Critical Thinking Group 4: DATA621 Homework 5

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Overview

In this homework assignment, you will explore, analyze and model a data set containing information on approximately 12,000 commercially available wines. The variables are mostly related to the chemical properties of the wine being sold. The response variable is the number of sample cases of wine that were purchased by wine distribution companies after sampling a wine. These cases would be used to provide tasting samples to restaurants and wine stores around the United States. The more sample cases purchased, the more likely is a wine to be sold at a high end restaurant. A large wine manufacturer is studying the data in order to predict the number of wine cases ordered based upon the wine characteristics. If the wine manufacturer can predict the number of cases, then that manufacturer will be able to adjust their wine offering to maximize sales.

Your objective is to build a count regression model to predict the number of cases of wine that will be sold given certain properties of the wine. HINT: Sometimes, the fact that a variable is missing is actually predictive of the target. You can only use the variables given to you (or variables that you derive from the variables provided).

Below is a short description of the variables of interest in the data set:

VARIABLE NAME	DEFINITION	THEORETICAL EFFECT
INDEX	Identification Variable (do not use)	None
TARGET	Number of Cases Purchased	None
AcidIndex	Proprietary method of testing total acidity of wine by using a weighted average	
Alcohol	Alcohol Content	
Chlorides	Chloride content of wine	
CitricAcid	Citric Acid Content	
Density	Density of Wine	
FixedAcidity	Fixed Acidity of Wine	
FreeSulfurDioxide	Sulfur Dioxide content of wine	
LabelAppeal	Marketing Score indicating the appeal of label design for consumers. High numbers suggest customers like the label design. Negative numbers suggest customes don't like the design.	Many consumers purchase based on the visual appeal of the wine label design. Higher numbers suggest better sales.
ResidualSugar	Residual Sugar of wine	
STARS	Wine rating by a team of experts. 4 Stars = Excellent, 1 Star = Poor	A high number of stars suggests high sales
Sulphates	Sulfate conten of wine	
TotalSulfurDioxide	Total Sulfur Dioxide of Wine	
VolatileAcidity	Volatile Acid content of wine	
pH	pH of wine	

Deliverables

A write-up of your solutions submitted in PDF format.

Assigned predictions (number of cases of wine sold) for the evaluation data set.

Data Load

We have two datasets.

- One is the `wine training dataset`, which includes 14 candidate predictors, 1 response variable and 12795 observations.
- Other one is the `wine evaluation dataset`, which also includes 14 candidate predictors, 1 response variable but 16129 observations.

We are going to study their missing values, data types and data statistics.

Training Dataset

	TARGET	INDEX	FixedAcidity	VolatileAcidity	CitricAcid	ResidualSugar	Chlorides	FreeSulfurDioxide	TotalSulfurDioxide	Density	pH	Sulphates	Alcohol	LabelAppeal	AcidIndex	STARS
1	3	1	3.2	1.16	-0.98	54.2	-0.567		268	0.99928	3.33	-0.59	9.9	0	8	2
2	3	2	4.5	0.16	-0.81	26.1	-0.425	15	-327	1.02792	3.38	0.7		-1	7	3
3	5	4	7.1	2.64	-0.88	14.8	0.037	214	142	0.99518	3.12	0.48	22	-1	8	3
4	3	5	5.7	0.385	0.04	18.8	-0.425	22	115	0.99964	2.24	1.83	6.2	-1	6	1
5	4	6	8	0.33	-1.26	9.4		-167	108	0.99457	3.12	1.77	13.7	0	9	2
6	0	7	11.3	0.32	0.59	2.2	0.556	-37	15	0.99994	3.2	1.29	15.4	0	11	
7	0	8	7.7	0.29	-0.4	21.5	0.06	287	156	0.99572	3.49	1.21	10.3	0	8	
8	4	11	6.5	-1.22	0.34	1.4	0.04	523	551	1.03236	3.2		11.6	1	7	3
9	3	12	14.8	0.27	1.05	11.25	-0.007	-213		0.99962	4.93	0.26	15	0	6	
10	6	13	5.5	-0.22	0.39	1.8	-0.277	62	180	0.94724	3.09	0.75	12.6	0	8	4

Showing 1 to 10 of 12,795 entries

```
## Observations: 12,795
## Variables: 16
## $ TARGET             <dbl> 3, 3, 5, 3, 4, 0, 0, 4, 3, 6, 0, 4, 3, 7, 4, 0, ...
## $ INDEX              <dbl> 1, 2, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17,...
## $ FixedAcidity       <dbl> 3.2, 4.5, 7.1, 5.7, 8.0, 11.3, 7.7, 6.5, 14.8, 5...
## $ VolatileAcidity    <dbl> 1.160, 0.160, 2.640, 0.385, 0.330, 0.320, 0.290,...
## $ CitricAcid         <dbl> -0.98, -0.81, -0.88, 0.04, -1.26, 0.59, -0.40, 0...
## $ ResidualSugar      <dbl> 54.20, 26.10, 14.80, 18.80, 9.40, 2.20, 21.50, 1...
## $ Chlorides          <dbl> -0.567, -0.425, 0.037, -0.425, NA, 0.556, 0.060,...
## $ FreeSulfurDioxide  <dbl> NA, 15, 214, 22, -167, -37, 287, 523, -213, 62, ...
## $ TotalSulfurDioxide <dbl> 268, -327, 142, 115, 108, 15, 156, 551, NA, 180,...
## $ Density            <dbl> 0.99280, 1.02792, 0.99518, 0.99640, 0.99457, 0.9...
## $ pH                 <dbl> 3.33, 3.38, 3.12, 2.24, 3.12, 3.20, 3.49, 3.20, ...
## $ Sulphates          <dbl> -0.59, 0.70, 0.48, 1.83, 1.77, 1.29, 1.21, NA, 0...
## $ Alcohol            <dbl> 9.9, NA, 22.0, 6.2, 13.7, 15.4, 10.3, 11.6, 15.0...
## $ LabelAppeal        <dbl> 0, -1, -1, -1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 2, 0, ...
## $ AcidIndex          <dbl> 8, 7, 8, 6, 9, 11, 8, 7, 6, 8, 5, 10, 7, 8, 9, 8...
## $ STARS              <dbl> 2, 3, 3, 1, 2, NA, NA, 3, NA, 4, 1, 2, 2, 3, NA,...
```

Evaluation Dataset

	IN	TARGET	FixedAcidity	VolatileAcidity	CitricAcid	ResidualSugar	Chlorides	FreeSulfurDioxide	TotalSulfurDioxide	Density	pH	Sulphates	Alcohol	LabelAppeal	AcidIndex	STARS
1	3		5.4	-0.86	0.27	-10.7	0.092	23	398	0.98527	5.02	0.64	12.3	-1	6	
2	9		12.4	0.385	-0.76	-19.7	1.169	-37	68	0.99048	3.37	1.09	16	0	6	2
3	10		7.2	1.75	0.17	-33	0.065	9	76	1.04641	4.61	0.68	8.55	0	8	1
4	18		6.2	0.1	1.8	1	-0.179	104	89	0.98877	3.2	2.11	12.3	-1	8	1
5	21		11.4	0.21	0.28	1.2	0.038	70	53	1.02899	2.54	-0.07	4.8	0	10	
6	30		17.6	0.04	-1.15	1.4	0.535	-250	140	0.95028	3.06	-0.02	11.4	1	8	4
7	31		15.5	0.53	-0.53	4.6	1.263	10	17	1.00002	3.07	0.75	8.5	0	12	3
8	37		15.9	1.19	1.14	31.9	-0.299	115	381	1.03416	2.99	0.31	11.4	1	7	
9	39		11.6	0.32	0.55	-50.9	0.076	35	83	1.00002	3.32	2.18	-0.5	0	12	
10	47		3.8	0.22	0.31	-7.7	0.039	40	129	0.90061	4.72	-0.64	10.9	0	7	

