results in Fixed Acidity, Citric acid, residual sugar, and density being removed from the model due to the predictors not being significant. To confirm we check the reduced model.

```
redWine2.lm <- lm(quality~volatileAcidity+chlorides+freeSulfurDioxide+
                    totalSulfurDioxide+pH+sulphates+alcohol)
summary(redWine2.lm)
```

```
##
## Call:
## lm(formula = quality ~ volatileAcidity + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.68918 -0.36757 -0.04653  0.46081  2.02954
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.4300987  0.4029168  10.995  < 2e-16 ***
## volatileAcidity     -1.0127527  0.1008429 -10.043  < 2e-16 ***
## chlorides           -2.0178138  0.3975417  -5.076 4.31e-07 ***
## freeSulfurDioxide    0.0050774  0.0021255   2.389    0.017 *
## totalSulfurDioxide -0.0034822  0.0006868  -5.070 4.43e-07 ***
## pH                  -0.4826614  0.1175581  -4.106 4.23e-05 ***
## sulphates            0.8826651  0.1099084   8.031 1.86e-15 ***
```

```
## alcohol             0.2893028  0.0167958  17.225  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6477 on 1591 degrees of freedom
## Multiple R-squared:  0.3595, Adjusted R-squared:  0.3567
## F-statistic: 127.6 on 7 and 1591 DF,  p-value: < 2.2e-16
```

```
require(leaps)
```

```
## Loading required package: leaps
```

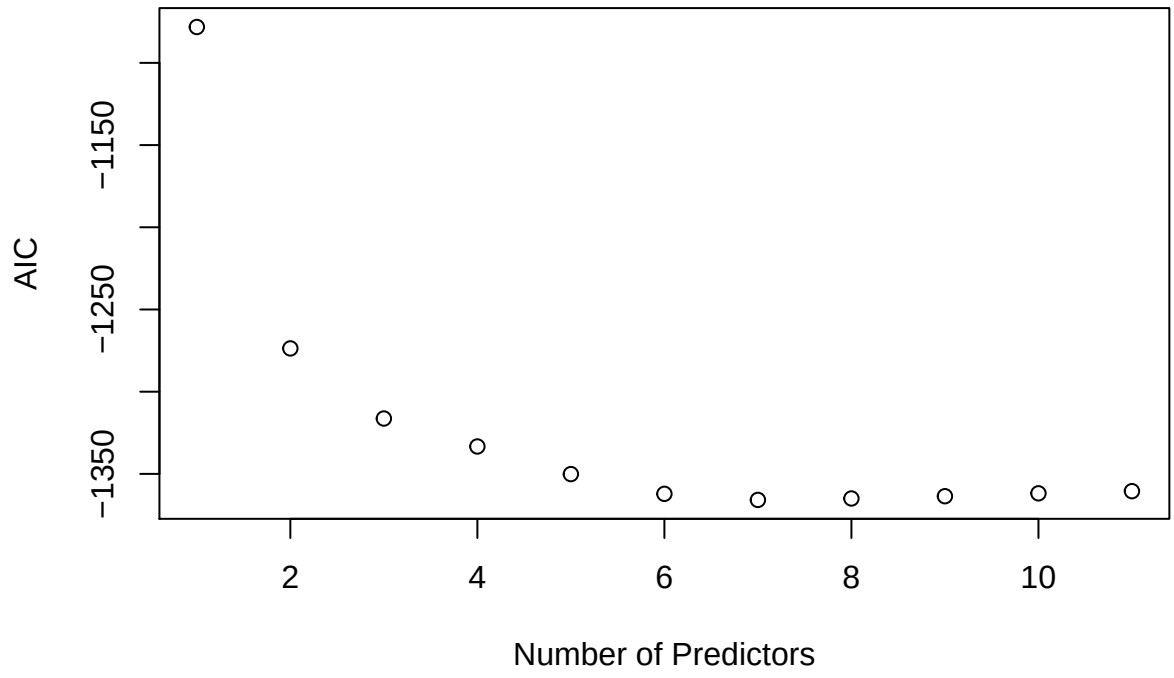
```
## Warning: package 'leaps' was built under R version 3.6.3
```

```
b <- regsubsets(wine_red$quality ~ ., wine_red, nvmax = 11)
rs <- summary(b)
rs$which
```

