

# Model Evaluation

## Contents

Overview . . . . .	1
Overall Model . . . . .	2
Transformation of Response Variable . . . . .	3
Evaluate the Fit of the Model . . . . .	4
Televote Model . . . . .	16
Transformation of Response Variable . . . . .	17
Evaluate the Fit of the Model . . . . .	18
Jury Model . . . . .	28
Transformation of Response Variable . . . . .	28
Evaluate the Fit of the Model . . . . .	29

## Overview

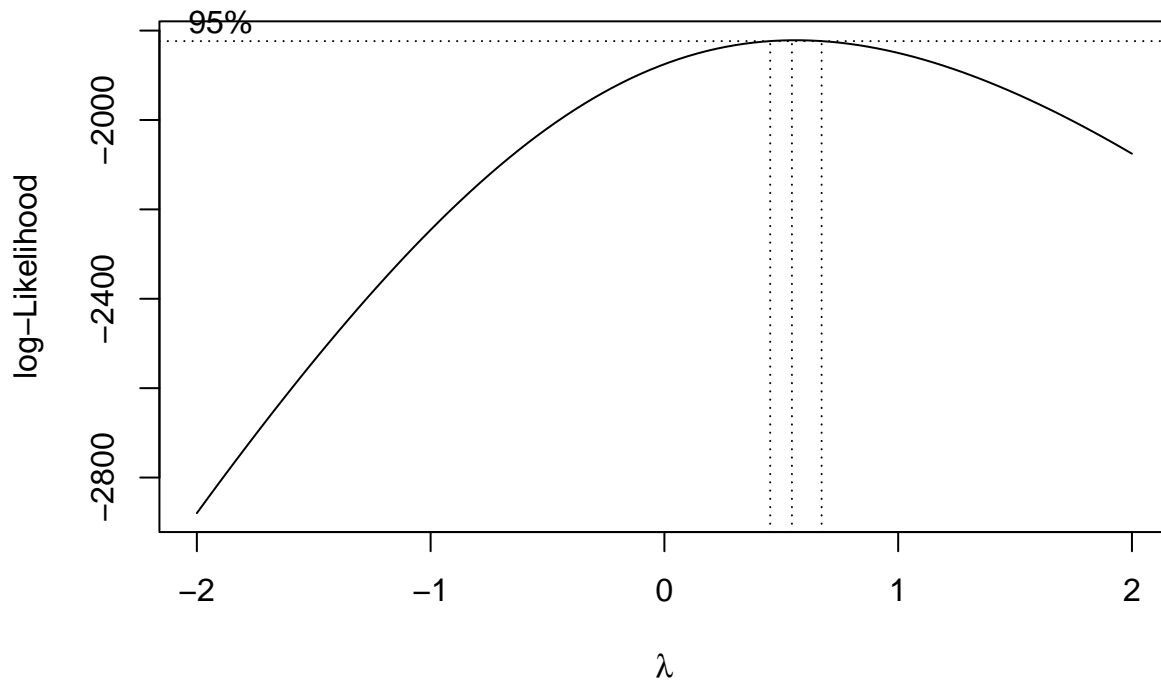
This section evaluates the fit of the model's using the car package. Multiple linear regression (MLR) requires the model residuals to be  $\sim \text{IID } N(0, \sigma^2)$ . The model residuals will be standardized for the assessment.

1. Normality Assumptions will be accessed using:
  - Normality tests from the nortest package
  - Visualizations such as histograms, QQ-plots, Residual Plots and Add Variable Plots
2. Constant Variance will be accessed using:
  - non-constant variance test
3. Multi-collinearity will be accessed using:
  - variance inflation factors
4. Outliers will be accessed using:
  - Cooks Distance

## Overall Model

```
##
## Call:
## lm(formula = overall_final_model_form, data = processed_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -9.5505 -2.3301 -0.2858  2.1846  7.8517
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3.7244     0.6169   6.037 2.64e-09 ***
## Average_Points    0.4798     0.1253   3.830 0.000141 ***
## acousticness      0.6959     0.1302   5.344 1.26e-07 ***
## speechiness       0.6973     0.1362   5.119 4.05e-07 ***
## METRIC_Citizens   0.3251     0.1399   2.324 0.020438 *
## TC_PerfType_Solo  1.4412     0.5613   2.568 0.010457 *
## key_0             1.2923     0.4516   2.861 0.004353 **
## CAP_DIST_km       0.2956     0.1280   2.309 0.021260 *
## OOA               1.2837     0.4512   2.845 0.004579 **
## FC_NonCOB         0.3604     0.1391   2.592 0.009766 **
## ComSONGLAN        0.2760     0.1287   2.145 0.032338 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.074 on 647 degrees of freedom
## Multiple R-squared:  0.1762, Adjusted R-squared:  0.1635
## F-statistic: 13.84 on 10 and 647 DF, p-value: < 2.2e-16
```