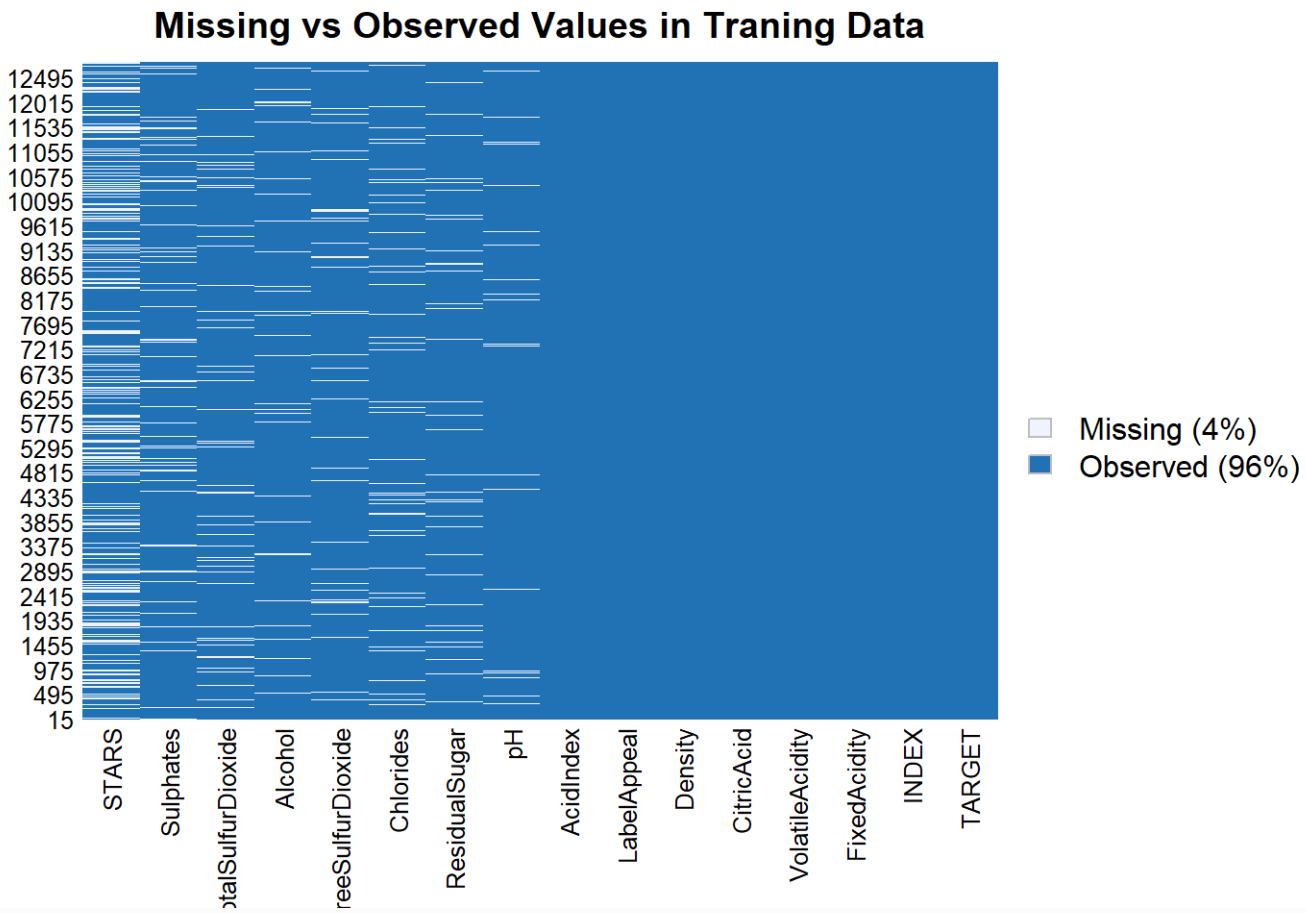
Showing 1 to 10 of 3,335 entries

```
## Observations: 3,335
## Variables: 16
## $ IN                <dbl> 3, 9, 10, 18, 21, 30, 31, 37, 39, 47, 60, 62, 63...
## $ TARGET            <lgl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, ...
## $ FixedAcidity      <dbl> 5.4, 12.4, 7.2, 6.2, 11.4, 17.6, 15.5, 15.9, 11....
## $ VolatileAcidity   <dbl> -0.860, 0.385, 1.750, 0.100, 0.210, 0.040, 0.530...
## $ CitricAcid        <dbl> 0.27, -0.76, 0.17, 1.80, 0.28, -1.15, -0.53, 1.1...
## $ ResidualSugar     <dbl> -10.70, -19.70, -33.00, 1.00, 1.20, 1.40, 4.60, ...
## $ Chlorides         <dbl> 0.092, 1.169, 0.065, -0.179, 0.038, 0.535, 1.263...
## $ FreeSulfurDioxide <dbl> 23, -37, 9, 104, 70, -250, 10, 115, 35, 40, NA, ...
## $ TotalSulfurDioxide <dbl> 398, 68, 76, 89, 53, 140, 17, 381, 83, 129, 583,...
## $ Density           <dbl> 0.98527, 0.99048, 1.04641, 0.98877, 1.02899, 0.9...
## $ pH                <dbl> 5.02, 3.37, 4.61, 3.20, 2.54, 3.06, 3.07, 2.99, ...
## $ Sulphates         <dbl> 0.64, 1.09, 0.68, 2.11, -0.07, -0.02, 0.75, 0.31...
## $ Alcohol           <dbl> 12.30, 16.00, 8.55, 12.30, 4.80, 11.40, 8.50, 11...
## $ LabelAppeal       <dbl> -1, 0, 0, -1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, -1, ...
## $ AcidIndex         <dbl> 6, 6, 8, 8, 10, 8, 12, 7, 12, 7, 8, 10, 9, 8, 9,...
## $ STARS             <dbl> NA, 2, 1, 1, NA, 4, 3, NA, NA, NA, 1, NA, 2, NA,...
```

Missing Values & Data Type Check

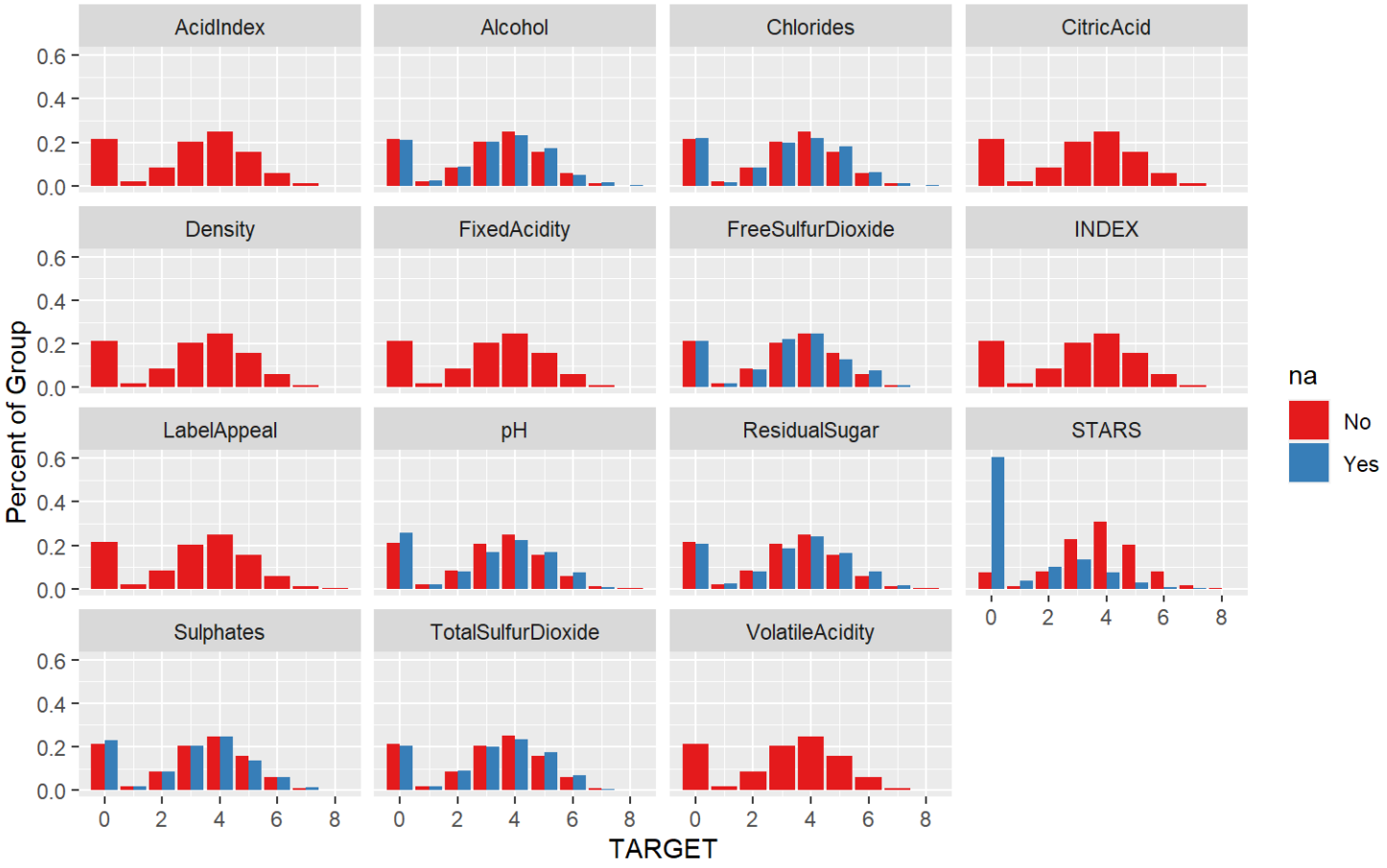
In the `wine training dataset`, there are 14 candidate predictors and 1 response variable with 12,795 observations. In the `wine evaluation dataset`, there are 14 candidate predictors with 3,335 observations. Both datasets have no missing values (eg: NA, NULL or ‘’).

Among the 12 candidate predictors, 3 are categorical (`LabelAppeal`,`AcidIndex`,`STARS`), the other 11 are continuous numerical. The response variable `TARGET` is categorical.



	Non_NAs	NAs	NA_Percent
TARGET	12795	0	0.0000000
INDEX	12795	0	0.0000000
FixedAcidity	12795	0	0.0000000
VolatileAcidity	12795	0	0.0000000
CitricAcid	12795	0	0.0000000
ResidualSugar	12179	616	0.0481438
Chlorides	12157	638	0.0498632
FreeSulfurDioxide	12148	647	0.0505666
TotalSulfurDioxide	12113	682	0.0533021
Density	12795	0	0.0000000
pH	12400	395	0.0308714
Sulphates	11585	1210	0.0945682

	Non_NAs	NAs	NA_Percent
Alcohol	12142	653	0.0510356
LabelAppeal	12795	0	0.0000000
AcidIndex	12795	0	0.0000000
STARS	9436	3359	0.2625244



Below is the summary of the datasets and some inference of it.

1. It seems there are Null values in the predictor variables but none ine response variables.
2. Each variables are in different scale.

Data Statistics Summary

A binary logistic regression model is built using the `training set`, therefore the `training set` is used for the following data exploration.
The data types in the raw dataset are all 'doubles', however the counter `INDEX` and the response variable `target`are categorical.