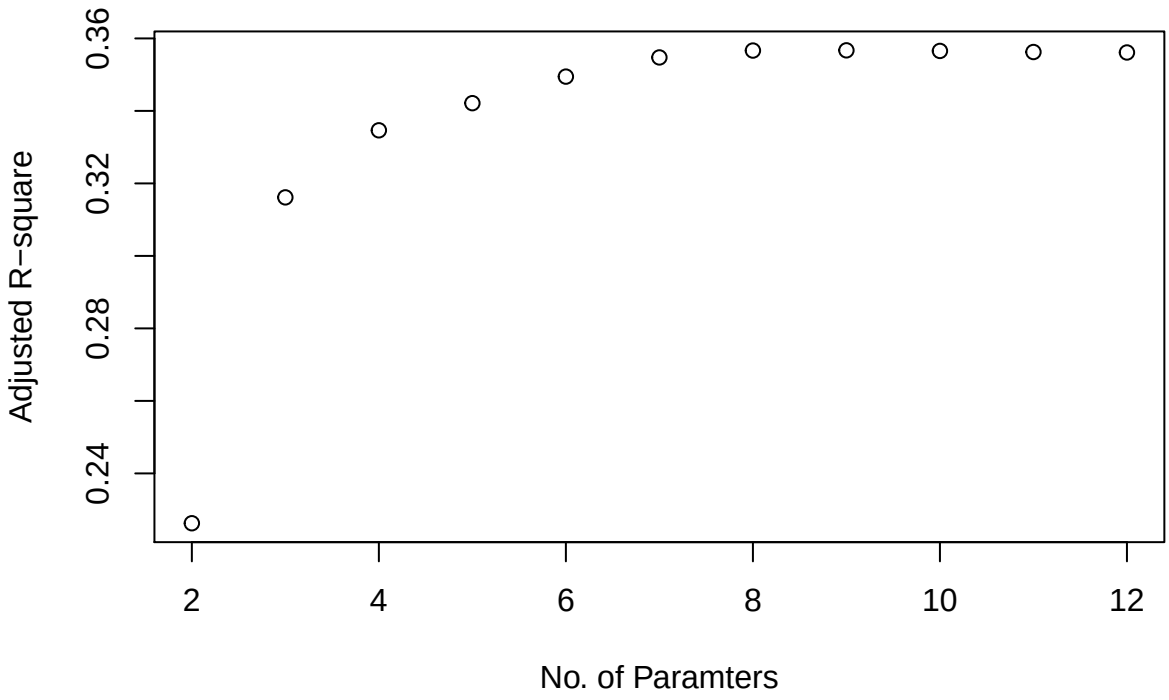
```
##    (Intercept) fixed.acidity volatile.acidity citric.acid residual.sugar
## 1         TRUE         FALSE            FALSE       FALSE          FALSE
## 2         TRUE         FALSE             TRUE       FALSE          FALSE
## 3         TRUE         FALSE             TRUE       FALSE          FALSE
## 4         TRUE         FALSE             TRUE       FALSE          FALSE
## 5         TRUE         FALSE             TRUE       FALSE          FALSE
## 6         TRUE         FALSE             TRUE       FALSE          FALSE
## 7         TRUE         FALSE             TRUE       FALSE          FALSE
## 8         TRUE         FALSE             TRUE        TRUE          FALSE
## 9         TRUE         FALSE             TRUE        TRUE           TRUE
## 10        TRUE          TRUE             TRUE        TRUE           TRUE
## 11        TRUE          TRUE             TRUE        TRUE           TRUE
##    chlorides free.sulfur.dioxide total.sulfur.dioxide density    pH sulphates
## 1      FALSE               FALSE                FALSE   FALSE FALSE     FALSE
## 2      FALSE               FALSE                FALSE   FALSE FALSE     FALSE
## 3      FALSE               FALSE                FALSE   FALSE FALSE      TRUE
## 4      FALSE               FALSE                 TRUE   FALSE FALSE      TRUE
## 5       TRUE               FALSE                 TRUE   FALSE FALSE      TRUE
## 6       TRUE               FALSE                 TRUE   FALSE  TRUE      TRUE
## 7       TRUE                TRUE                 TRUE   FALSE  TRUE      TRUE
## 8       TRUE                TRUE                 TRUE   FALSE  TRUE      TRUE
## 9       TRUE                TRUE                 TRUE   FALSE  TRUE      TRUE
## 10      TRUE                TRUE                 TRUE   FALSE  TRUE      TRUE
## 11      TRUE                TRUE                 TRUE    TRUE  TRUE      TRUE
##    alcohol
## 1     TRUE
## 2     TRUE
## 3     TRUE
## 4     TRUE
## 5     TRUE
## 6     TRUE
## 7     TRUE
## 8     TRUE
## 9     TRUE
## 10    TRUE
## 11    TRUE
```

AIC

```
AIC <- 1591*log(rs$rss/1591) + (2:12) * 2
plot(AIC ~ I(1:11), ylab = "AIC", xlab = "Number of Predictors")
```



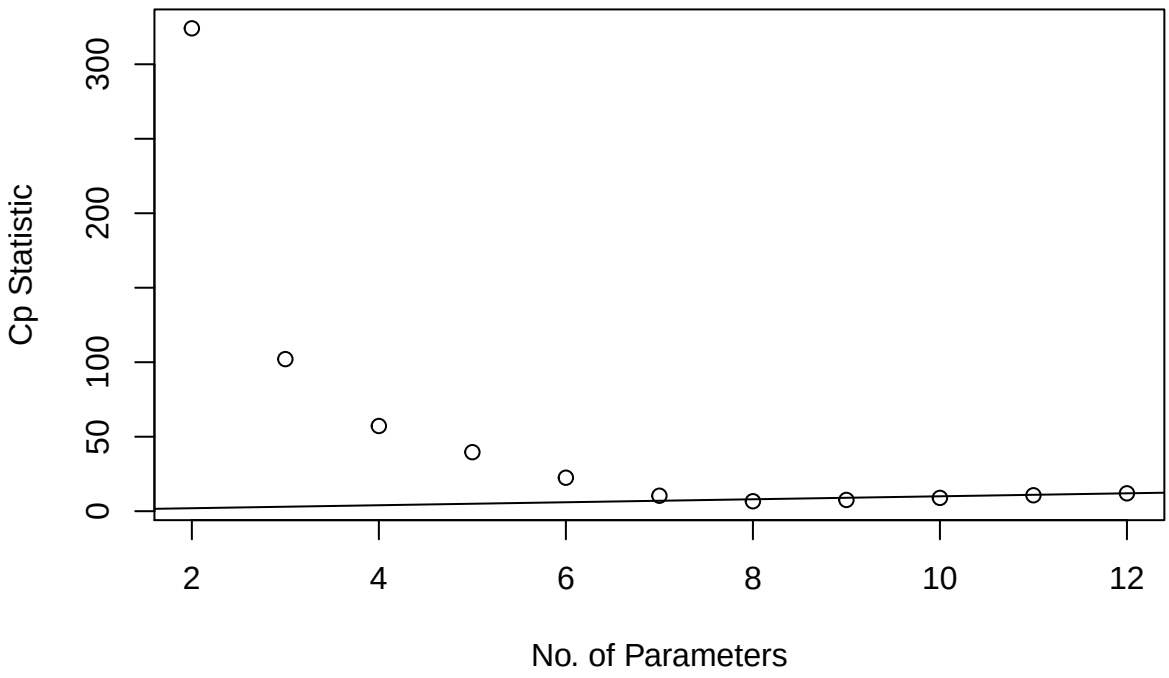

```
plot(2:12,rs$adjr2,xlab='No. of Paramters', ylab = 'Adjusted R-square')
```




```
which.max(rs$adjr2)
```

```
## [1] 8
```

```
plot(2:12, rs$cp, xlab="No. of Parameters", ylab = "Cp Statistic")
abline(0,1)
```