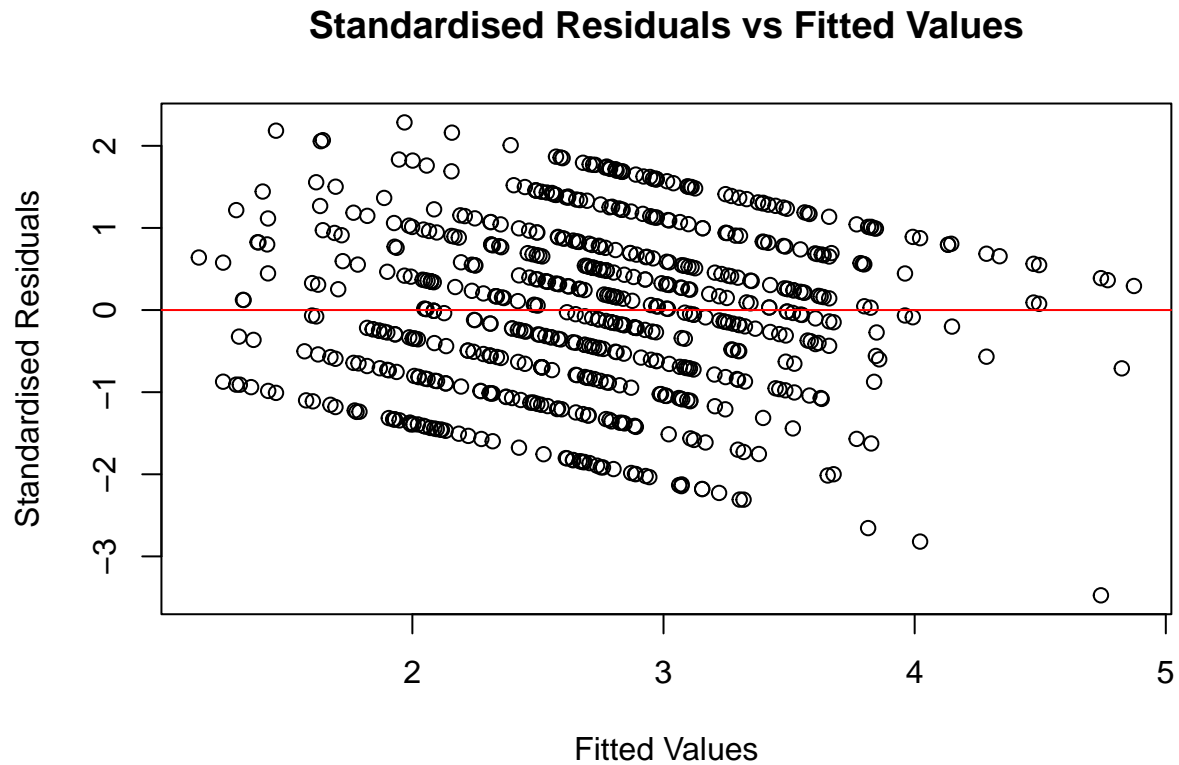
## Transformation of Response Variable



```
##
## Call:
## lm(formula = overall_final_model_bct_form, data = processed_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.7417 -1.0276  0.0449  1.1112  3.3083
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.71220    0.29239   5.856 7.55e-09 ***
## Average_Points  0.20209    0.05938   3.403 0.000706 ***
## acousticness    0.34061    0.06173   5.518 4.96e-08 ***
## speechiness     0.33666    0.06456   5.215 2.48e-07 ***
## METRIC_Citizens 0.12269    0.06630   1.851 0.064672 .
## TC_PerfType_Solo 0.69660    0.26601   2.619 0.009035 **
## key_0           0.65422    0.21405   3.056 0.002332 **
## CAP_DIST_km     0.12426    0.06069   2.048 0.041007 *
## OOA             0.62781    0.21385   2.936 0.003446 **
## FC_NonCOB       0.18387    0.06591   2.790 0.005428 **
## ComSONGLAN      0.14046    0.06099   2.303 0.021585 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

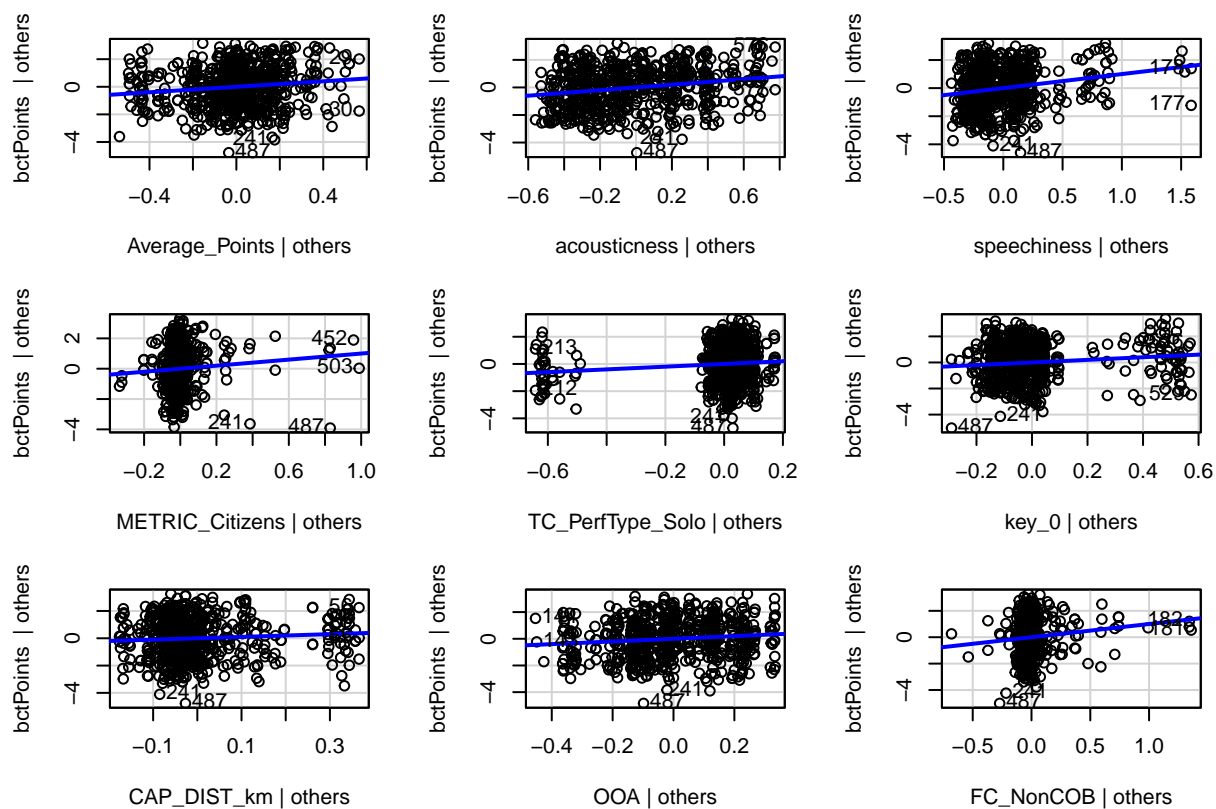
```
## Residual standard error: 1.457 on 647 degrees of freedom
## Multiple R-squared:  0.169, Adjusted R-squared:  0.1562
## F-statistic: 13.16 on 10 and 647 DF,  p-value: < 2.2e-16
```

Evaluate the Fit of the Model

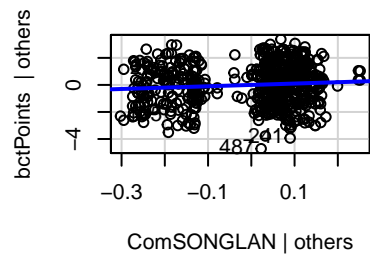


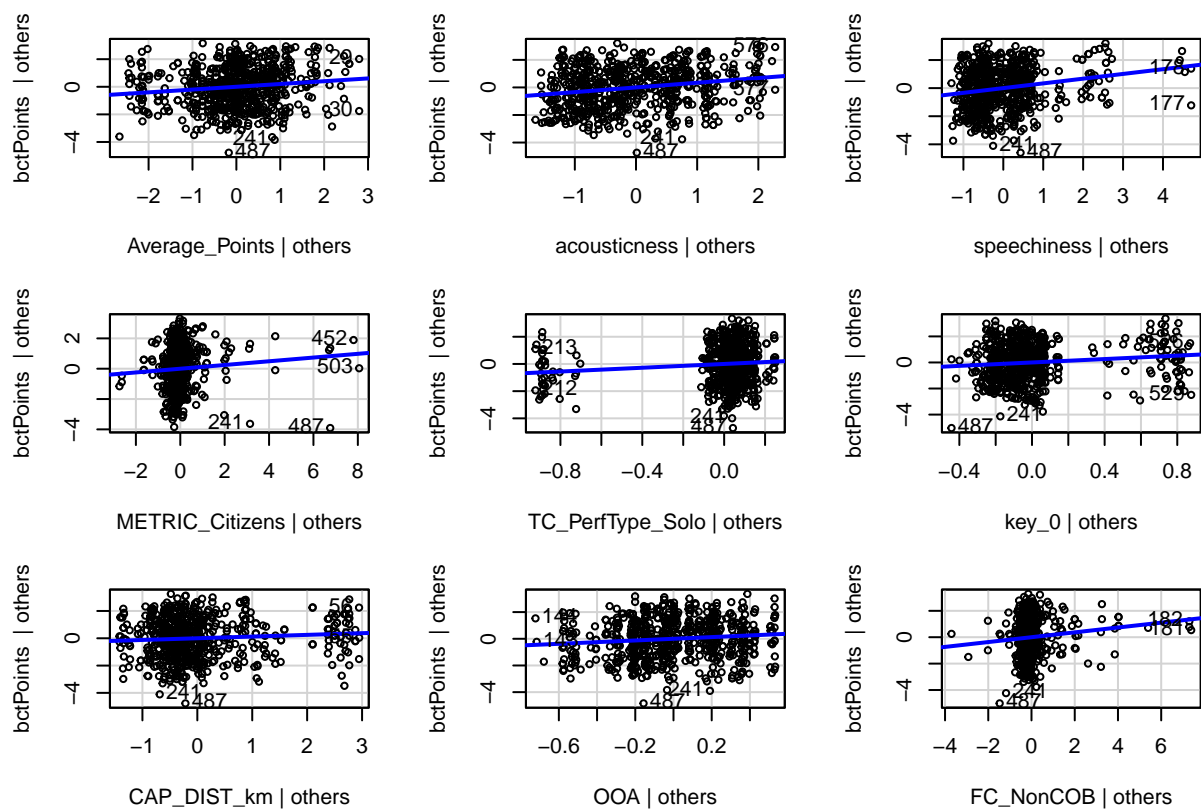
	rstudent	p	bonf.p	signif	cutoff
487	-3.473914	0.0005472	0.3600624	0	0.05