The statistics of all variables are list below:

```
##      TARGET       FixedAcidity      VolatileAcidity      CitricAcid
##  Min.   :0.000   Min.   :-18.100   Min.   :-2.7900   Min.   :-3.2400
##  1st Qu.:2.000   1st Qu.:  5.200   1st Qu.: 0.1300   1st Qu.: 0.0300
##  Median :3.000   Median :  6.900   Median : 0.2800   Median : 0.3100
##  Mean   :3.029   Mean   :  7.076   Mean   : 0.3241   Mean   : 0.3084
##  3rd Qu.:4.000   3rd Qu.:  9.500   3rd Qu.: 0.6400   3rd Qu.: 0.5800
##  Max.   :8.000   Max.   : 34.400   Max.   : 3.6800   Max.   : 3.8600
##
##  ResidualSugar        Chlorides       FreeSulfurDioxide TotalSulfurDioxide
##  Min.   :-127.800   Min.   :-1.1710   Min.   :-555.00   Min.   :-823.0
##  1st Qu.:  -2.000   1st Qu.:-0.0310   1st Qu.:   0.00   1st Qu.:  27.0
##  Median :   3.900   Median : 0.0460   Median :  30.00   Median : 123.0
##  Mean   :   5.419   Mean   : 0.0548   Mean   :  30.85   Mean   : 120.7
##  3rd Qu.:  15.900   3rd Qu.: 0.1530   3rd Qu.:  70.00   3rd Qu.: 208.0
##  Max.   : 141.150   Max.   : 1.3510   Max.   : 623.00   Max.   :1057.0
##  NA's   :616        NA's   :638       NA's   :647       NA's   :682
##     Density             pH          Sulphates          Alcohol
##  Min.   :0.8881   Min.   :0.480   Min.   :-3.1300   Min.   :-4.70
##  1st Qu.:0.9877   1st Qu.:2.960   1st Qu.: 0.2800   1st Qu.: 9.00
##  Median :0.9945   Median :3.200   Median : 0.5000   Median :10.40
##  Mean   :0.9942   Mean   :3.208   Mean   : 0.5271   Mean   :10.49
##  3rd Qu.:1.0005   3rd Qu.:3.470   3rd Qu.: 0.8600   3rd Qu.:12.40
##  Max.   :1.0992   Max.   :6.130   Max.   : 4.2400   Max.   :26.50
##                   NA's   :395     NA's   :1210      NA's   :653
##   LabelAppeal          AcidIndex          STARS
##  Min.   :-2.000000   Min.   : 4.000   Min.   :1.000
##  1st Qu.:-1.000000   1st Qu.: 7.000   1st Qu.:1.000
##  Median : 0.000000   Median : 8.000   Median :2.000
##  Mean   :-0.009066   Mean   : 7.773   Mean   :2.042
##  3rd Qu.: 1.000000   3rd Qu.: 8.000   3rd Qu.:3.000
##  Max.   : 2.000000   Max.   :17.000   Max.   :4.000
##                                       NA's   :3359
```

The statistics of TARGET Variable.