——AIC Forward——-

```
step(redWine.lm)
```

```
## Start:  AIC=-1375.49
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + densityRed +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - densityRed           1     0.287 666.70 -1376.8
## - fixedAcidity         1     0.389 666.80 -1376.5
## - residualSugar        1     0.498 666.91 -1376.3
## - citricAcid           1     0.646 667.06 -1375.9
## <none>                             666.41 -1375.5
## - freeSulfurDioxide    1     1.694 668.10 -1373.4
## - pH                   1     1.957 668.37 -1372.8
## - chlorides            1     8.391 674.80 -1357.5
## - totalSulfurDioxide   1     8.427 674.84 -1357.4
## - sulphates            1    26.971 693.38 -1314.0
## - volatileAcidity      1    33.620 700.03 -1298.8
## - alcohol              1    45.672 712.08 -1271.5
##
## Step:  AIC=-1376.8
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + pH +
```

```
##     sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - fixedAcidity         1     0.108 666.81 -1378.5
## - residualSugar        1     0.231 666.93 -1378.2
## - citricAcid           1     0.654 667.35 -1377.2
## <none>                             666.70 -1376.8
## - freeSulfurDioxide    1     1.829 668.53 -1374.4
## - pH                   1     4.325 671.02 -1368.5
## - totalSulfurDioxide   1     8.728 675.43 -1358.0
## - chlorides            1     8.761 675.46 -1357.9
## - sulphates            1    27.287 693.98 -1314.7
## - volatileAcidity      1    35.000 701.70 -1297.0
## - alcohol              1   119.669 786.37 -1114.8
##
## Step:  AIC=-1378.54
## quality ~ volatileAcidity + citricAcid + residualSugar + chlorides +
##     freeSulfurDioxide + totalSulfurDioxide + pH + sulphates +
##     alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - residualSugar        1     0.257 667.06 -1379.9
## - citricAcid           1     0.565 667.37 -1379.2
## <none>                             666.81 -1378.5
## - freeSulfurDioxide    1     1.901 668.71 -1376.0
## - pH                   1     7.065 673.87 -1363.7
## - chlorides            1     9.940 676.75 -1356.9
## - totalSulfurDioxide   1    10.031 676.84 -1356.7
## - sulphates            1    27.673 694.48 -1315.5
## - volatileAcidity      1    36.234 703.04 -1295.9
## - alcohol              1   120.633 787.44 -1114.7
##
## Step:  AIC=-1379.93
## quality ~ volatileAcidity + citricAcid + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - citricAcid           1     0.475 667.54 -1380.8
## <none>                             667.06 -1379.9
## - freeSulfurDioxide    1     2.064 669.13 -1377.0
## - pH                   1     7.138 674.20 -1364.9
## - totalSulfurDioxide   1     9.828 676.89 -1358.5
## - chlorides            1     9.832 676.89 -1358.5
## - sulphates            1    27.446 694.51 -1317.5
## - volatileAcidity      1    35.977 703.04 -1297.9
## - alcohol              1   122.667 789.73 -1112.0
##
## Step:  AIC=-1380.79
## quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## <none>                             667.54 -1380.8
## - freeSulfurDioxide    1     2.394 669.93 -1377.1
```

```
## - pH                  1     7.073 674.61 -1365.9
## - totalSulfurDioxide  1    10.787 678.32 -1357.2
## - chlorides           1    10.809 678.35 -1357.1
## - sulphates           1    27.060 694.60 -1319.2
## - volatileAcidity     1    42.318 709.85 -1284.5
## - alcohol             1   124.483 792.02 -1109.4

##
## Call:
## lm(formula = quality ~ volatileAcidity + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol)
##
## Coefficients:
##        (Intercept)     volatileAcidity           chlorides   freeSulfurDioxide
##           4.430099           -1.012753           -2.017814            0.005077
## totalSulfurDioxide                  pH           sulphates             alcohol
##          -0.003482           -0.482661            0.882665            0.289303
```