outlier_residuals
39
77
103
177
241
360

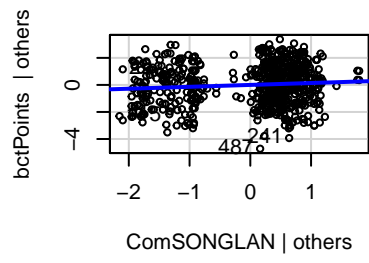


## Leverage Plots

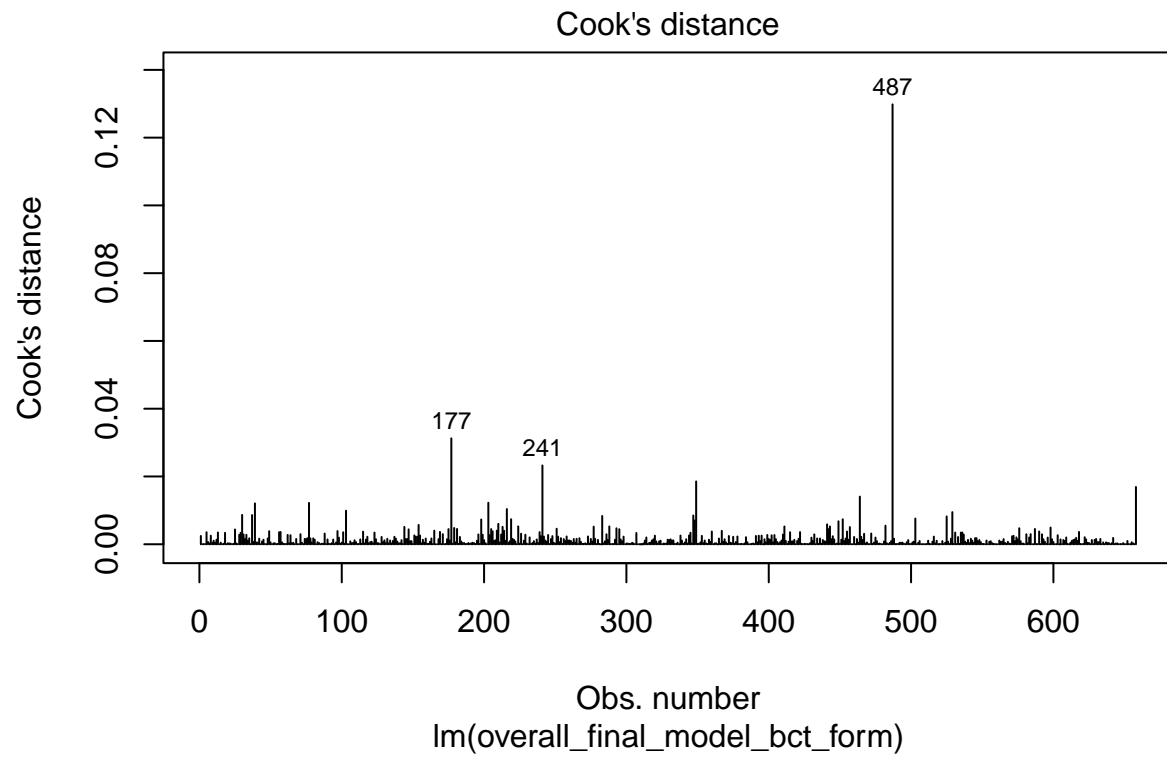


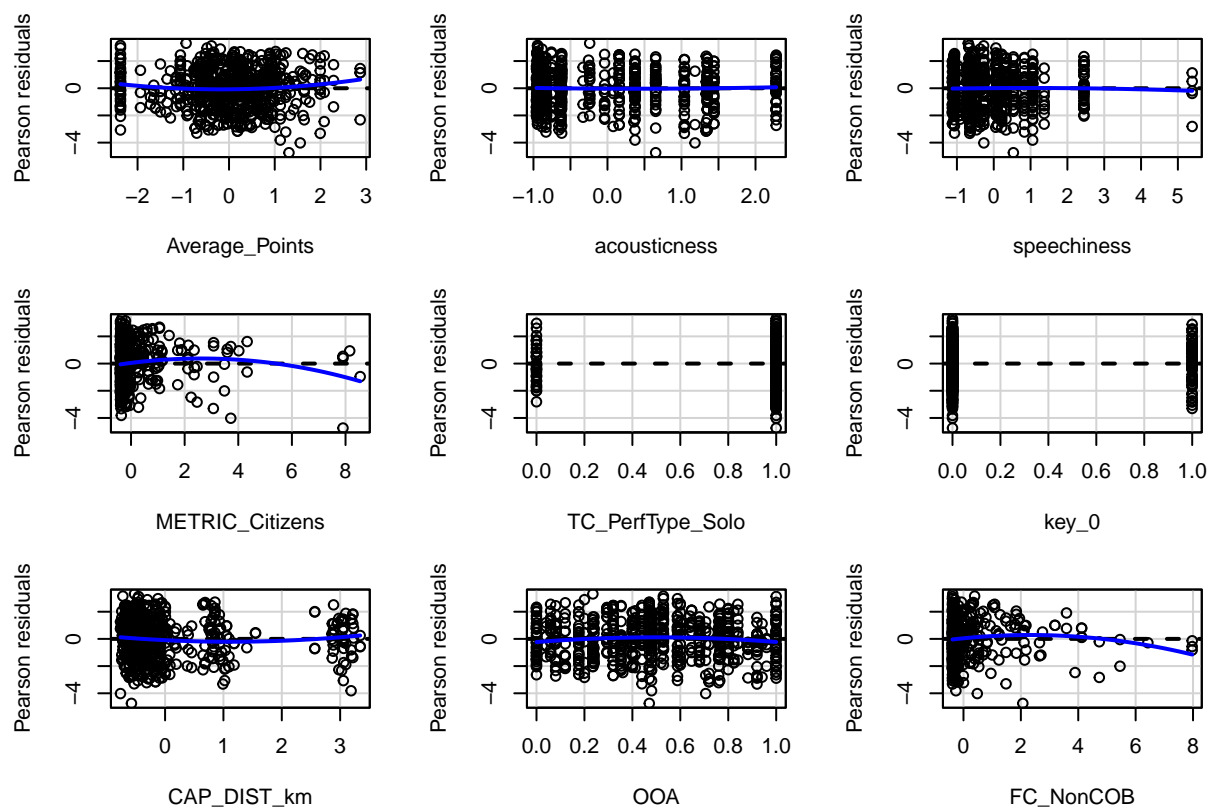


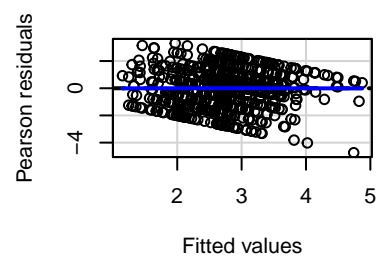
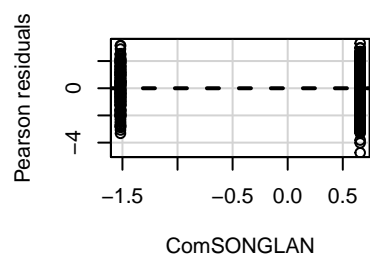
## Added-Variable Plots

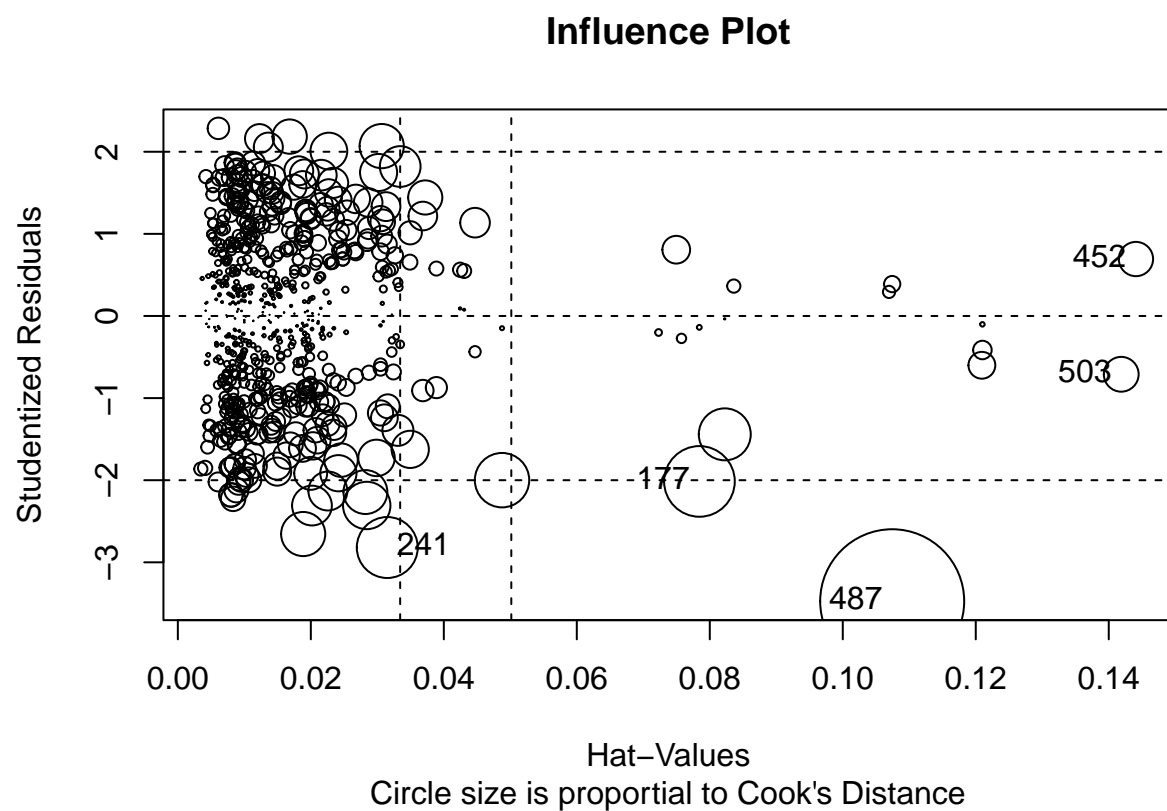










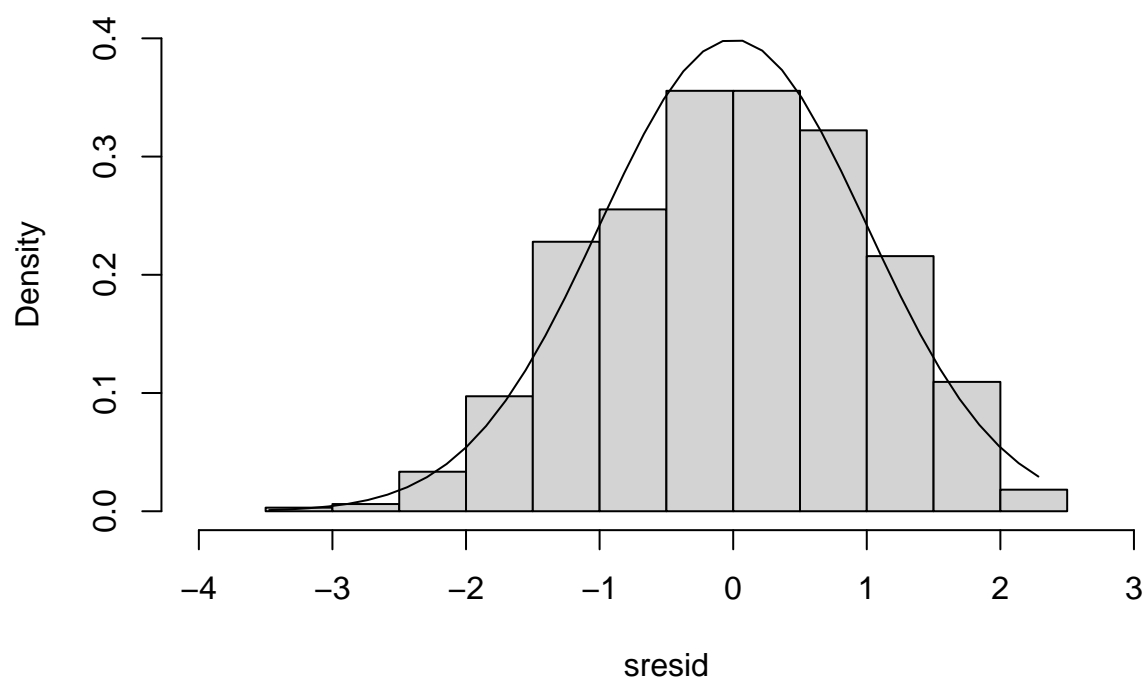


Normality Test

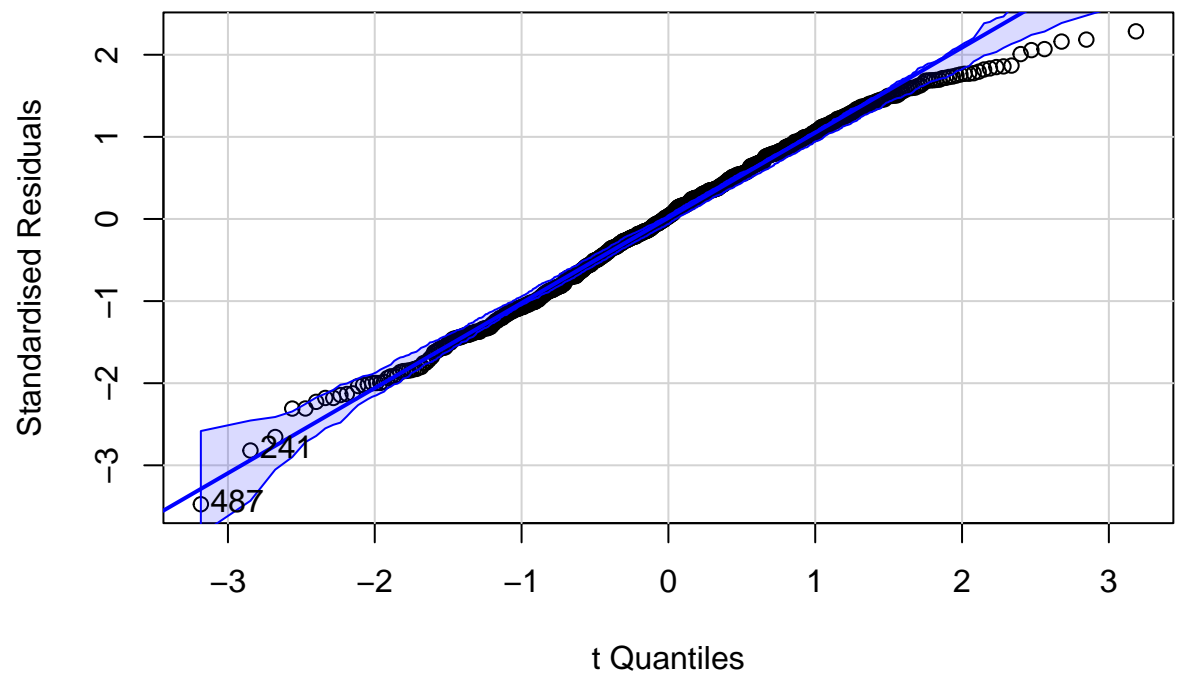
- Ho: The data is normally distributed
- Ha: the data is not normally distributed

NormTest	Stat	Pval
shapiro.test	0.99127	0.00063
ad.test	1.17303	0.00458
cvm.test	0.16383	0.01564
lille.test	0.03283	0.08898
person.test	37.02432	0.04352
sf.test	0.99178	0.00149

### Distribution of Standardised Residuals



QQ-Plot of Overall Model Standardised Residuals

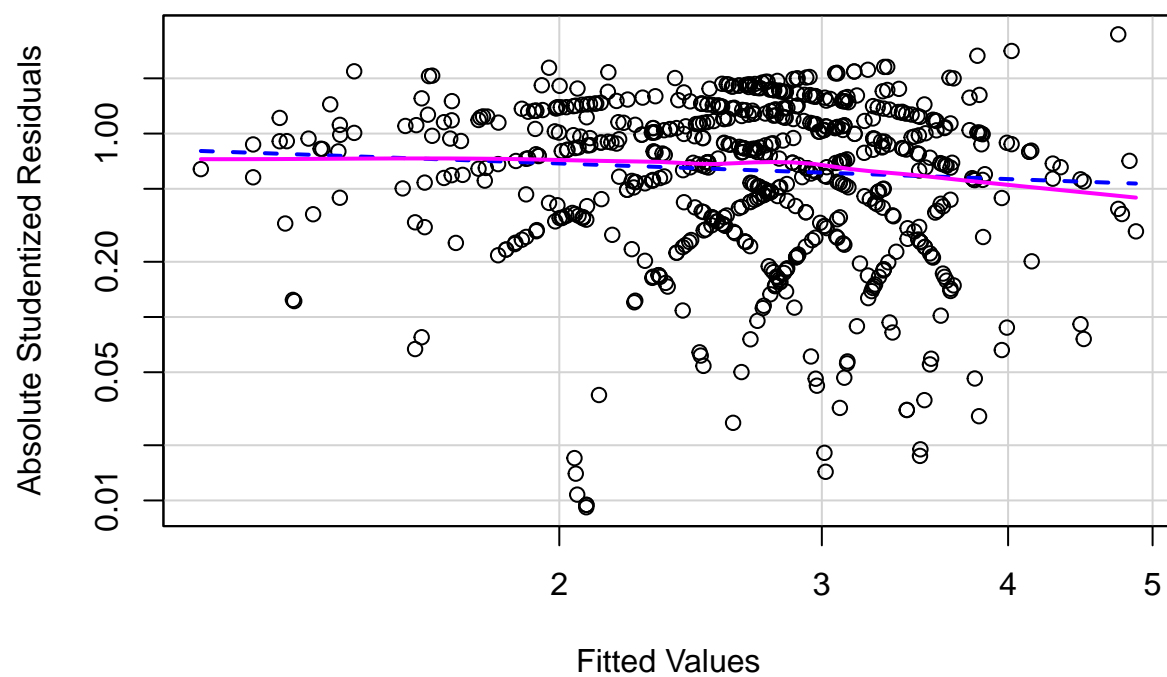


Non-Constant Error Variance Test

- Ho: constant error variance
- Ha: Non-constant error Variance

Non-constant Variance Score Test	
Chi-Sq Statistic	0.03663
P-Value	0.84821

## Spread–Level Plot for Overall Model



	VIF	$\sqrt{\text{VIF}} > 2$
Average_Points	1.091139	0
acousticness	1.179141	0
speechiness	1.289927	0
METRIC_Citizens	1.360161	0
TC_PerfType_Solo	1.104542	0
key_0	1.246838	0
CAP_DIST_km	1.139690	0
OOA	1.188927	0
FC_NonCOB	1.344230	0
ComSONGLAN	1.150996	0

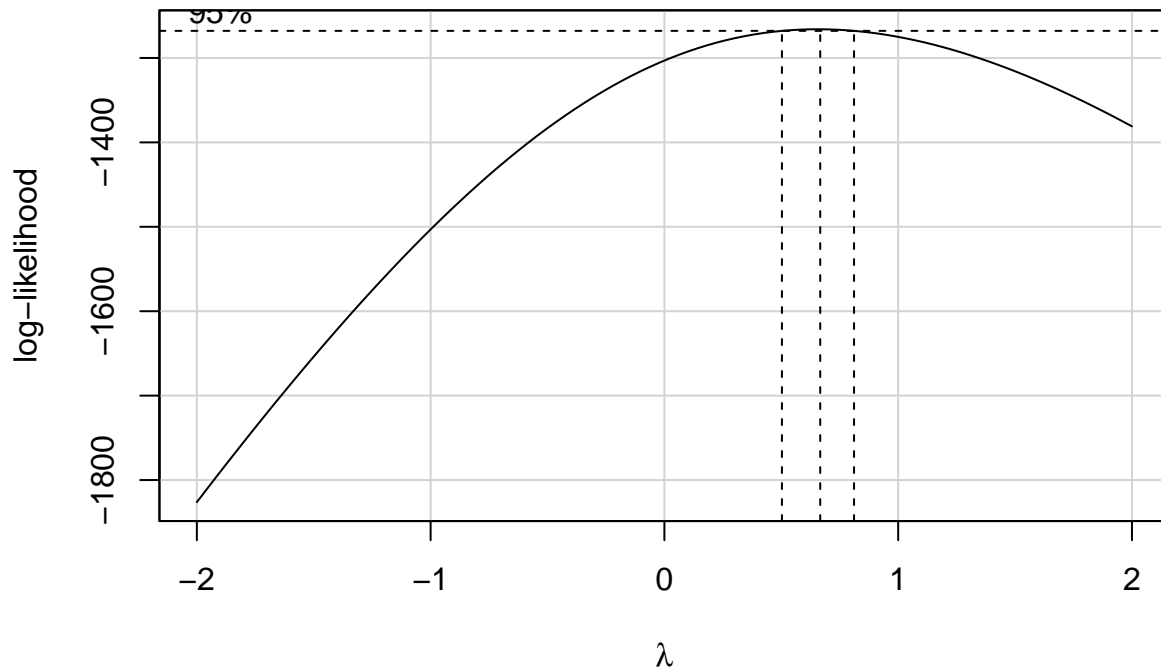
## Televote Model