- **TARGET:** Number of Cases Purchased as Actual

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    StdD    Skew    Kurt
##    0.00    2.00    3.00    3.03    4.00    8.00    1.93   -0.33   -0.88
```

Data Exploration

The first step we did was to import the data from GitHub, remove the index and look at the structure of the data.

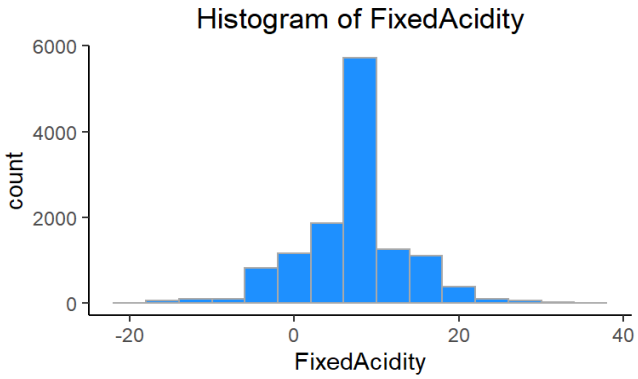
Outliers

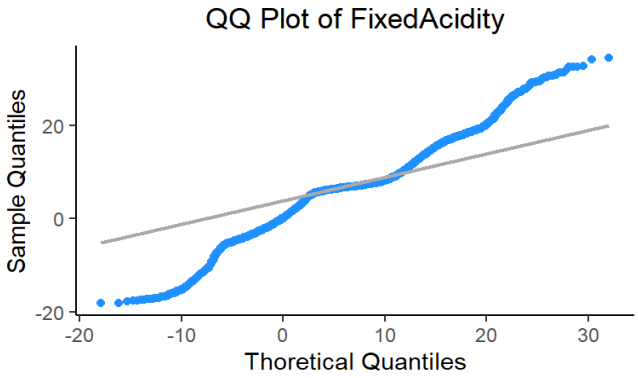
The box plot below shows that outliners exist in variables `FixedAcidity`, `VolatileAcidity`, `CitricAcid`,`ResidualSugar`, `Chlorides`, `FreeSulfurDioxide`, `TotalSulfurDioxide`, `Density`, `pH`, `Sulphates`, `Alcohol`,`LabelAppeal` and`AcidIndex`. We use scaled training set to draw the box plot to show the corresponding outliers by ratio.

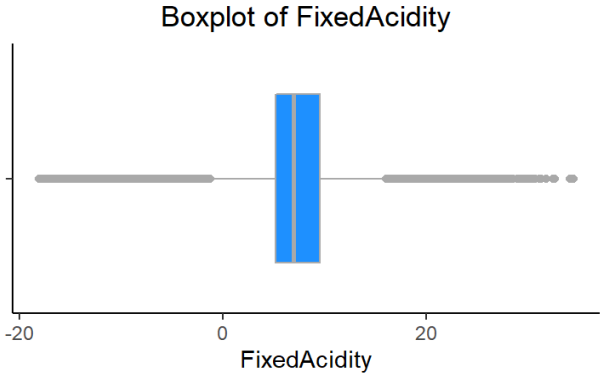
Histogram of attributes