——AIC Backward——

```
step(redWine.lm, distraction = "backward")
```

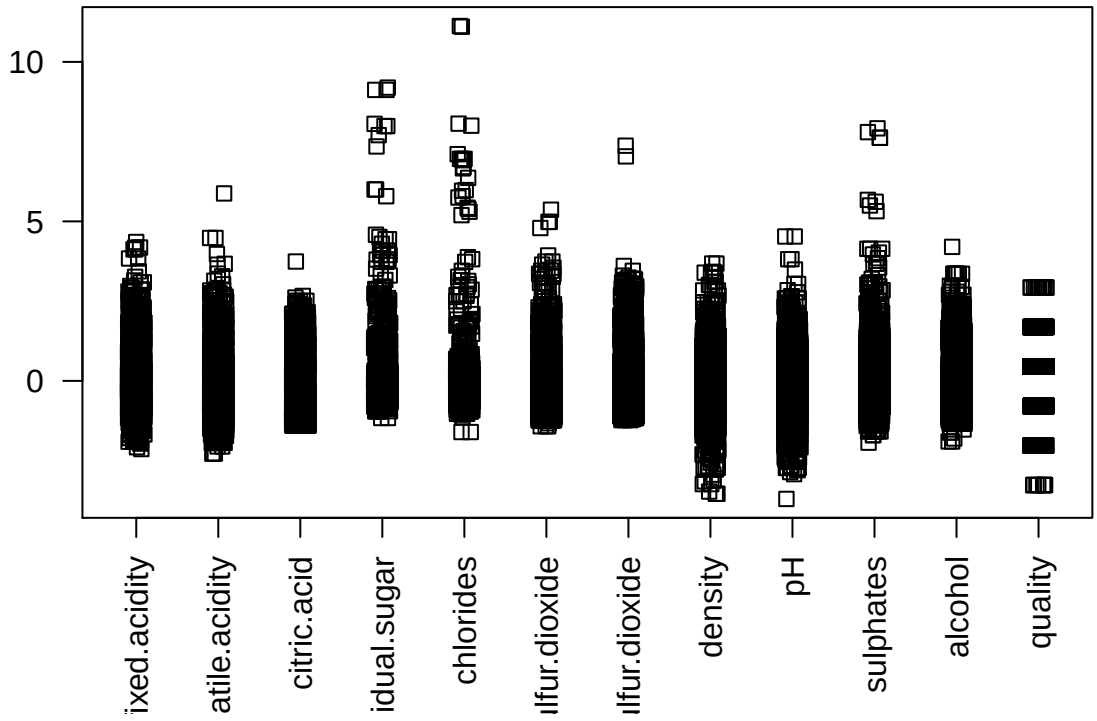
```
## Start:  AIC=-1375.49
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + densityRed +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - densityRed           1     0.287 666.70 -1376.8
## - fixedAcidity         1     0.389 666.80 -1376.5
## - residualSugar        1     0.498 666.91 -1376.3
## - citricAcid           1     0.646 667.06 -1375.9
## <none>                             666.41 -1375.5
## - freeSulfurDioxide    1     1.694 668.10 -1373.4
## - pH                   1     1.957 668.37 -1372.8
## - chlorides            1     8.391 674.80 -1357.5
## - totalSulfurDioxide   1     8.427 674.84 -1357.4
## - sulphates            1    26.971 693.38 -1314.0
## - volatileAcidity      1    33.620 700.03 -1298.8
## - alcohol              1    45.672 712.08 -1271.5
##
## Step:  AIC=-1376.8
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + pH +
##     sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - fixedAcidity         1     0.108 666.81 -1378.5
## - residualSugar        1     0.231 666.93 -1378.2
## - citricAcid           1     0.654 667.35 -1377.2
## <none>                             666.70 -1376.8
## - freeSulfurDioxide    1     1.829 668.53 -1374.4
## - pH                   1     4.325 671.02 -1368.5
```

```
## - totalSulfurDioxide  1     8.728 675.43 -1358.0
## - chlorides           1     8.761 675.46 -1357.9
## - sulphates           1    27.287 693.98 -1314.7
## - volatileAcidity     1    35.000 701.70 -1297.0
## - alcohol             1   119.669 786.37 -1114.8
##
## Step:  AIC=-1378.54
## quality ~ volatileAcidity + citricAcid + residualSugar + chlorides +
##     freeSulfurDioxide + totalSulfurDioxide + pH + sulphates +
##     alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - residualSugar        1     0.257 667.06 -1379.9
## - citricAcid           1     0.565 667.37 -1379.2
## <none>                             666.81 -1378.5
## - freeSulfurDioxide    1     1.901 668.71 -1376.0
## - pH                   1     7.065 673.87 -1363.7
## - chlorides            1     9.940 676.75 -1356.9
## - totalSulfurDioxide   1    10.031 676.84 -1356.7
## - sulphates            1    27.673 694.48 -1315.5
## - volatileAcidity      1    36.234 703.04 -1295.9
## - alcohol              1   120.633 787.44 -1114.7
##
## Step:  AIC=-1379.93
## quality ~ volatileAcidity + citricAcid + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - citricAcid           1     0.475 667.54 -1380.8
## <none>                             667.06 -1379.9
## - freeSulfurDioxide    1     2.064 669.13 -1377.0
## - pH                   1     7.138 674.20 -1364.9
## - totalSulfurDioxide   1     9.828 676.89 -1358.5
## - chlorides            1     9.832 676.89 -1358.5
## - sulphates            1    27.446 694.51 -1317.5
## - volatileAcidity      1    35.977 703.04 -1297.9
## - alcohol              1   122.667 789.73 -1112.0
##
## Step:  AIC=-1380.79
## quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## <none>                             667.54 -1380.8
## - freeSulfurDioxide    1     2.394 669.93 -1377.1
## - pH                   1     7.073 674.61 -1365.9
## - totalSulfurDioxide   1    10.787 678.32 -1357.2
## - chlorides            1    10.809 678.35 -1357.1
## - sulphates            1    27.060 694.60 -1319.2
## - volatileAcidity      1    42.318 709.85 -1284.5
## - alcohol              1   124.483 792.02 -1109.4

##
## Call:
```

```
## lm(formula = quality ~ volatileAcidity + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol)
##
## Coefficients:
##        (Intercept)     volatileAcidity           chlorides   freeSulfurDioxide
##           4.430099          -1.012753          -2.017814           0.005077
## totalSulfurDioxide                  pH          sulphates             alcohol
##          -0.003482          -0.482661           0.882665           0.289303
```