```
##
## Call:
## lm(formula = televote_final_model_form, data = televote_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -7.3561 -1.9688 -0.0461  1.7443  6.7011
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    5.1314     0.3466  14.806 < 2e-16 ***
## METRIC_Citizens 0.5344     0.1555   3.436 0.000668 ***
## Average_Points  0.8126     0.1607   5.057 7.22e-07 ***
## TC_NumNeigh     0.7464     0.1742   4.286 2.42e-05 ***
## speechiness     0.5175     0.1656   3.125 0.001943 **
## acousticness    0.4804     0.1681   2.858 0.004550 **
## FC_NonCitizens  0.6452     0.1767   3.652 0.000304 ***
## VBlocs1_TC_13  -6.8165     2.1841  -3.121 0.001968 **
## OOA              0.8913     0.6028   1.479 0.140203
## CAP_DIST_km      0.3029     0.1726   1.755 0.080254 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.772 on 317 degrees of freedom
## Multiple R-squared:  0.3384, Adjusted R-squared:  0.3196
## F-statistic: 18.02 on 9 and 317 DF,  p-value: < 2.2e-16
```



## Transformation of Response Variable

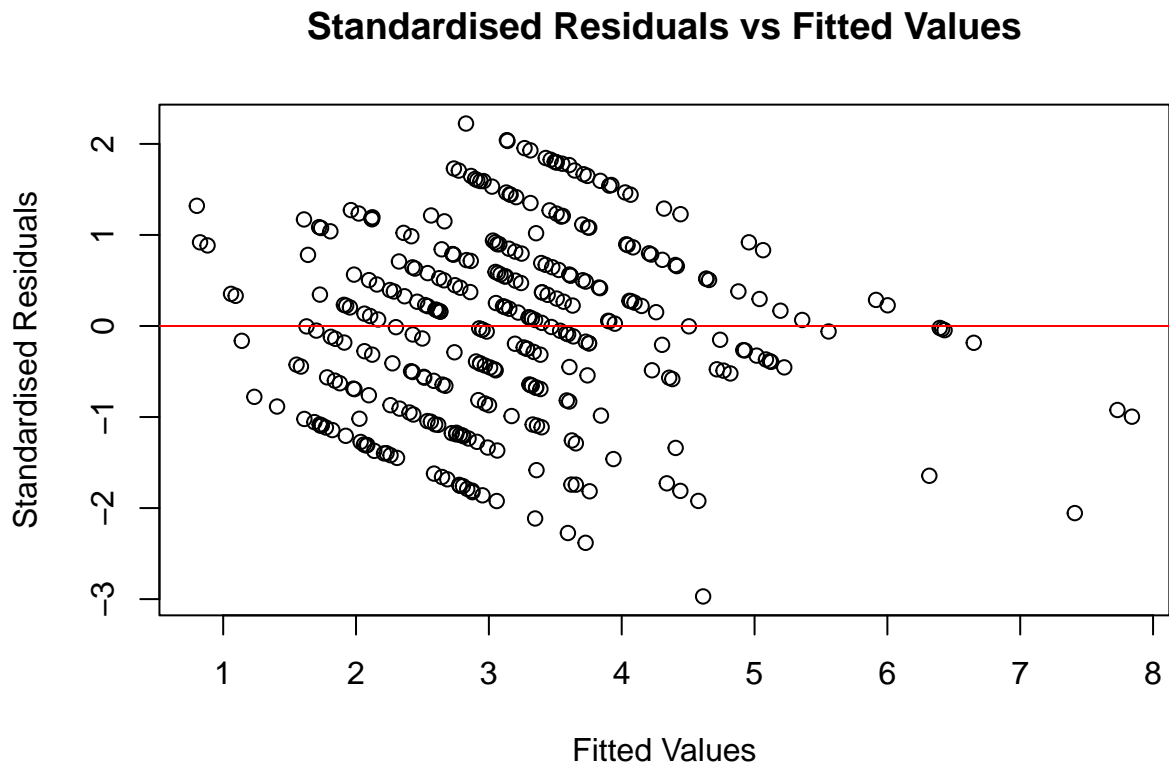
### Profile Log-likelihood