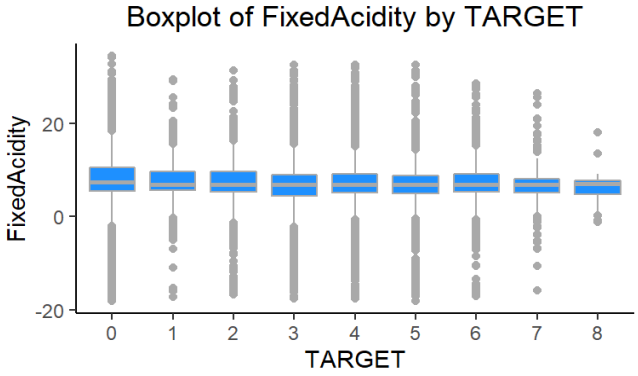
Lets analyze the attributes of the dataset individually in terms of Histogram,, QQ Plot and BoxPlot in comparison to TARGET

- **FixedAcidity:** This variable tells us about the FixedAcidity of wine.

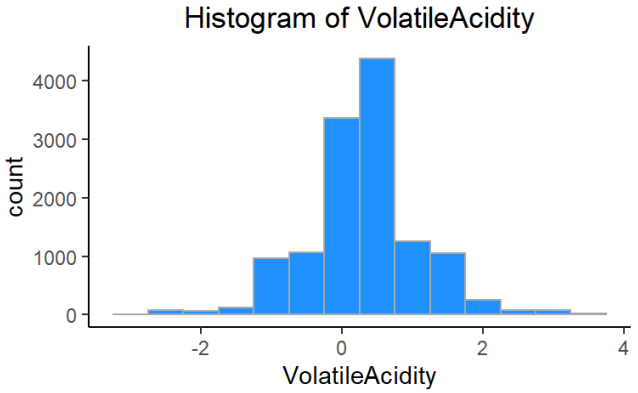


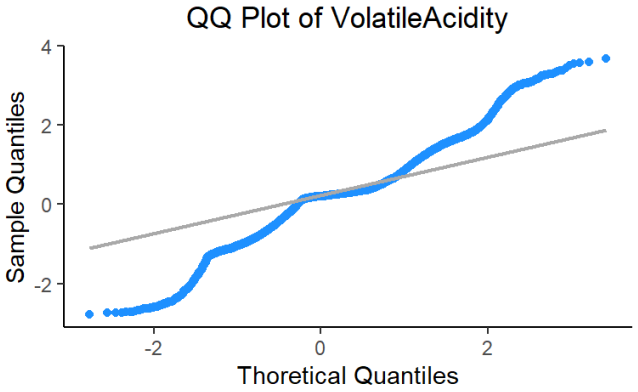


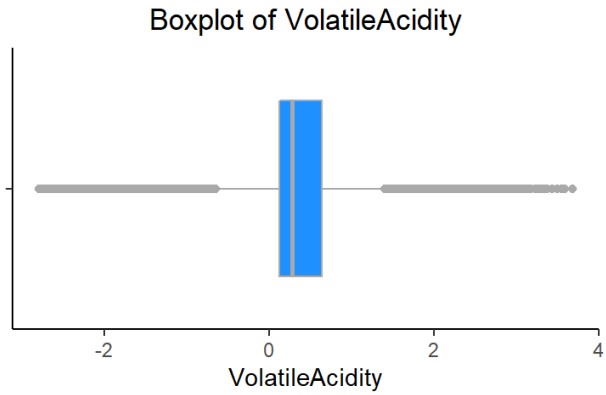


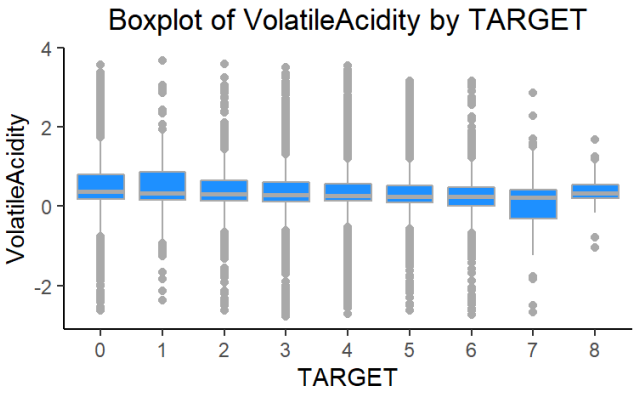


- **VolatileAcidity:** This variable tells us about the VolatileAcidity content of Wine.

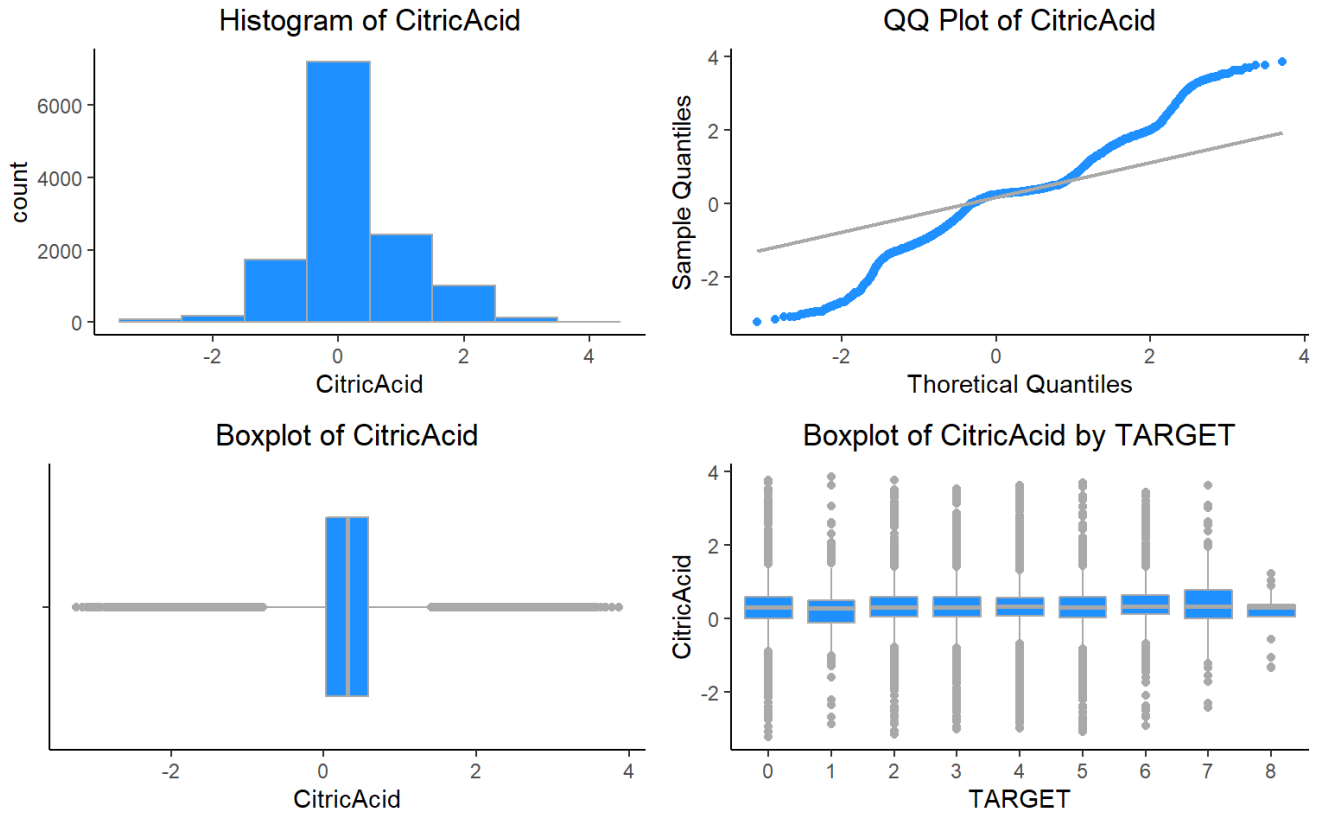




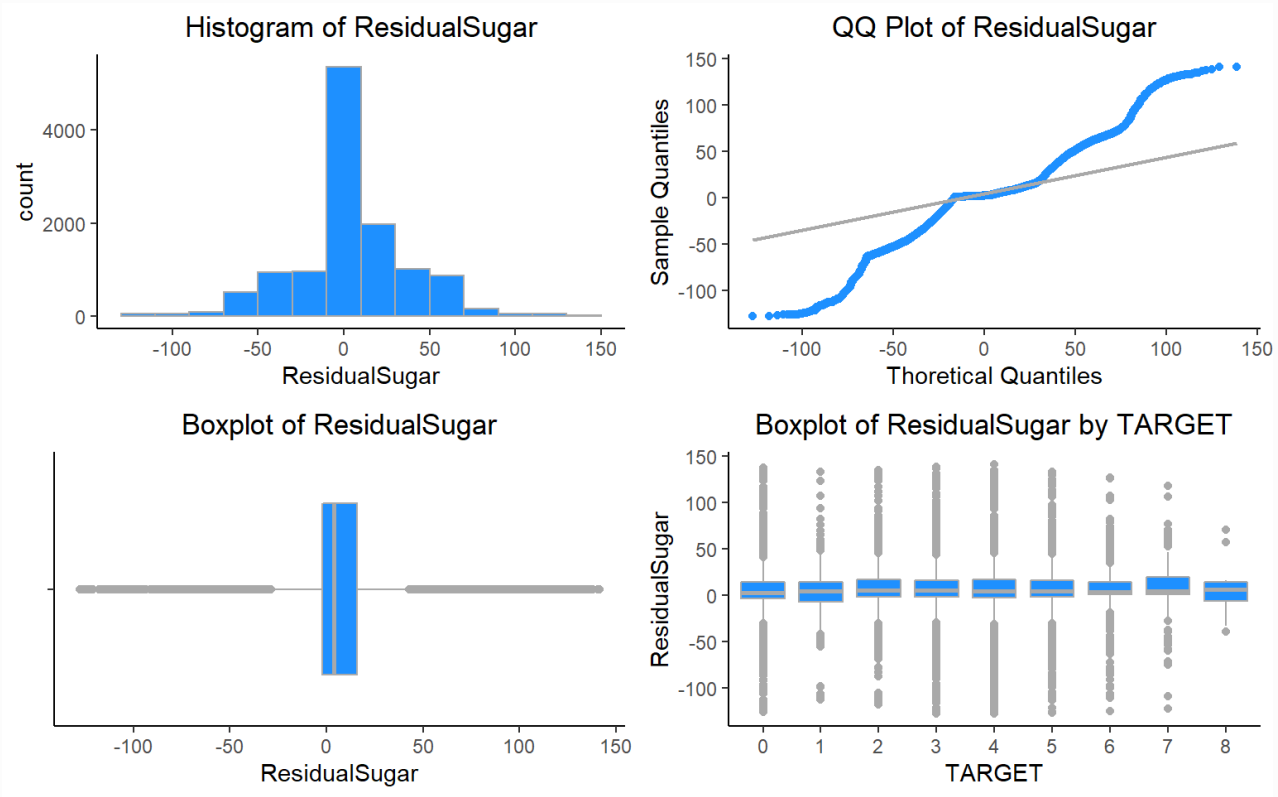




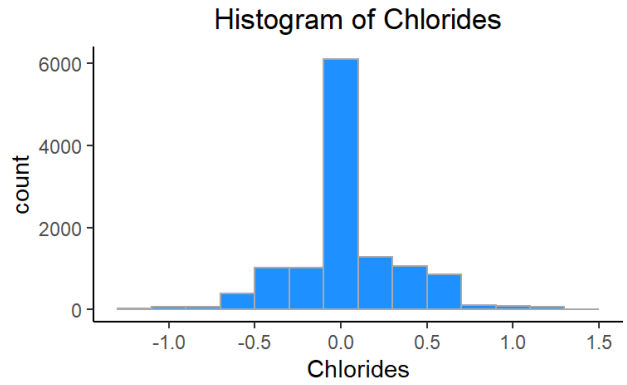
- **CitricAcid:** This variable tells us about the Citric Acid Content of wine.

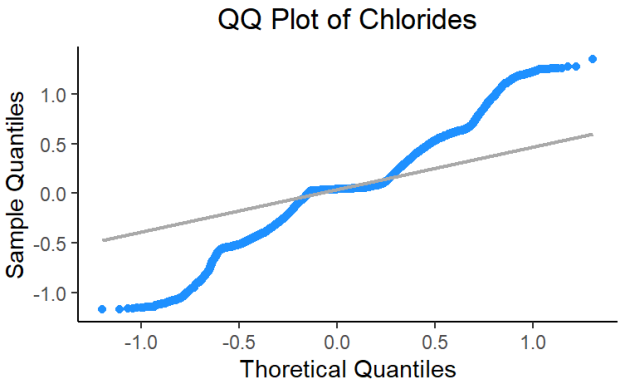


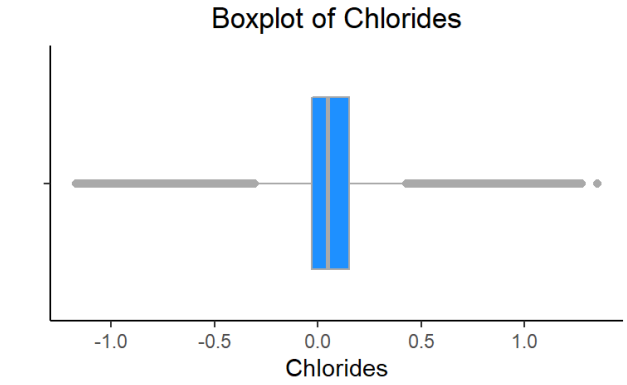
- **ResidualSugar:** This variable tells us about the ResidualSugar of wine.