——————————————————————Check Models——————————————————————
————————————-

```
stripchart(data.frame(scale(wine_red)),method = "jitter", las=2,vertical= TRUE)
```



——————————————————————————————-BIC——————————————————————————————
———————————— ——-BIC Backward——-

```
n = length(resid(redWine.lm))
BIC_backward = step(redWine.lm,distraction = "backward", k = log(n))
```

```
## Start:  AIC=-1310.96
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + densityRed +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
```

```
## - densityRed          1     0.287 666.70 -1317.7
## - fixedAcidity        1     0.389 666.80 -1317.4
## - residualSugar       1     0.498 666.91 -1317.2
## - citricAcid          1     0.646 667.06 -1316.8
## - freeSulfurDioxide   1     1.694 668.10 -1314.3
## - pH                  1     1.957 668.37 -1313.7
## <none>                            666.41 -1311.0
## - chlorides           1     8.391 674.80 -1298.3
## - totalSulfurDioxide  1     8.427 674.84 -1298.2
## - sulphates           1    26.971 693.38 -1254.9
## - volatileAcidity     1    33.620 700.03 -1239.6
## - alcohol             1    45.672 712.08 -1212.3
##
## Step:  AIC=-1317.65
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + pH +
##     sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - fixedAcidity         1     0.108 666.81 -1324.8
## - residualSugar        1     0.231 666.93 -1324.5
## - citricAcid           1     0.654 667.35 -1323.5
## - freeSulfurDioxide    1     1.829 668.53 -1320.7
## <none>                            666.70 -1317.7
## - pH                   1     4.325 671.02 -1314.7
## - totalSulfurDioxide   1     8.728 675.43 -1304.2
## - chlorides            1     8.761 675.46 -1304.2
## - sulphates            1    27.287 693.98 -1260.9
## - volatileAcidity      1    35.000 701.70 -1243.2
## - alcohol              1   119.669 786.37 -1061.1
##
## Step:  AIC=-1324.77
## quality ~ volatileAcidity + citricAcid + residualSugar + chlorides +
##     freeSulfurDioxide + totalSulfurDioxide + pH + sulphates +
##     alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - residualSugar        1     0.257 667.06 -1331.5
## - citricAcid           1     0.565 667.37 -1330.8
## - freeSulfurDioxide    1     1.901 668.71 -1327.6
## <none>                            666.81 -1324.8
## - pH                   1     7.065 673.87 -1315.3
## - chlorides            1     9.940 676.75 -1308.5
## - totalSulfurDioxide   1    10.031 676.84 -1308.3
## - sulphates            1    27.673 694.48 -1267.1
## - volatileAcidity      1    36.234 703.04 -1247.5
## - alcohol              1   120.633 787.44 -1066.2
##
## Step:  AIC=-1331.53
## quality ~ volatileAcidity + citricAcid + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - citricAcid           1     0.475 667.54 -1337.8
```

```
## - freeSulfurDioxide   1     2.064 669.13 -1334.0
## <none>                            667.06 -1331.5
## - pH                  1     7.138 674.20 -1321.9
## - totalSulfurDioxide  1     9.828 676.89 -1315.5
## - chlorides           1     9.832 676.89 -1315.5
## - sulphates           1    27.446 694.51 -1274.4
## - volatileAcidity     1    35.977 703.04 -1254.9
## - alcohol             1   122.667 789.73 -1069.0
##
## Step:  AIC=-1337.77
## quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - freeSulfurDioxide   1     2.394 669.93 -1339.4
## <none>                            667.54 -1337.8
## - pH                  1     7.073 674.61 -1328.3
## - totalSulfurDioxide  1    10.787 678.32 -1319.5
## - chlorides           1    10.809 678.35 -1319.5
## - sulphates           1    27.060 694.60 -1281.6
## - volatileAcidity     1    42.318 709.85 -1246.9
## - alcohol             1   124.483 792.02 -1071.7
##
## Step:  AIC=-1339.42
## quality ~ volatileAcidity + chlorides + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## <none>                            669.93 -1339.4
## - pH                  1     5.919 675.85 -1332.7
## - totalSulfurDioxide  1     9.233 679.16 -1324.9
## - chlorides           1    10.647 680.58 -1321.6
## - sulphates           1    27.445 697.38 -1282.6
## - volatileAcidity     1    44.972 714.90 -1242.9
## - alcohol             1   125.812 795.74 -1071.6
```