```
##
## Call:
## lm(formula = televote_final_model_bct_form, data = televote_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.6127 -1.0874  0.0907  1.1155  3.5345
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2.75365    0.20088   13.708 < 2e-16 ***
## METRIC_Citizens 0.28085    0.09013    3.116 0.002000 **
## Average_Points  0.44003    0.09313    4.725 3.47e-06 ***
## TC_NumNeigh     0.44883    0.10095    4.446 1.21e-05 ***
## speechiness     0.30365    0.09599    3.163 0.001711 **
## acousticness    0.28053    0.09743    2.879 0.004257 **
## FC_NonCitizens  0.35982    0.10241    3.514 0.000506 ***
## VBlocs1_TC_13  -3.80137    1.26592   -3.003 0.002888 **
## OOA              0.52110    0.34938    1.492 0.136818
## CAP_DIST_km      0.19110    0.10006    1.910 0.057054 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.607 on 317 degrees of freedom
```

## Multiple R-squared: 0.3246, Adjusted R-squared: 0.3054  
## F-statistic: 16.92 on 9 and 317 DF, p-value: < 2.2e-16

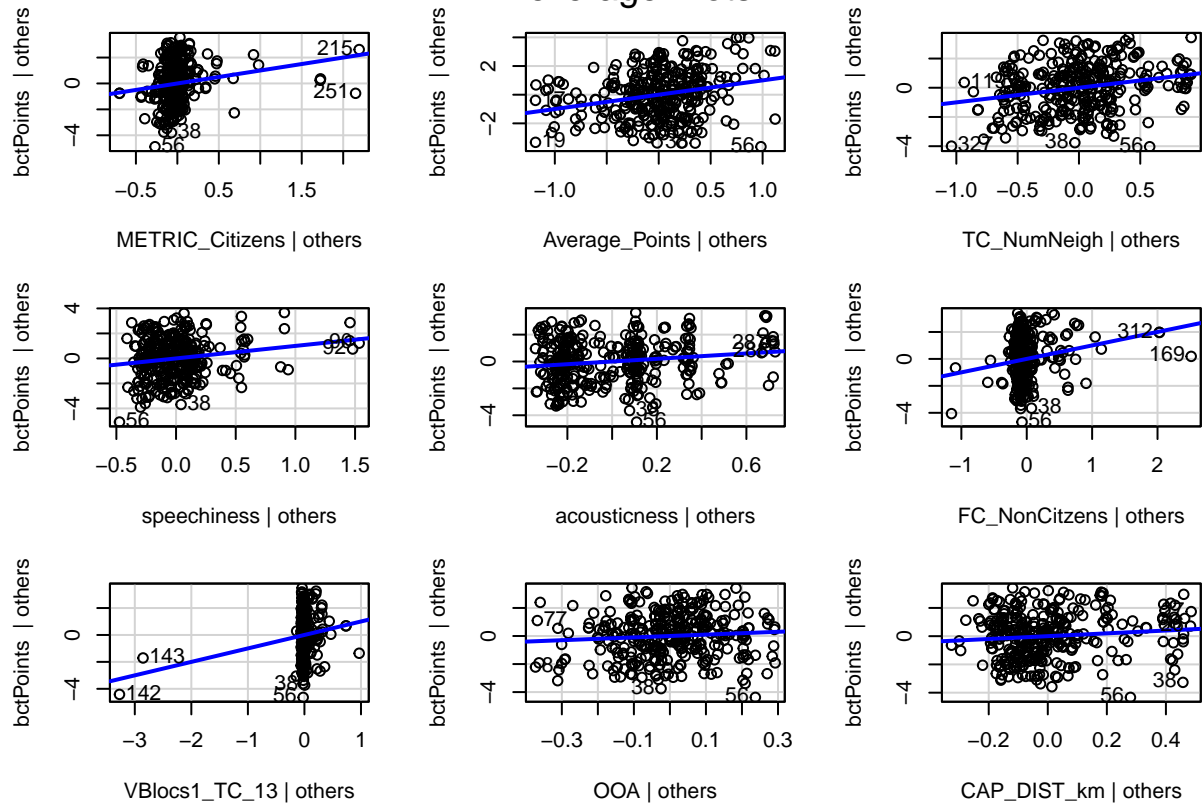
Evaluate the Fit of the Model



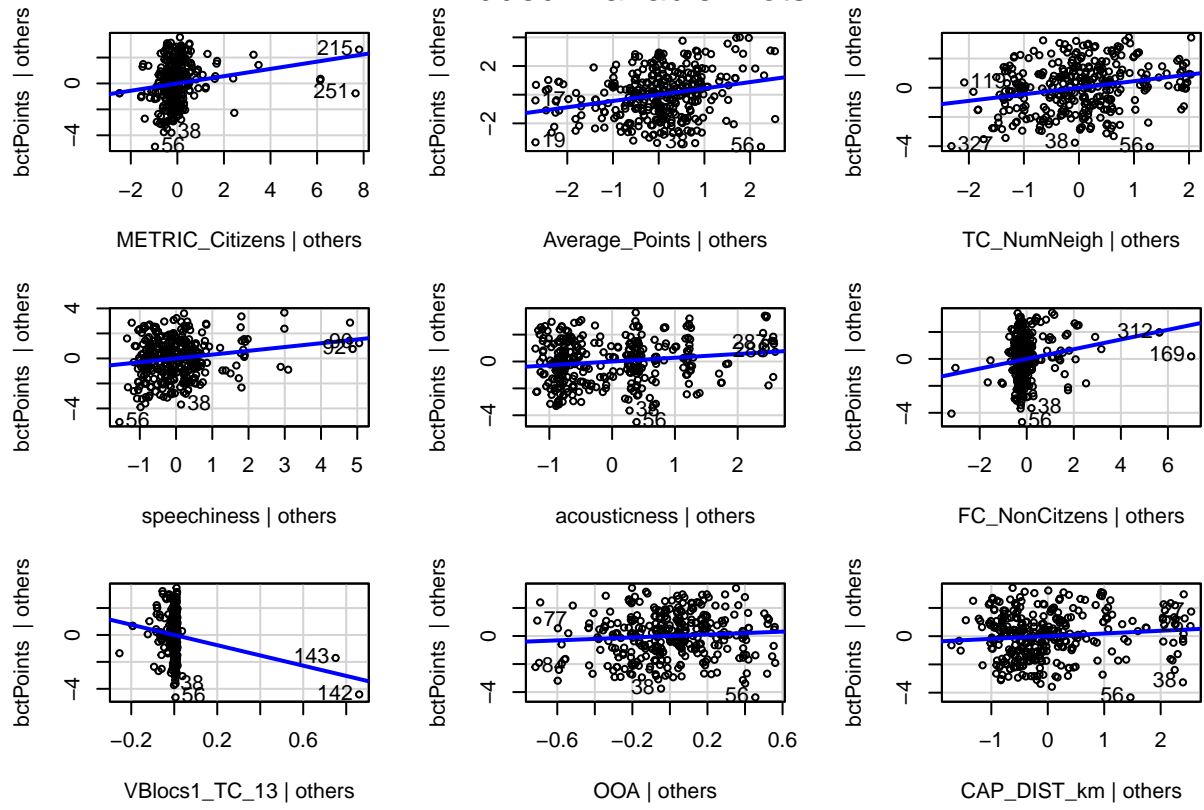
	rstudent	p	bonf.p	signif	cutoff
56	-2.970711	0.0031989	1.046038	0	0.05

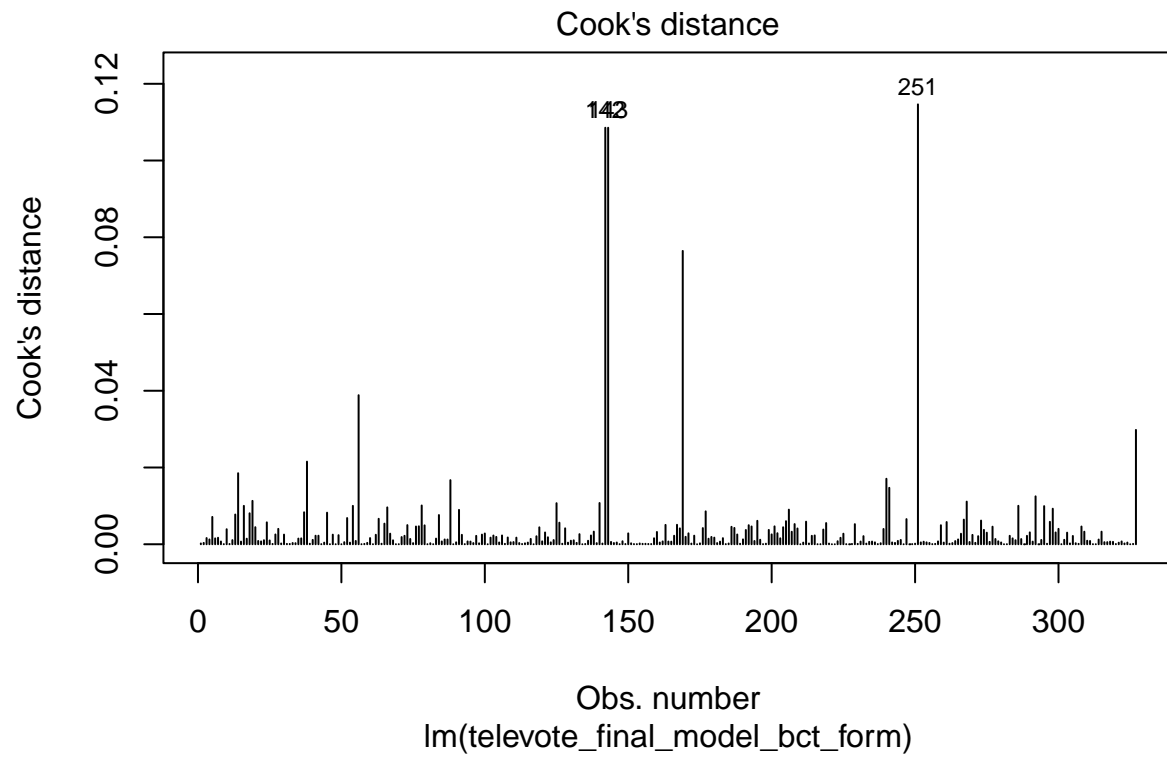
outlier_residuals
38
45
54
56
251

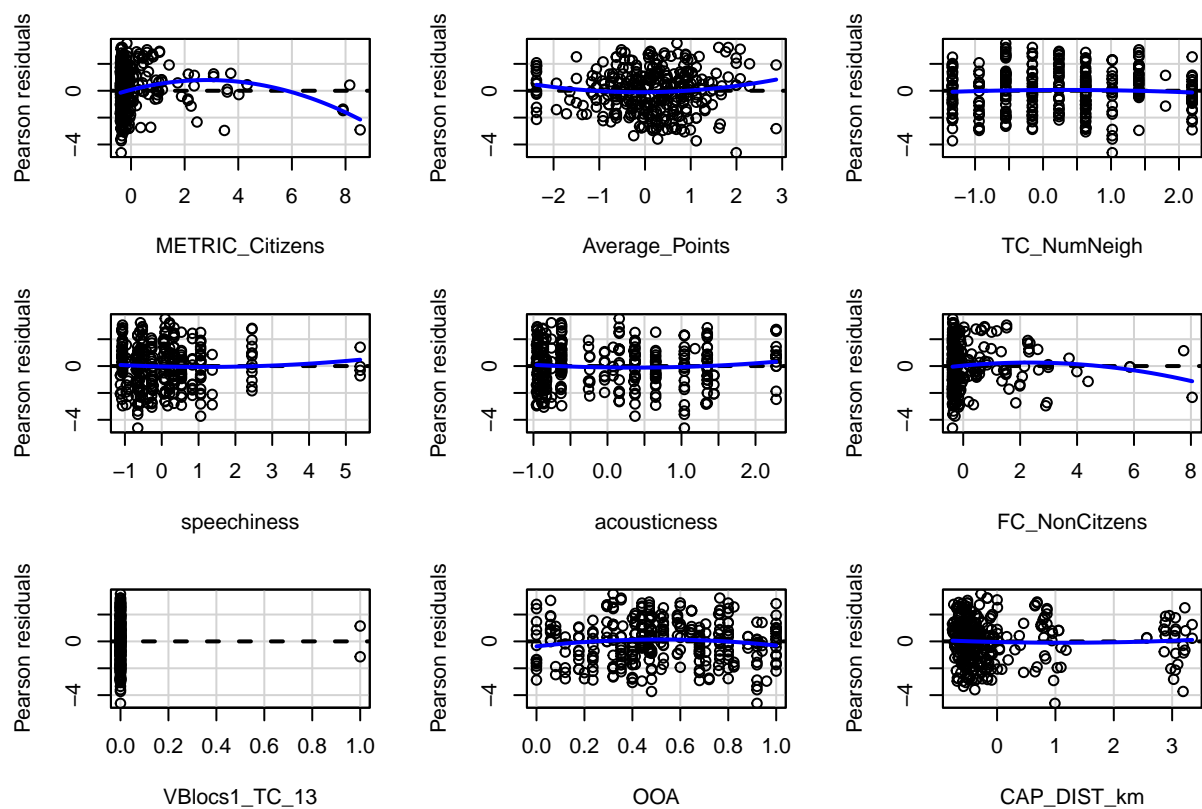
## Leverage Plots

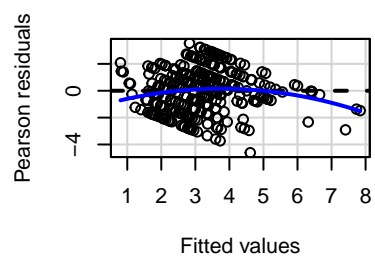


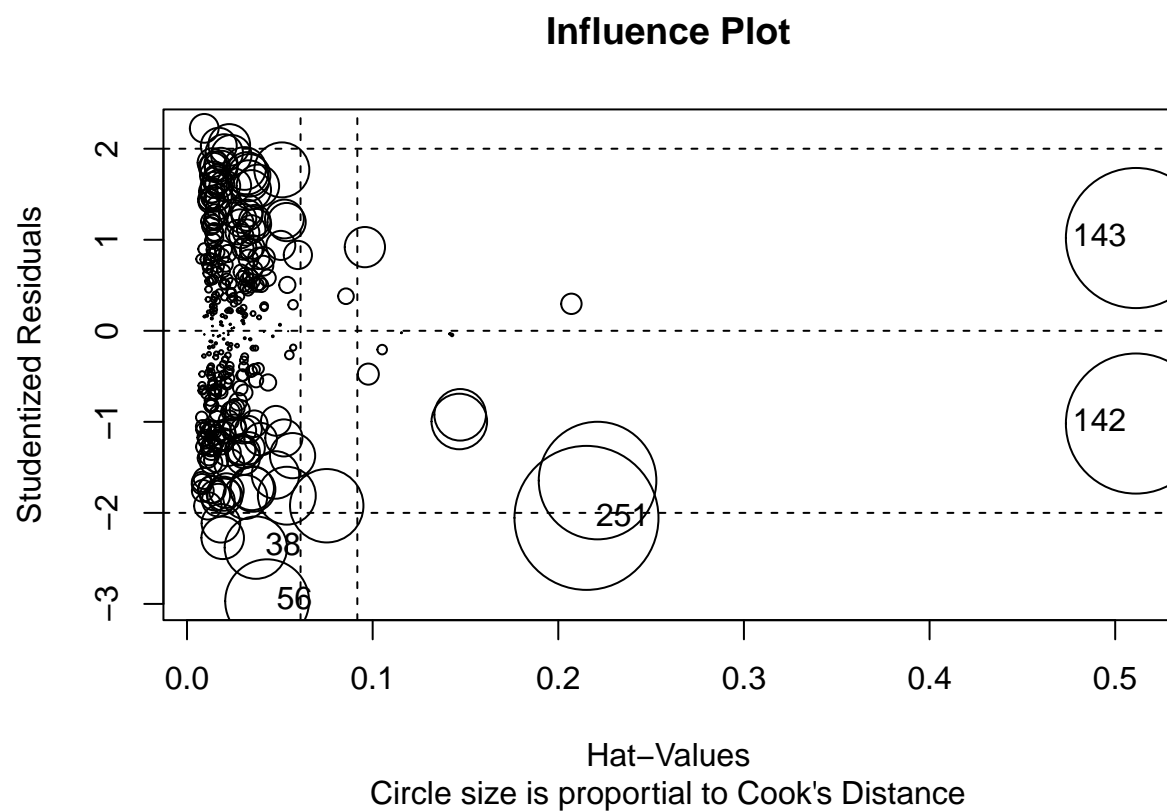
## Added-Variable Plots











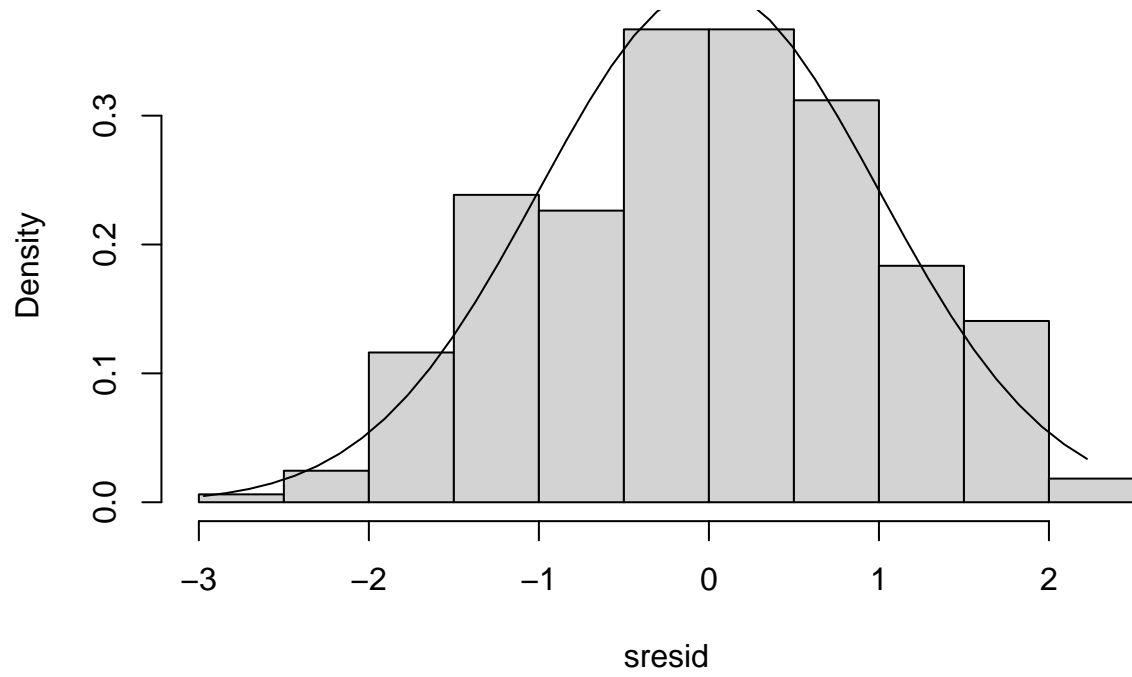
Normality Test

- $H_0$ : The data is normally distributed
- $H_a$ : the data is not normally distributed

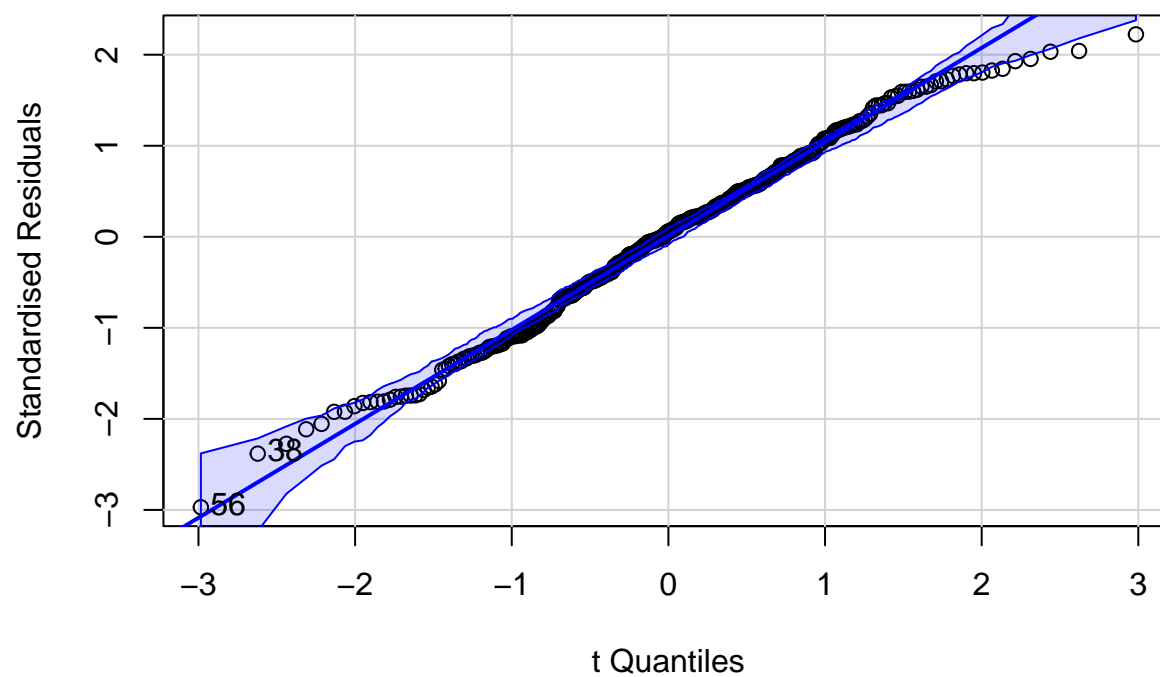
NormTest	Stat	Pval
shapiro.test	0.99075	0.03758
ad.test	0.59623	0.11856
cvm.test	0.07592	0.23336
lille.test	0.0381	0.29588