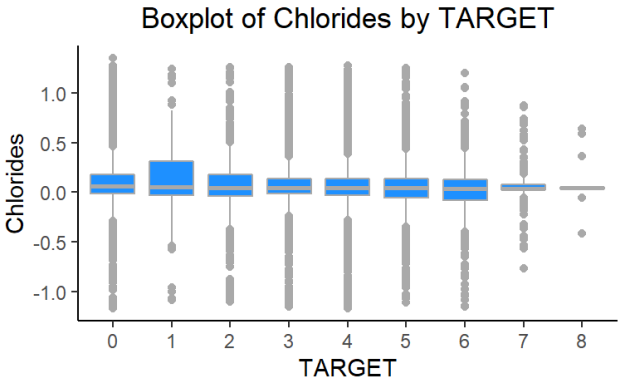


- **Chlorides:** This variable tells us about the Chloride content of wine.

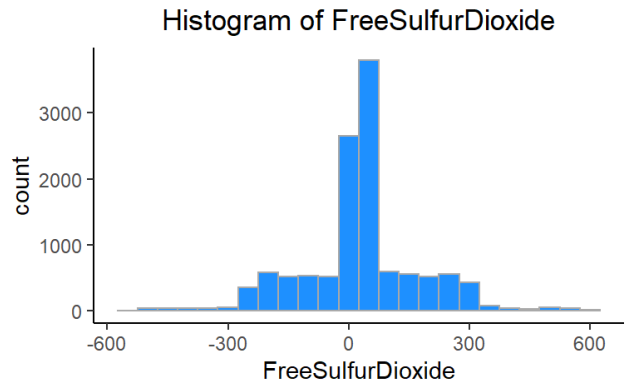


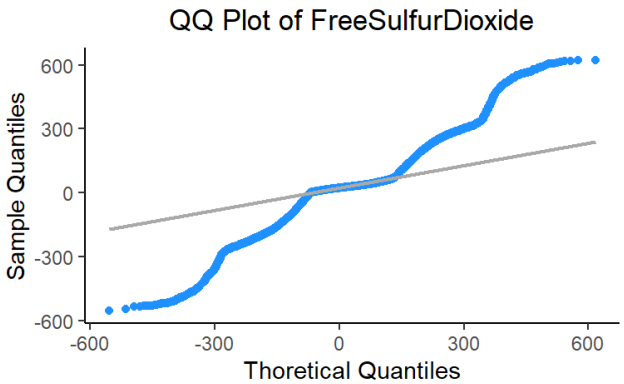


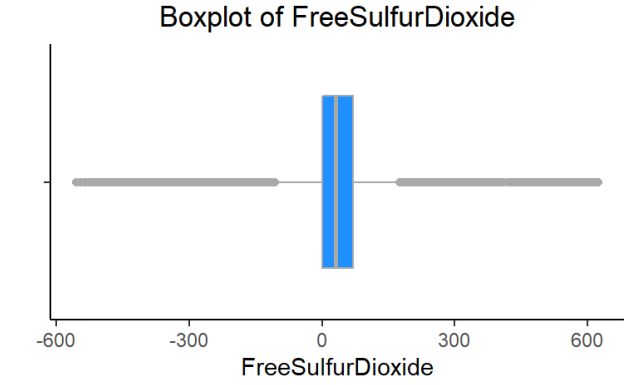


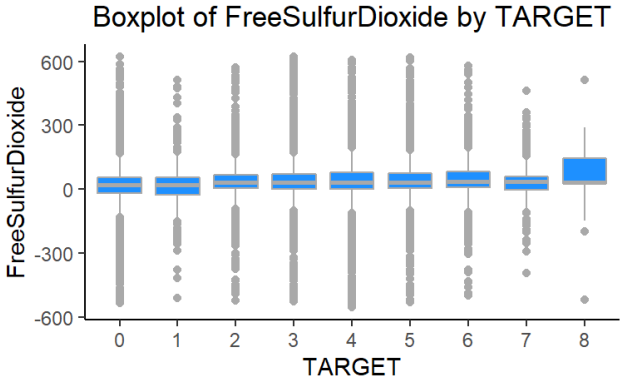


- **FreeSulfurDioxide** : This variable tells us about the Sulfur Dioxide content of wine.

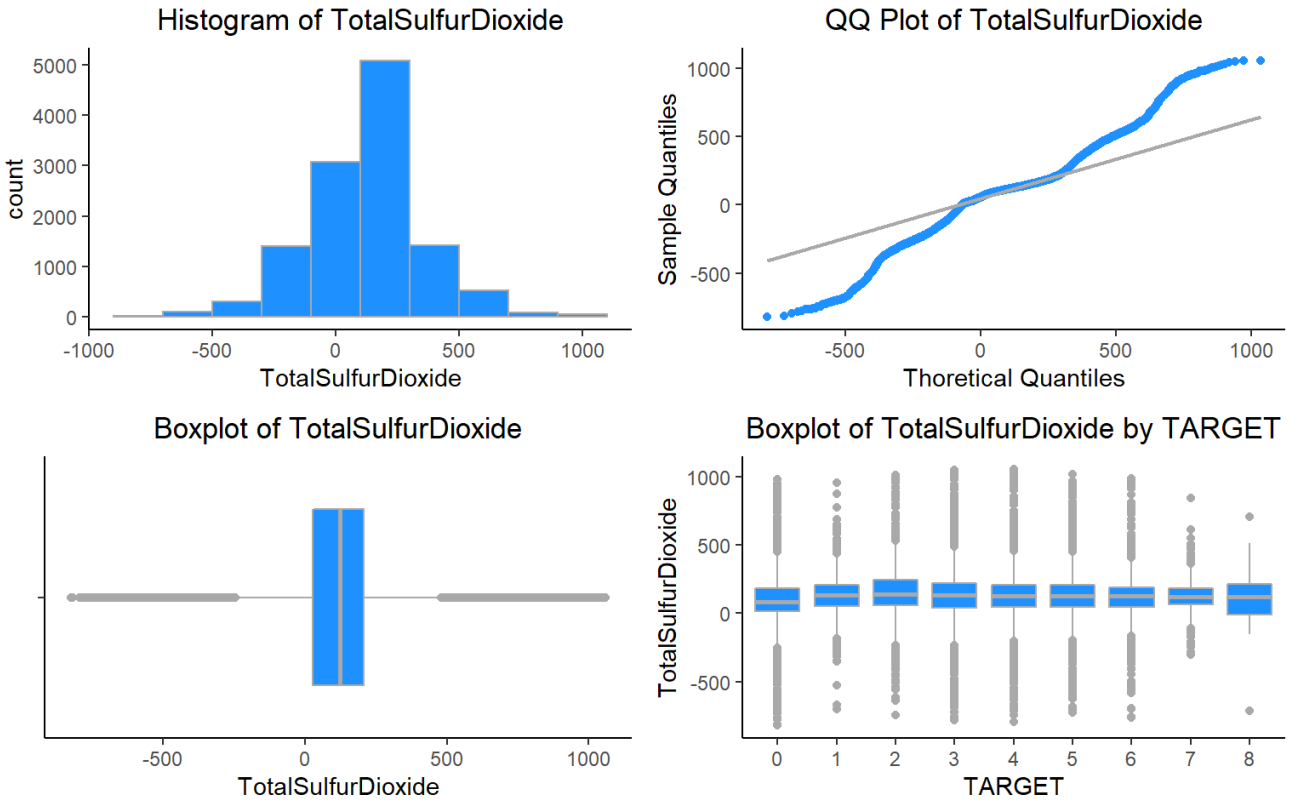




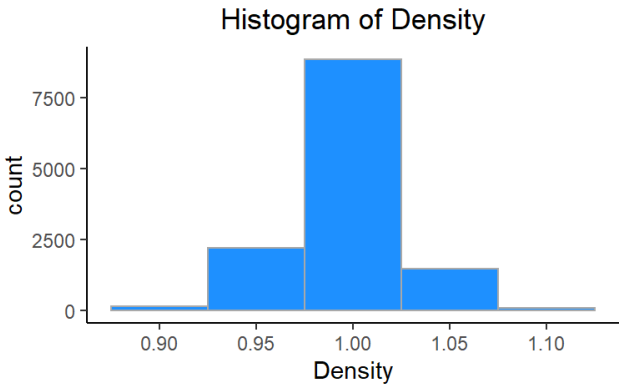


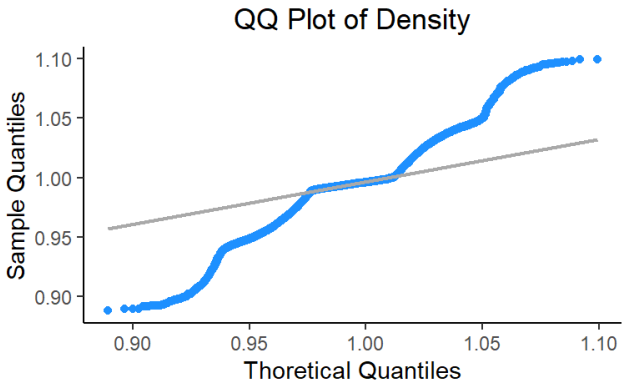


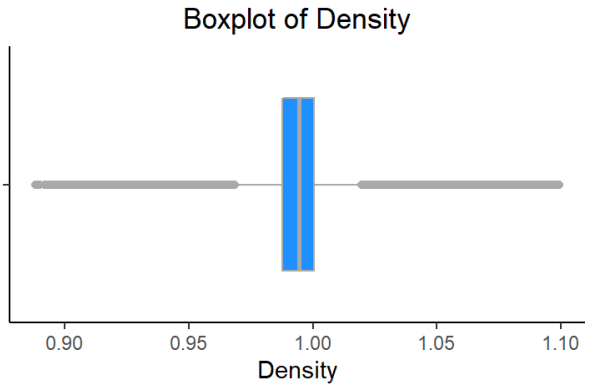
- **TotalSulfurDioxide** : This variable tells us about the Total Sulfur Dioxide of Wine.

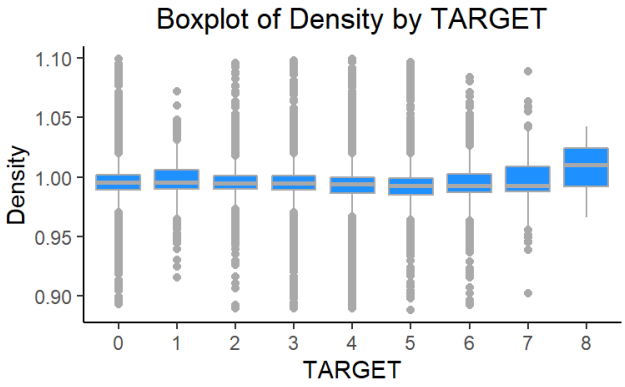


- **Density:** This variable tells us about the Density of wine.

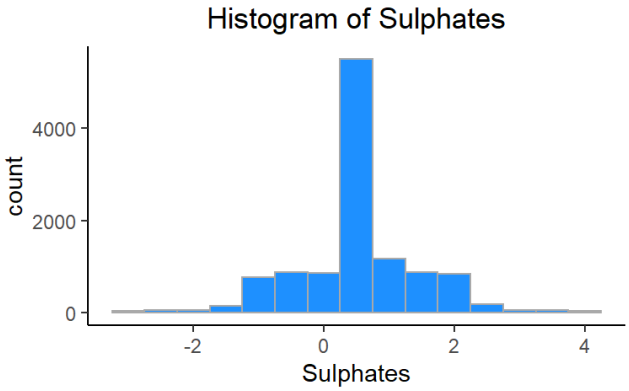


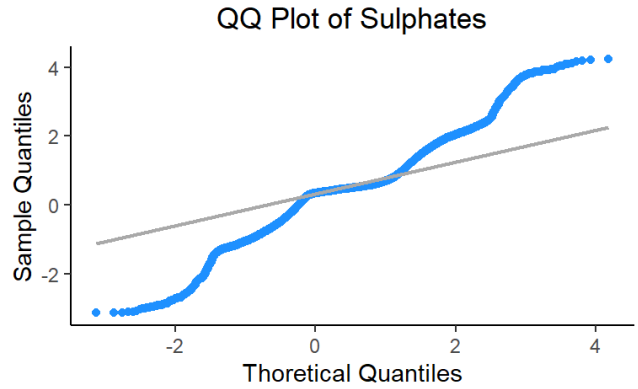


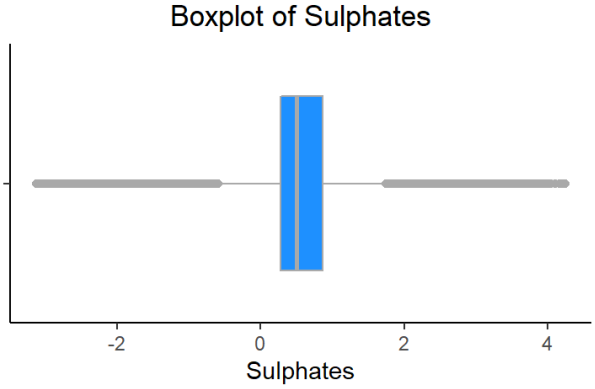