—-BIC Forward—-

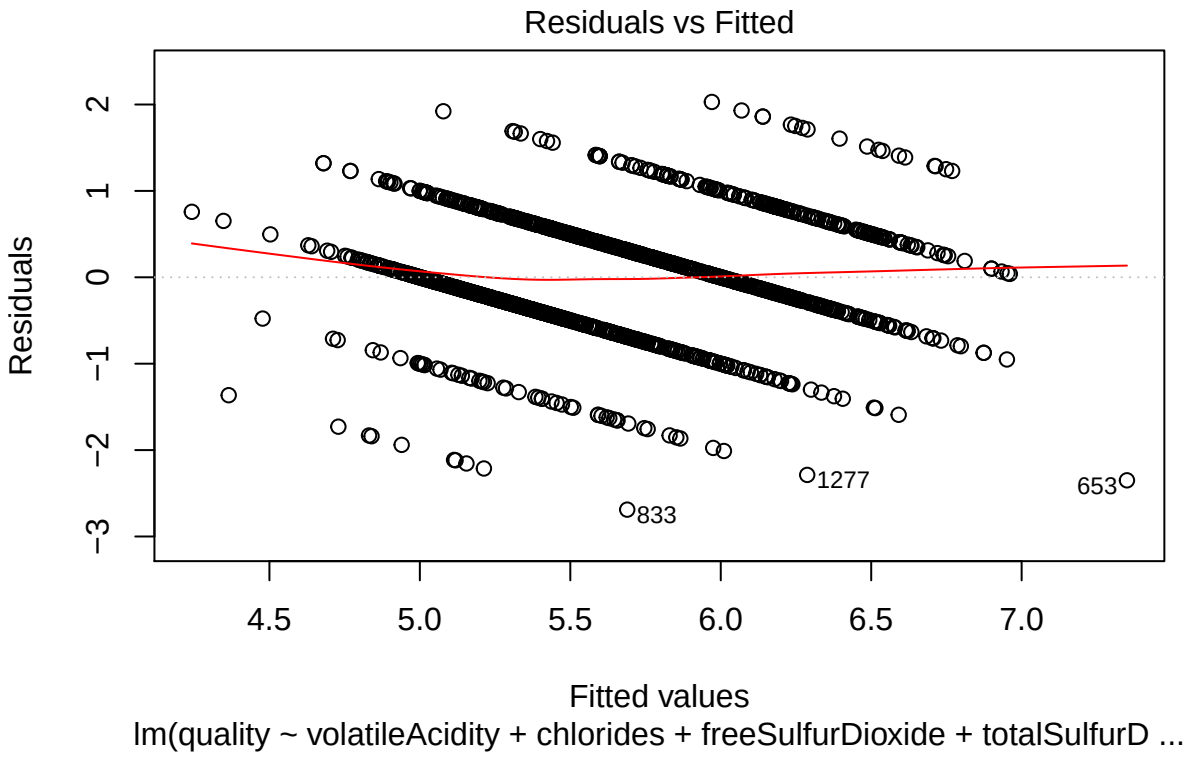
```
n = length(resid(redWine.lm))
BIC_backward = step(redWine.lm, k = log(n))
```

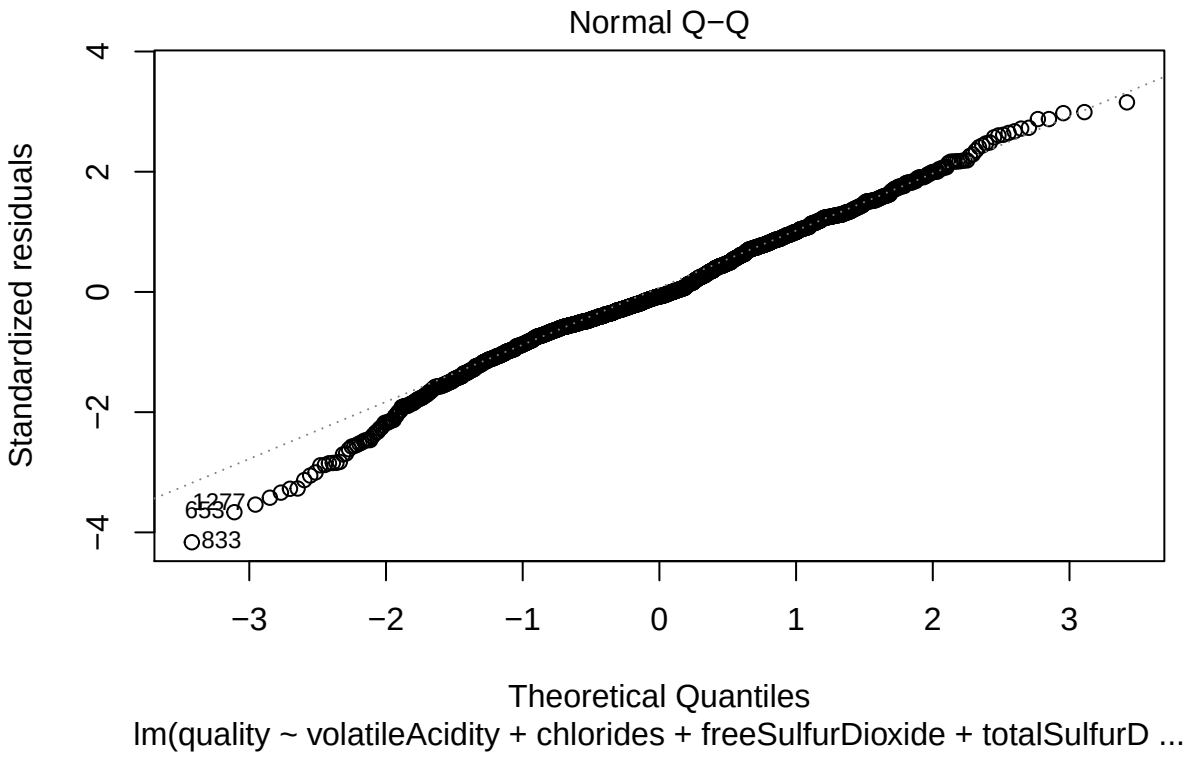
```
## Start:  AIC=-1310.96
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + densityRed +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - densityRed          1     0.287 666.70 -1317.7
## - fixedAcidity        1     0.389 666.80 -1317.4
## - residualSugar       1     0.498 666.91 -1317.2
## - citricAcid          1     0.646 667.06 -1316.8
## - freeSulfurDioxide   1     1.694 668.10 -1314.3
## - pH                  1     1.957 668.37 -1313.7
```