person.test	21.13761	0.27253
sf.test	0.99202	0.07153



### Distribution of Studentised Residuals



### QQ-Plot of Televote Model Standardised Residuals

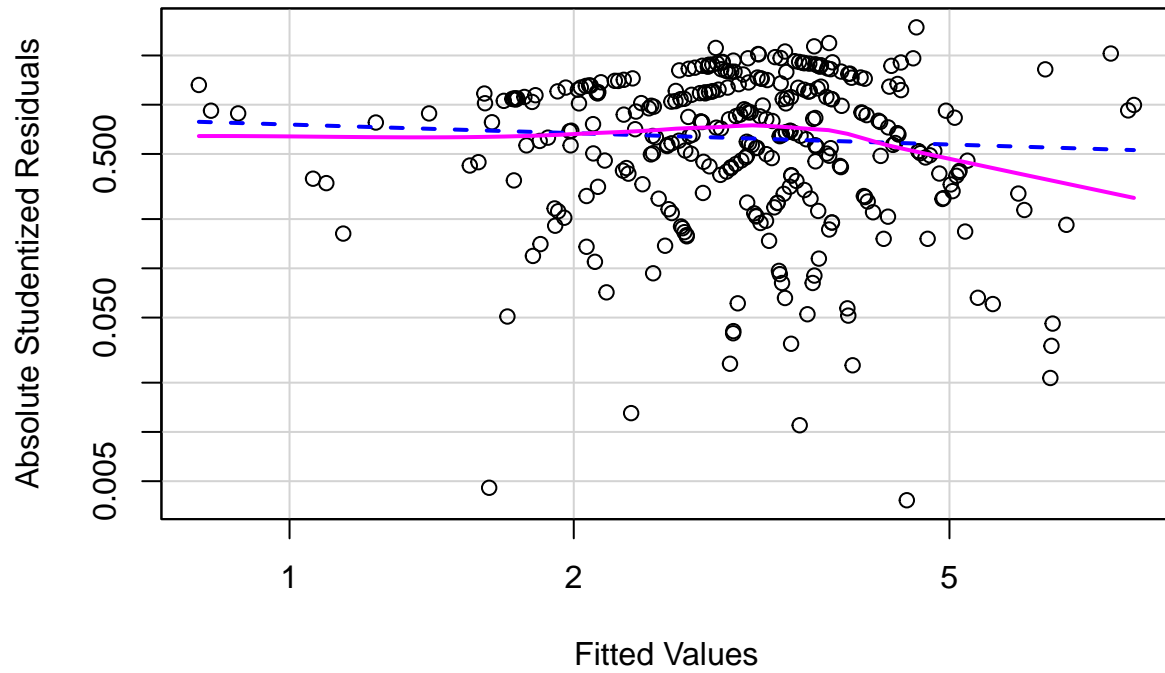


#### Non-Constant Error Variance Test

- $H_0$ : constant error variance
- $H_a$ : Non-constant error Variance

Non-constant Variance Score Test	
Chi-Sq Statistic	0.05524
P-Value	0.81418

## Spread–Level Plot for Televote Model



	VIF	$\sqrt{\text{VIF}} > 2$
METRIC_Citizens	1.440215	0
Average_Points	1.072688	0
TC_NumNeigh	1.440252	0
speechiness	1.231842	0
acousticness	1.059780	0
FC_NonCitizens	1.599009	0
VBlocs1_TC_13	1.233766	0
OOA	1.147115	0
CAP_DIST_km	1.291723	0

## Jury Model

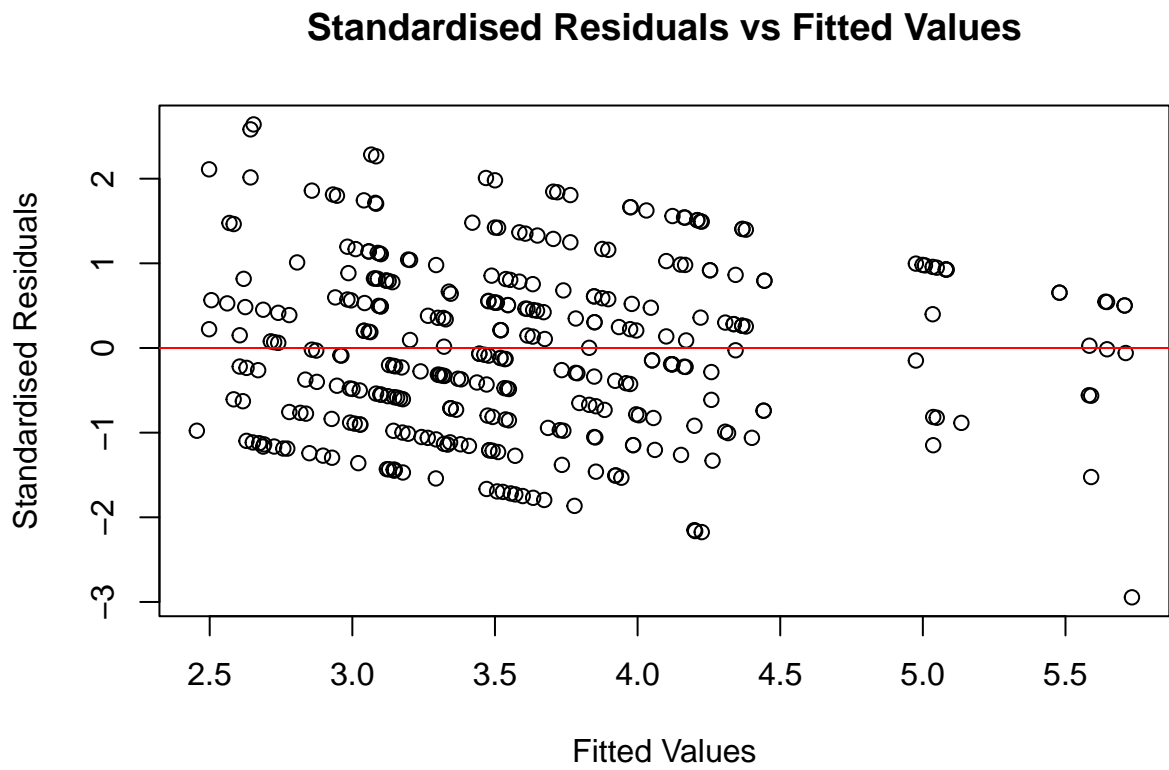
```
##
## Call:
## lm(formula = jury_final_model_form, data = jury_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -6.136 -2.494 -0.291  2.024  8.297
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      4.0865     0.4637   8.812 < 2e-16 ***
## CAP_DIST_km       0.6617     0.1854   3.568 0.000414 ***
## acousticness     0.5032     0.1747   2.880 0.004247 **
## speechiness      0.8932     0.2004   4.457 1.15e-05 ***
## TC_PerfType_Mixed -9.6005     3.2765 -2.930 0.003632 **
## TC_LANGFAM_Armenian -3.1767     0.9880 -3.215 0.001435 **
## VBlocs1_TC_1      3.0611     0.6177   4.956 1.17e-06 ***
## ComVBlocs1_y      -2.2750     0.6857 -3.318 0.001011 **
## VBlocs1_FC_1       0.8442     0.4283   1.971 0.049601 *
## VBlocs2_TC_1       1.5367     0.4794   3.205 0.001484 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.027 on 321 degrees of freedom
## Multiple R-squared:  0.2132, Adjusted R-squared:  0.1912
## F-statistic: 9.667 on 9 and 321 DF,  p-value: 4.405e-13
```

## Transformation of Response Variable