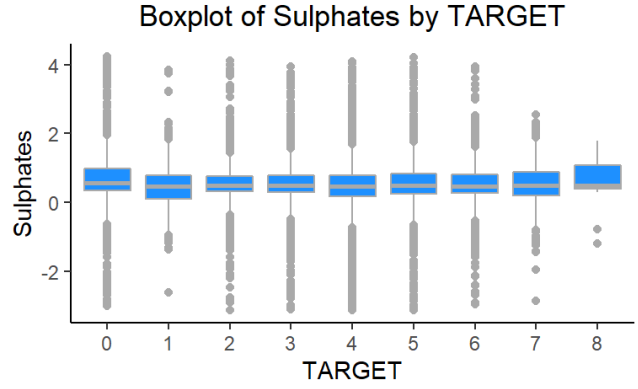


- **Sulphates:** This variable tells us about the Sulphates content of wine.

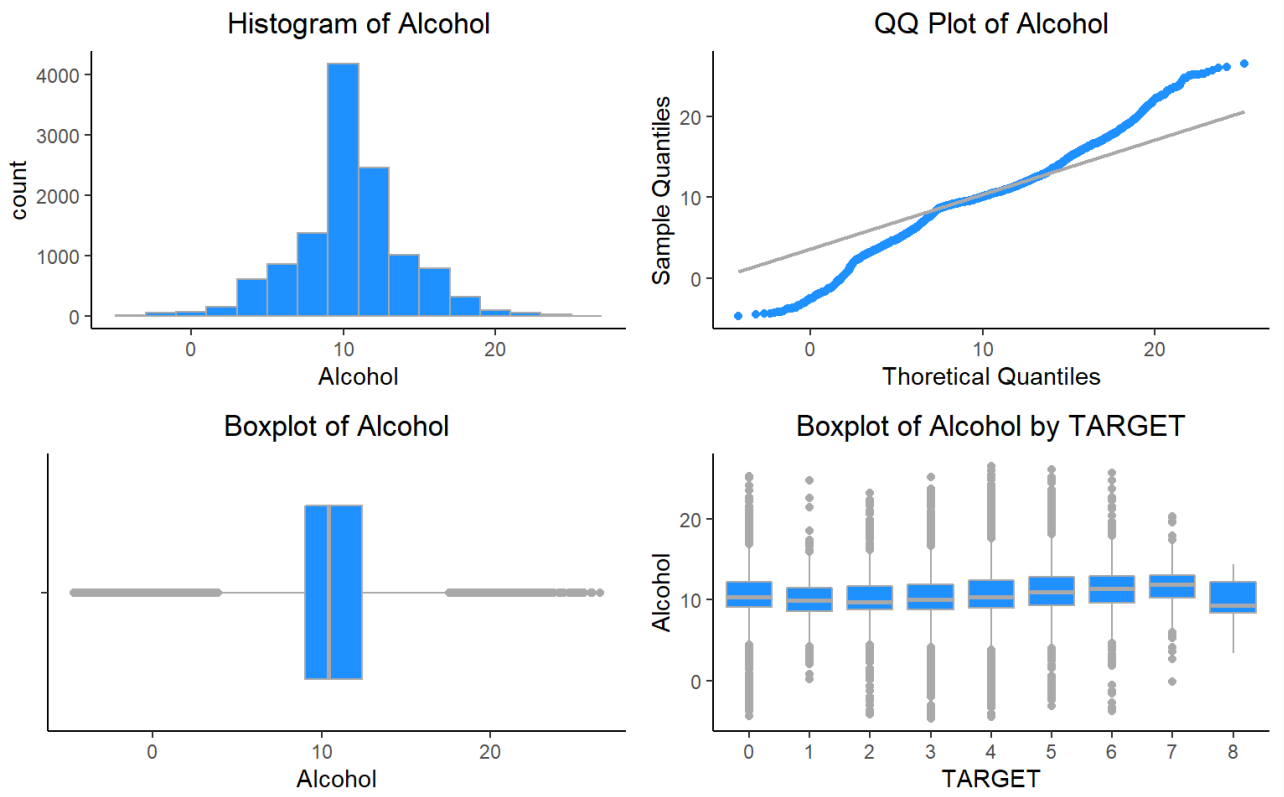




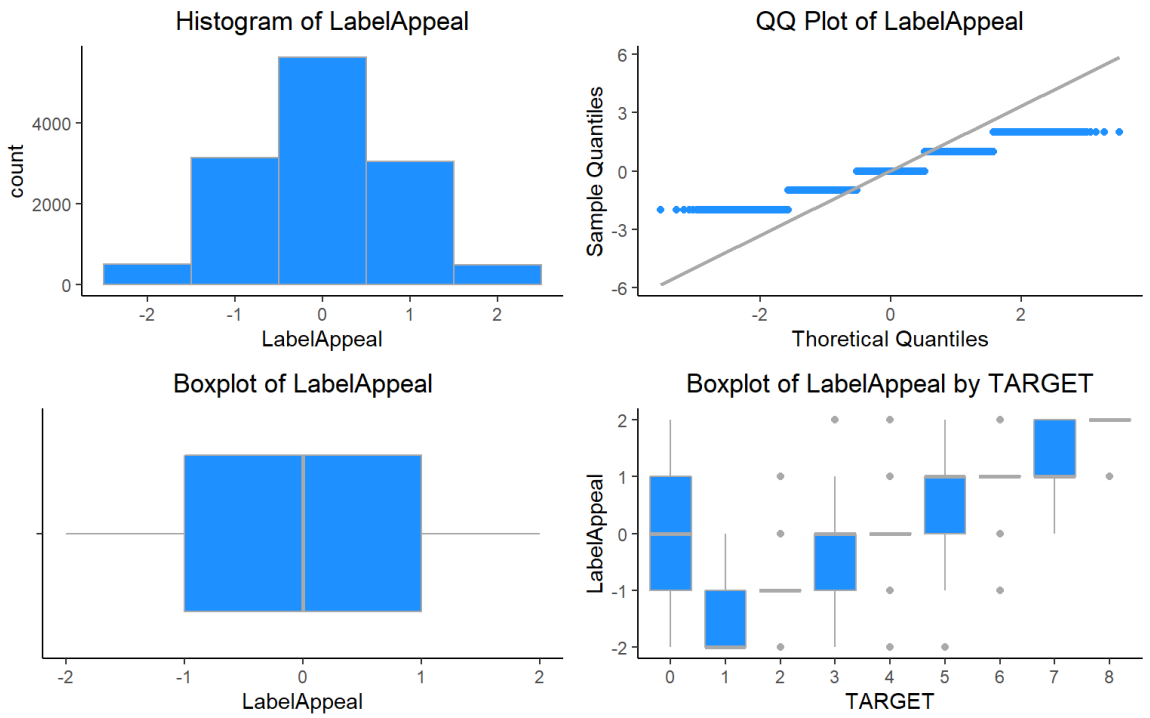




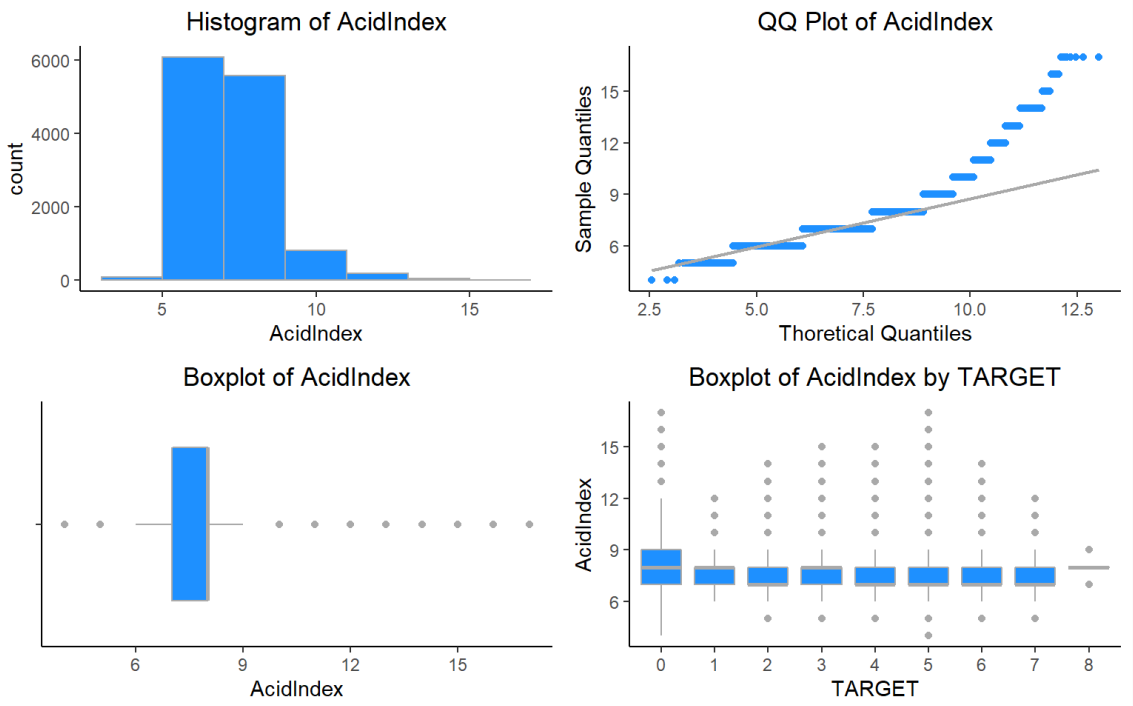
- **Alcohol:** This variable tells us about the Alcohol content.



- **LabelAppeal:** Marketing Score indicating the appeal of label design for consumers. High numbers suggest customers like the label design. Negative numbers suggest customers don't like the design. Many consumers purchase based on the visual appeal of the wine label design. Higher numbers suggest better sales.

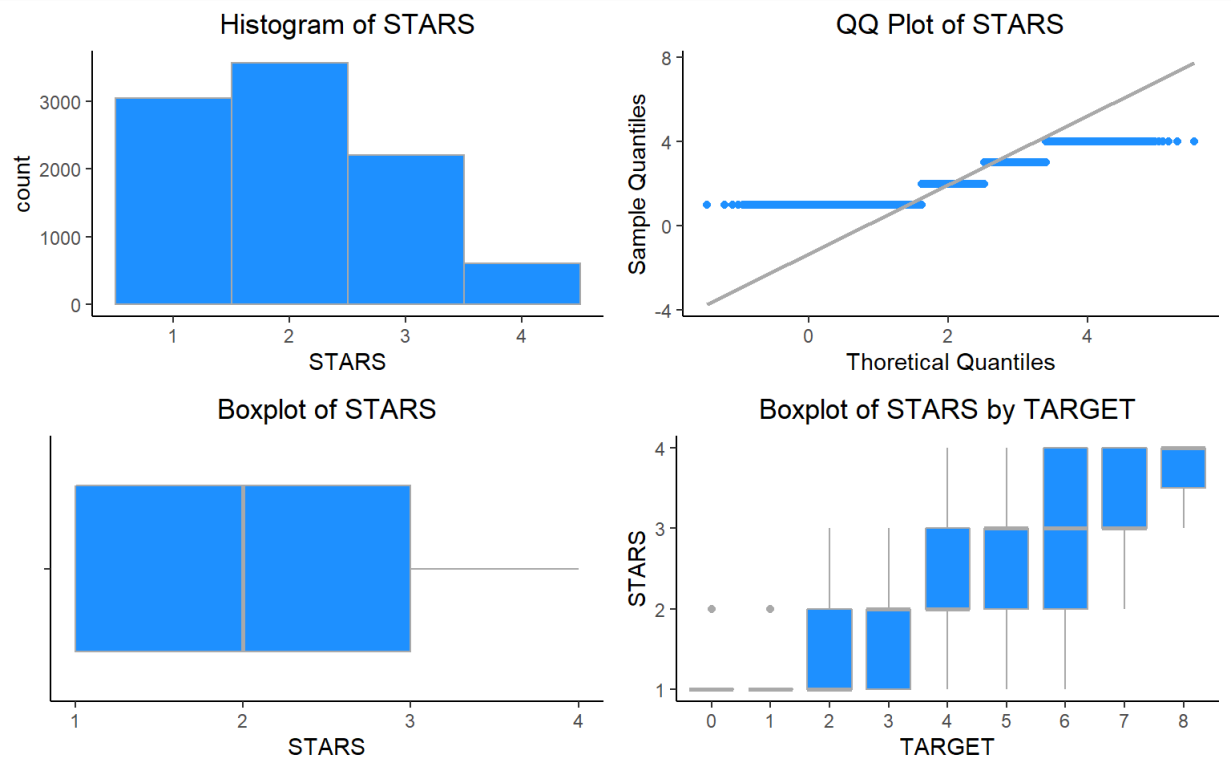


- **AcidIndex:** Proprietary method of testing total acidity of wine by using a weighted average.

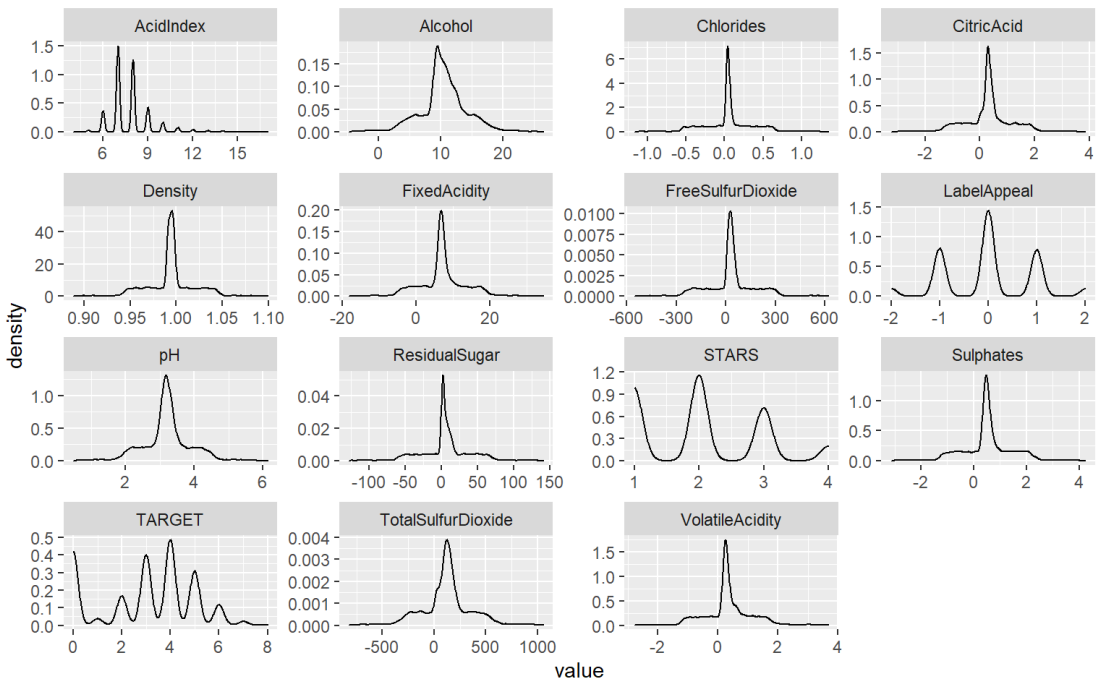