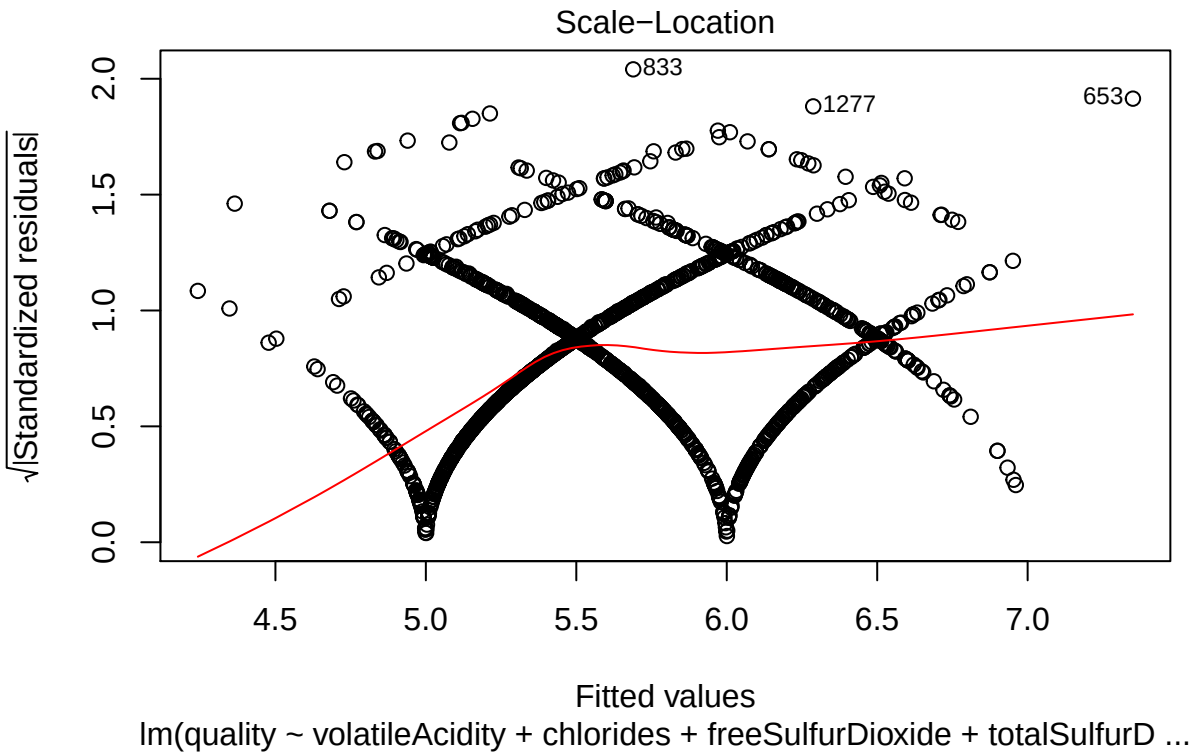
```
## <none>                             666.41 -1311.0
## - chlorides           1     8.391 674.80 -1298.3
## - totalSulfurDioxide  1     8.427 674.84 -1298.2
## - sulphates           1    26.971 693.38 -1254.9
## - volatileAcidity     1    33.620 700.03 -1239.6
## - alcohol             1    45.672 712.08 -1212.3
##
## Step:  AIC=-1317.65
## quality ~ fixedAcidity + volatileAcidity + citricAcid + residualSugar +
##     chlorides + freeSulfurDioxide + totalSulfurDioxide + pH +
##     sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - fixedAcidity         1     0.108 666.81 -1324.8
## - residualSugar        1     0.231 666.93 -1324.5
## - citricAcid           1     0.654 667.35 -1323.5
## - freeSulfurDioxide    1     1.829 668.53 -1320.7
## <none>                             666.70 -1317.7
## - pH                   1     4.325 671.02 -1314.7
## - totalSulfurDioxide   1     8.728 675.43 -1304.2
## - chlorides            1     8.761 675.46 -1304.2
## - sulphates            1    27.287 693.98 -1260.9
## - volatileAcidity      1    35.000 701.70 -1243.2
## - alcohol              1   119.669 786.37 -1061.1
##
## Step:  AIC=-1324.77
## quality ~ volatileAcidity + citricAcid + residualSugar + chlorides +
##     freeSulfurDioxide + totalSulfurDioxide + pH + sulphates +
##     alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - residualSugar        1     0.257 667.06 -1331.5
## - citricAcid           1     0.565 667.37 -1330.8
## - freeSulfurDioxide    1     1.901 668.71 -1327.6
## <none>                             666.81 -1324.8
## - pH                   1     7.065 673.87 -1315.3
## - chlorides            1     9.940 676.75 -1308.5
## - totalSulfurDioxide   1    10.031 676.84 -1308.3
## - sulphates            1    27.673 694.48 -1267.1
## - volatileAcidity      1    36.234 703.04 -1247.5
## - alcohol              1   120.633 787.44 -1066.2
##
## Step:  AIC=-1331.53
## quality ~ volatileAcidity + citricAcid + chlorides + freeSulfurDioxide +
##     totalSulfurDioxide + pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - citricAcid           1     0.475 667.54 -1337.8
## - freeSulfurDioxide    1     2.064 669.13 -1334.0
## <none>                             667.06 -1331.5
## - pH                   1     7.138 674.20 -1321.9
## - totalSulfurDioxide   1     9.828 676.89 -1315.5
## - chlorides            1     9.832 676.89 -1315.5
## - sulphates            1    27.446 694.51 -1274.4
```