```
##
## Call:
## lm(formula = jury_final_model_pt_form, data = jury_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.051 -1.185 -0.045  1.071  3.804
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.73582     0.23066  11.861 < 2e-16 ***
## CAP_DIST_km       0.34953     0.09104   3.840 0.000148 ***
## acousticness     0.22920     0.08669   2.644 0.008598 **
## speechiness      0.32980     0.09305   3.544 0.000452 ***
## TC_LANGFAM_Armenian -1.49410     0.49134 -3.041 0.002553 **
## VBlocs1_TC_1      1.41307     0.30606   4.617 5.63e-06 ***
## ComVBlocs1_y      -1.03563     0.34079 -3.039 0.002569 **
## VBlocs1_FC_1       0.41954     0.21305   1.969 0.049787 *
## VBlocs2_TC_1       0.81313     0.23839   3.411 0.000730 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

## Residual standard error: 1.506 on 322 degrees of freedom  
## Multiple R-squared: 0.1852, Adjusted R-squared: 0.165  
## F-statistic: 9.149 on 8 and 322 DF, p-value: 2.378e-11

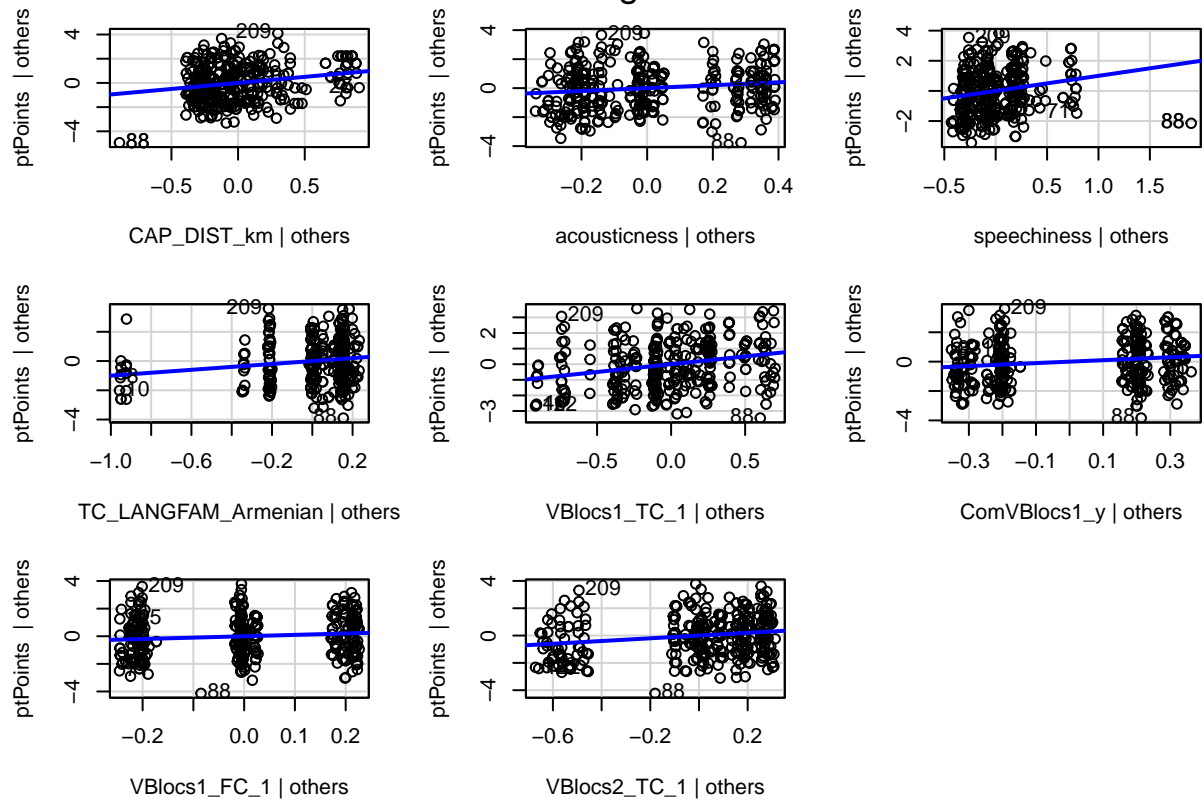
Evaluate the Fit of the Model



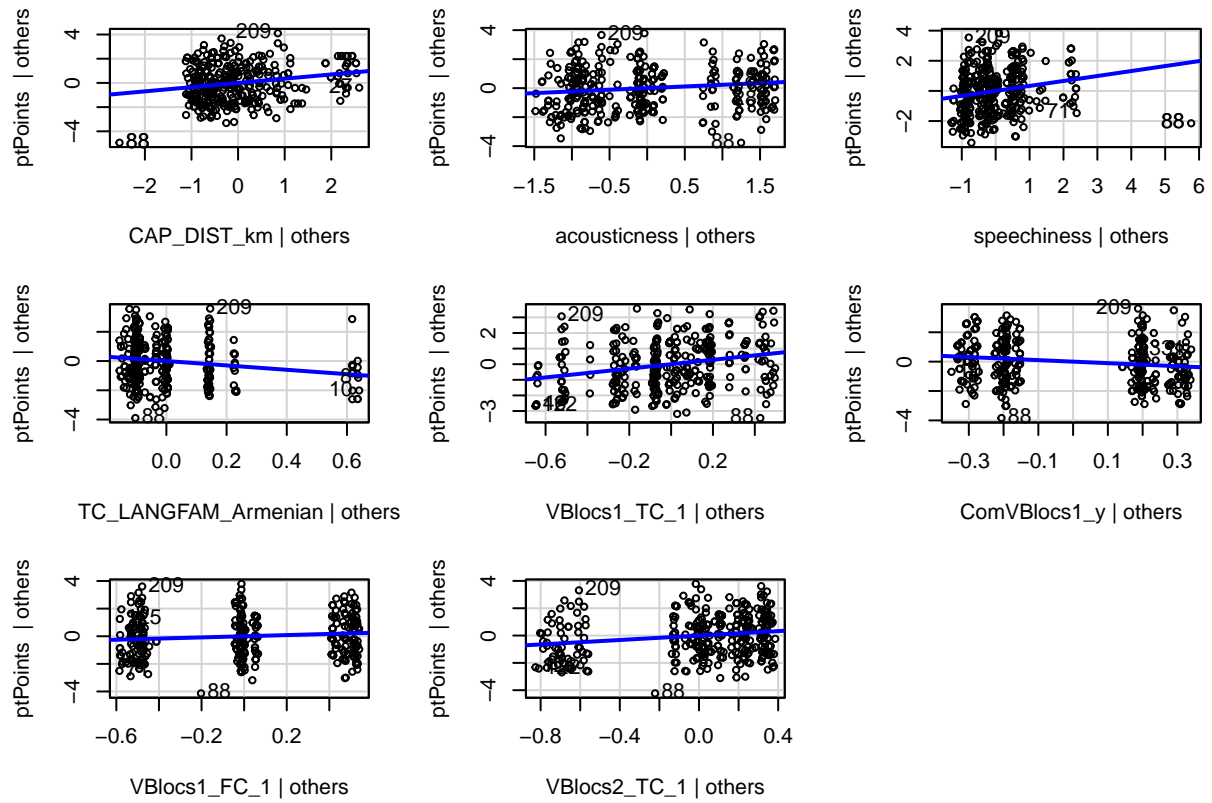
	rstudent	p	bonf.p	signif	cutoff
88	-2.945099	0.0034643	1.146697	0	0.05