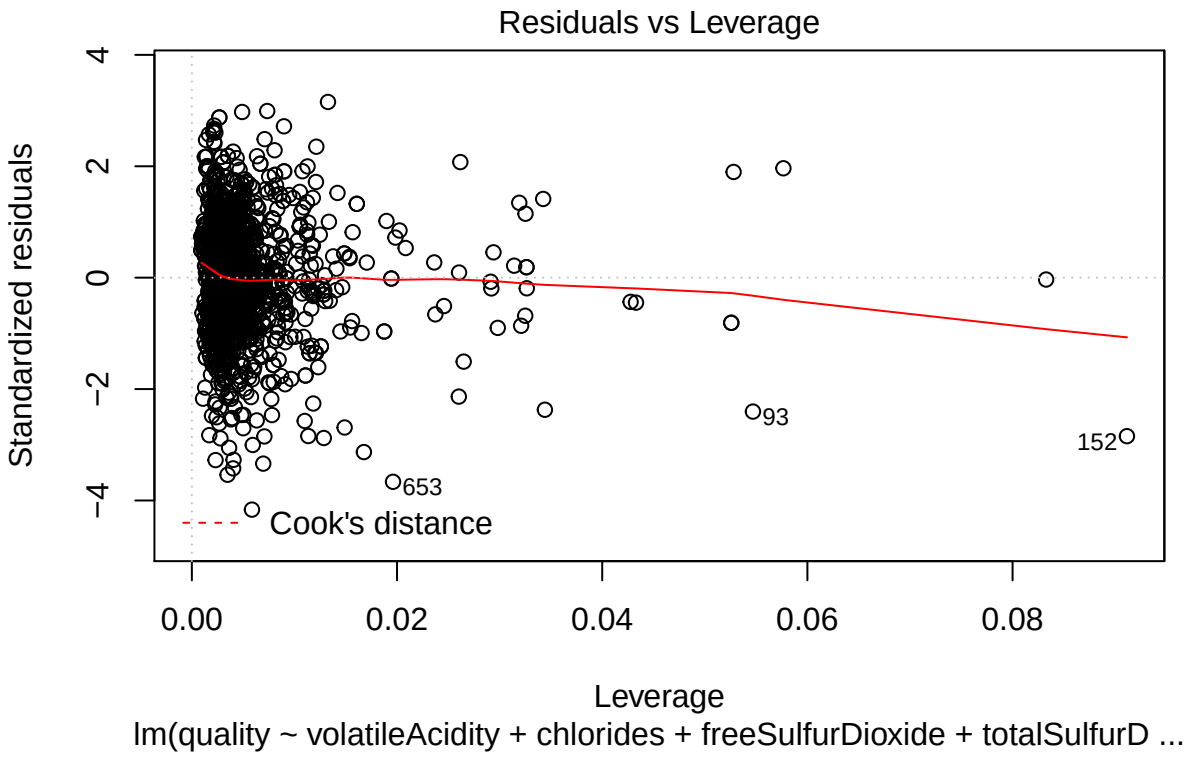
```
## - volatileAcidity     1    35.977 703.04 -1254.9
## - alcohol             1   122.667 789.73 -1069.0
##
## Step:  AIC=-1337.77
## quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## - freeSulfurDioxide   1     2.394 669.93 -1339.4
## <none>                            667.54 -1337.8
## - pH                  1     7.073 674.61 -1328.3
## - totalSulfurDioxide  1    10.787 678.32 -1319.5
## - chlorides           1    10.809 678.35 -1319.5
## - sulphates           1    27.060 694.60 -1281.6
## - volatileAcidity     1    42.318 709.85 -1246.9
## - alcohol             1   124.483 792.02 -1071.7
##
## Step:  AIC=-1339.42
## quality ~ volatileAcidity + chlorides + totalSulfurDioxide +
##     pH + sulphates + alcohol
##
##                       Df Sum of Sq    RSS     AIC
## <none>                            669.93 -1339.4
## - pH                  1     5.919 675.85 -1332.7
## - totalSulfurDioxide  1     9.233 679.16 -1324.9
## - chlorides           1    10.647 680.58 -1321.6
## - sulphates           1    27.445 697.38 -1282.6
## - volatileAcidity     1    44.972 714.90 -1242.9
## - alcohol             1   125.812 795.74 -1071.6
```

```
plot(lm(formula = quality ~ volatileAcidity + chlorides + freeSulfurDioxide +
          totalSulfurDioxide + pH + sulphates + alcohol))
```


Residuals vs Fitted
Residuals
2
1
0
−1
−2
−3
4.5
5.0
5.5
6.0
6.5
7.0
1277
653
833
Fitted values
lm(quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurD ...


Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurD ...
1277
653
833
−4
−2
0
2
4
−3
−2
−1
0
1
2
3


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
833
1277
653
4.5
5.0
5.5
6.0
6.5
7.0
Fitted values
lm(quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurD ...


Residuals vs Leverage
Standardized residuals
4
2
0
−2
−4
0.00
0.02
0.04
0.06
0.08
Leverage
lm(quality ~ volatileAcidity + chlorides + freeSulfurDioxide + totalSulfurD ...
653
93
152
Cook's distance