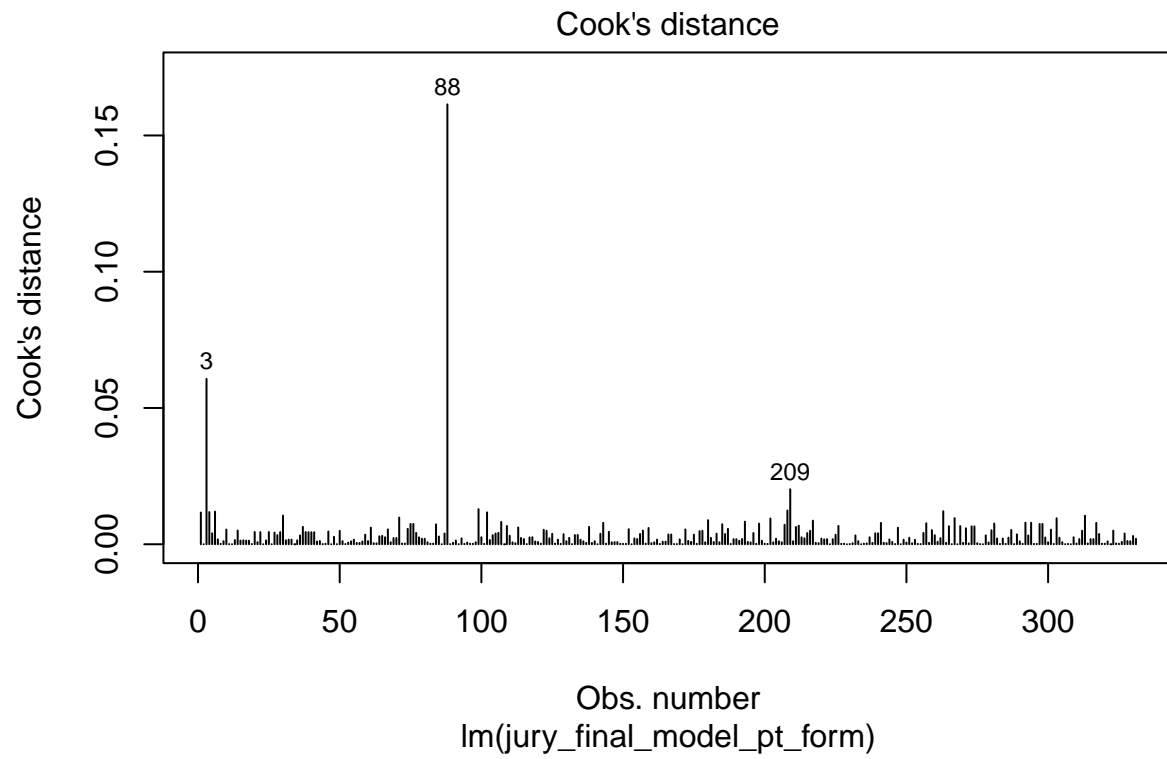
outlier_residuals
88
257
263
313

## Leverage Plots

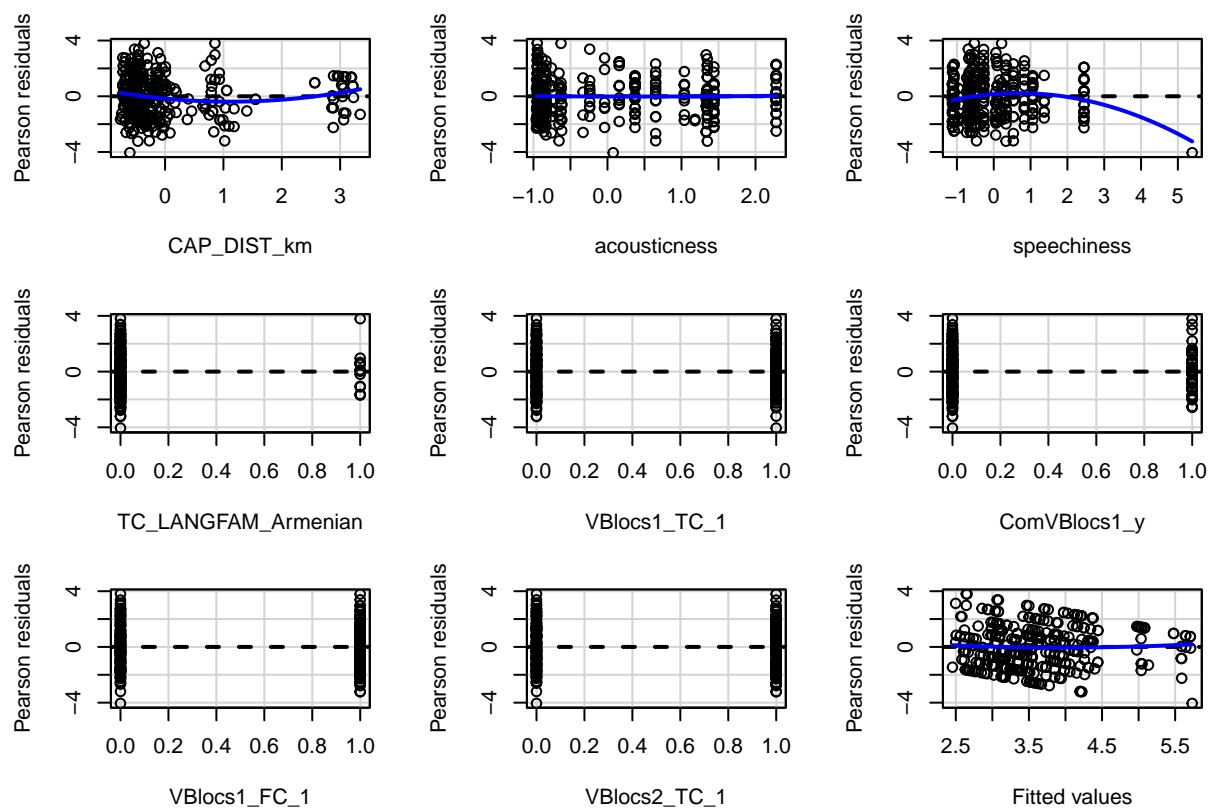


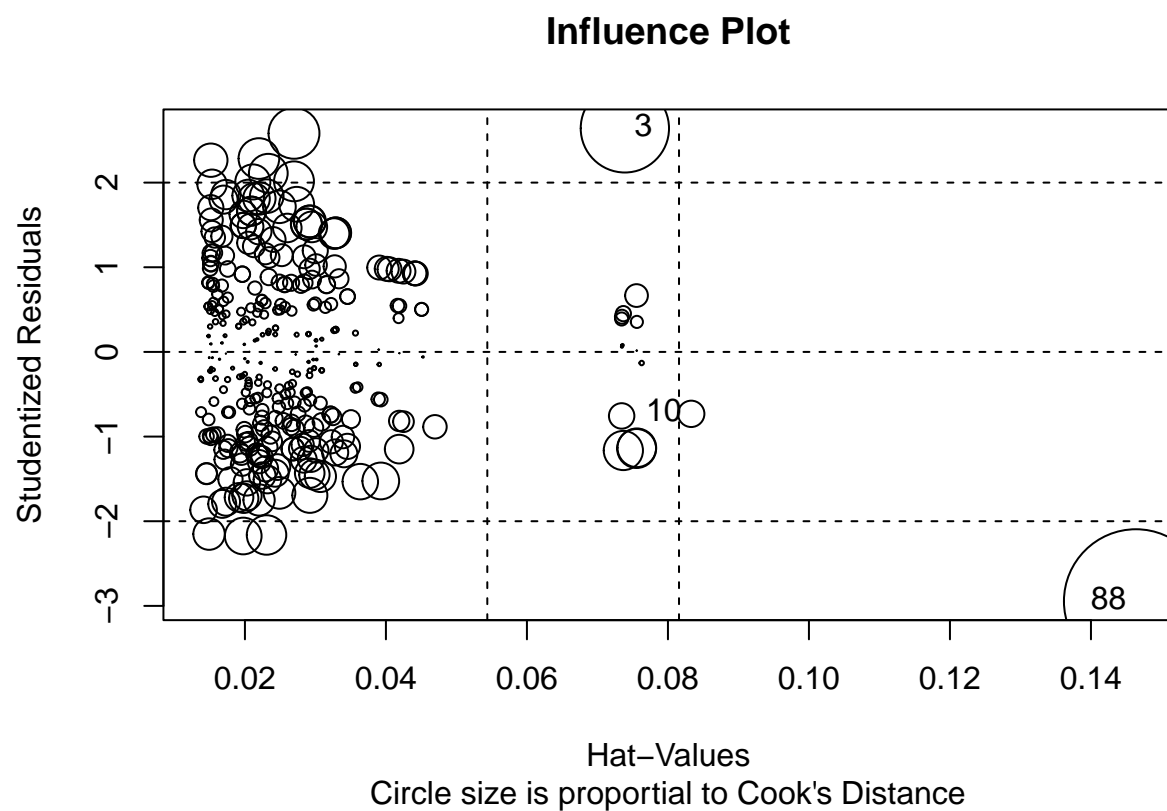
## Added-Variable Plots









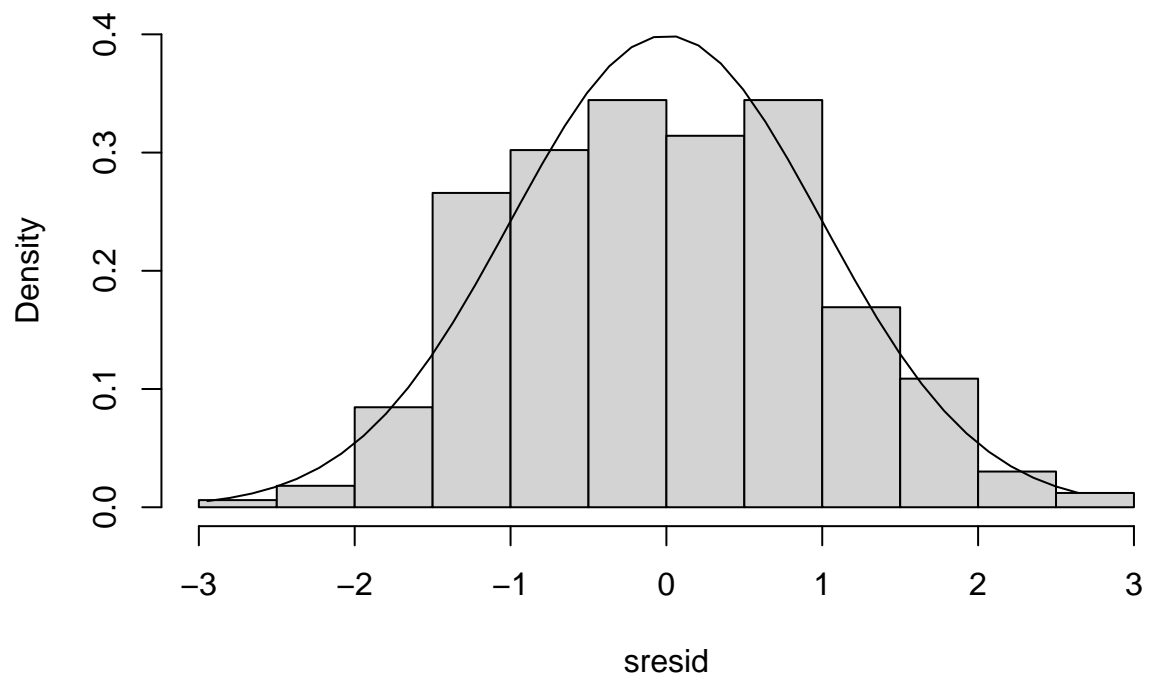


Normality Test

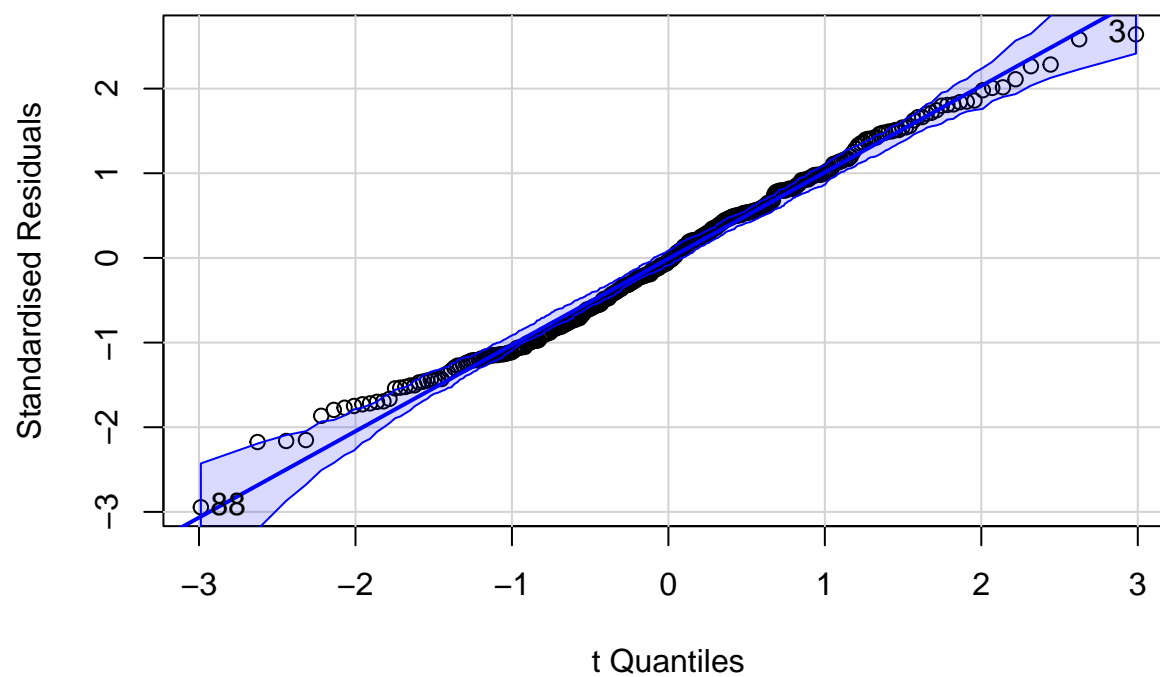
- Ho: The data is normally distributed
- Ha: the data is not normally distributed

NormTest	Stat	Pval
shapiro.test	0.99153	0.05511
ad.test	0.89016	0.02271
cvm.test	0.13742	0.03478
lille.test	0.0473	0.0716
person.test	30.56798	0.03228
sf.test	0.99221	0.07562

### Distribution of Studentised Residuals



### QQ-Plot of Jury Vote Model Standardised Residuals

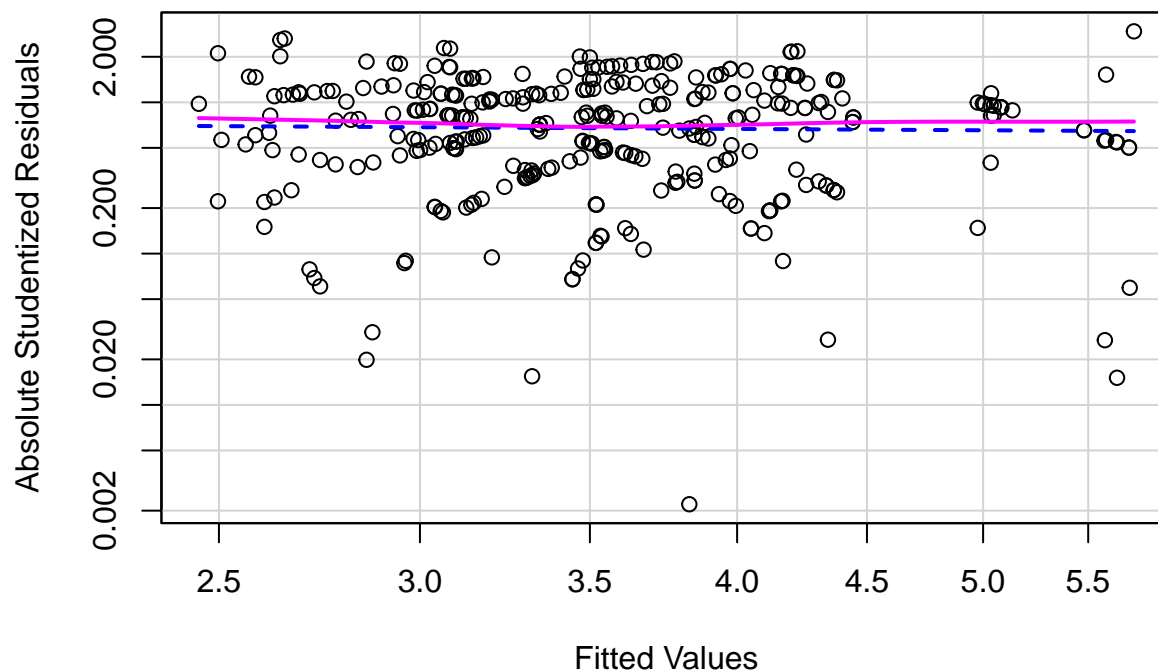


#### Non-Constant Error Variance Test

- $H_0$ : constant error variance
- $H_a$ : Non-constant error Variance

Non-constant Variance Score Test	
Chi-Sq Statistic	0.21531
P-Value	0.64264

### Spread–Level Plot for Jury Vote Model



	VIF	$\sqrt{\text{VIF}} > 2$
CAP_DIST_km	1.181514	0
acousticness	1.220900	0
speechiness	1.187223	0
TC_LANGFAM_Armenian	1.523284	0
VBlocs1_TC_1	3.249223	0
ComVBlocs1_y	2.641876	0
VBlocs1_FC_1	1.654895	0
VBlocs2_TC_1	2.067919	0