`AcidIndex` seems to be skewed slightly. It also has a skew of 1.68. This is not enough to worry about.

- **STARS:** Wine rating by a team of experts. 4 Stars = Excellent, 1 Star = Poor. A high number of stars suggests high sales.

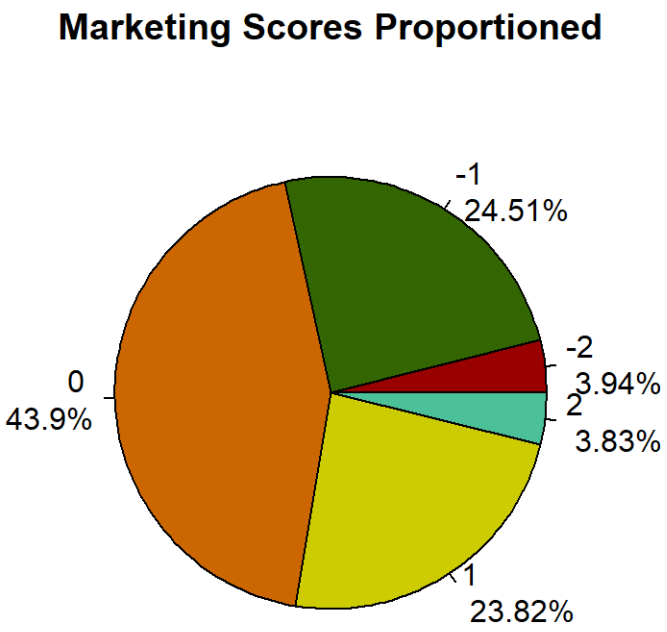


Density Plot



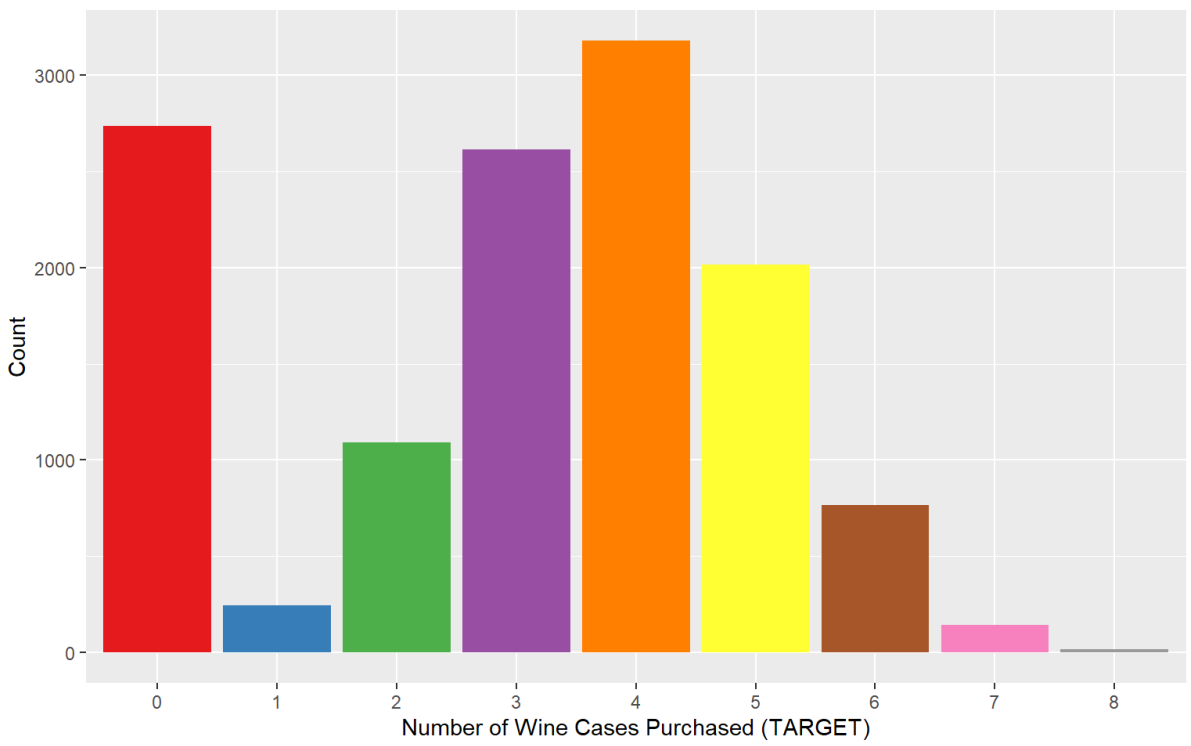
The scaled histogram and density plots show that variables `AcidIndex` is right skewed; `AcidIndex`, `STARS`,`LabelAppeal` and `TARGET` have multimodal distribution; while most others seem to be normally distrbuted due to the bell curve they display.

Label Scores



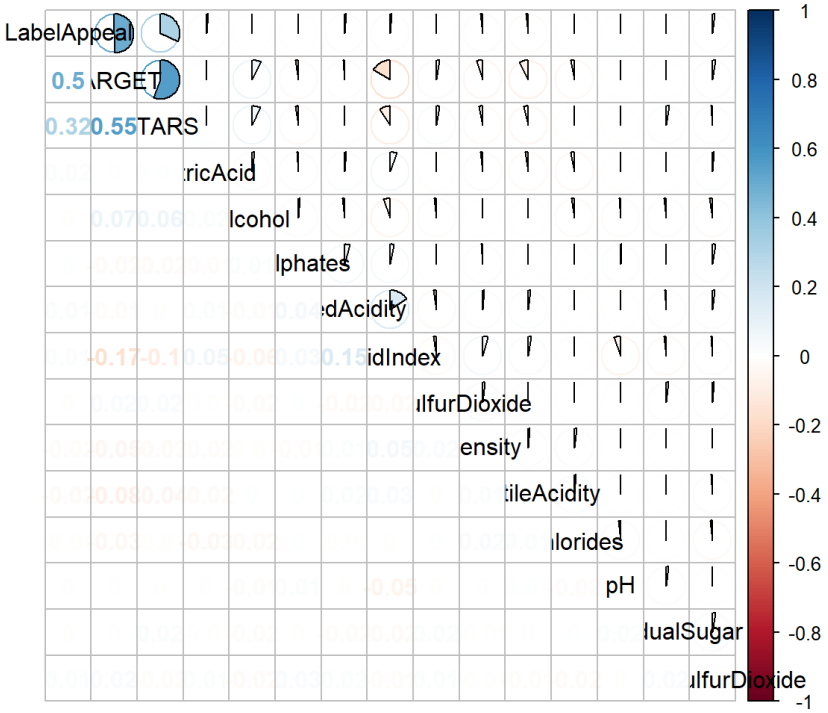
Univariate Analysis

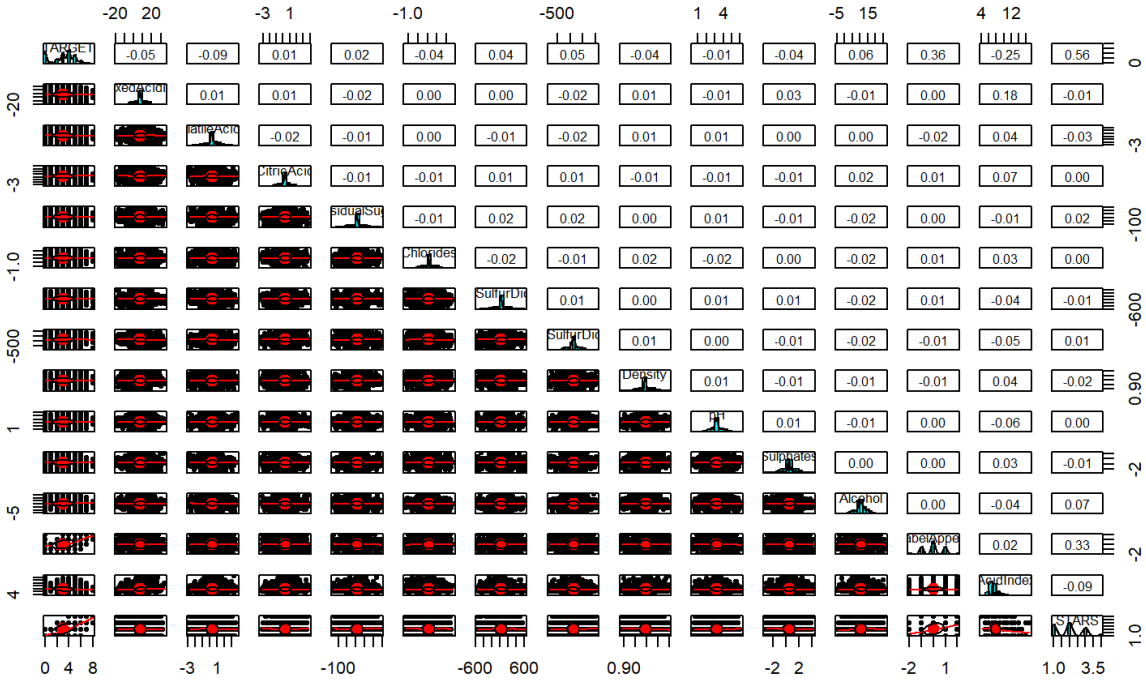
Response Variable



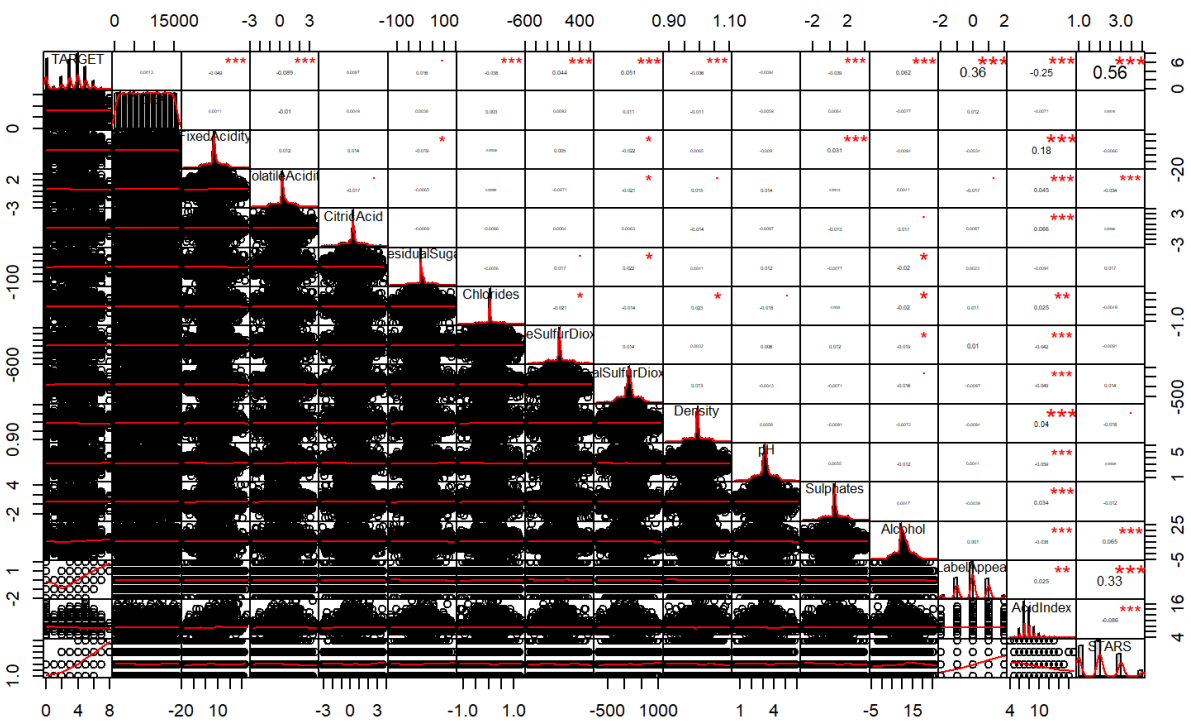
Correlation Plot

We implement a correlation matrix to better understand the correlation between variables in the dataset.

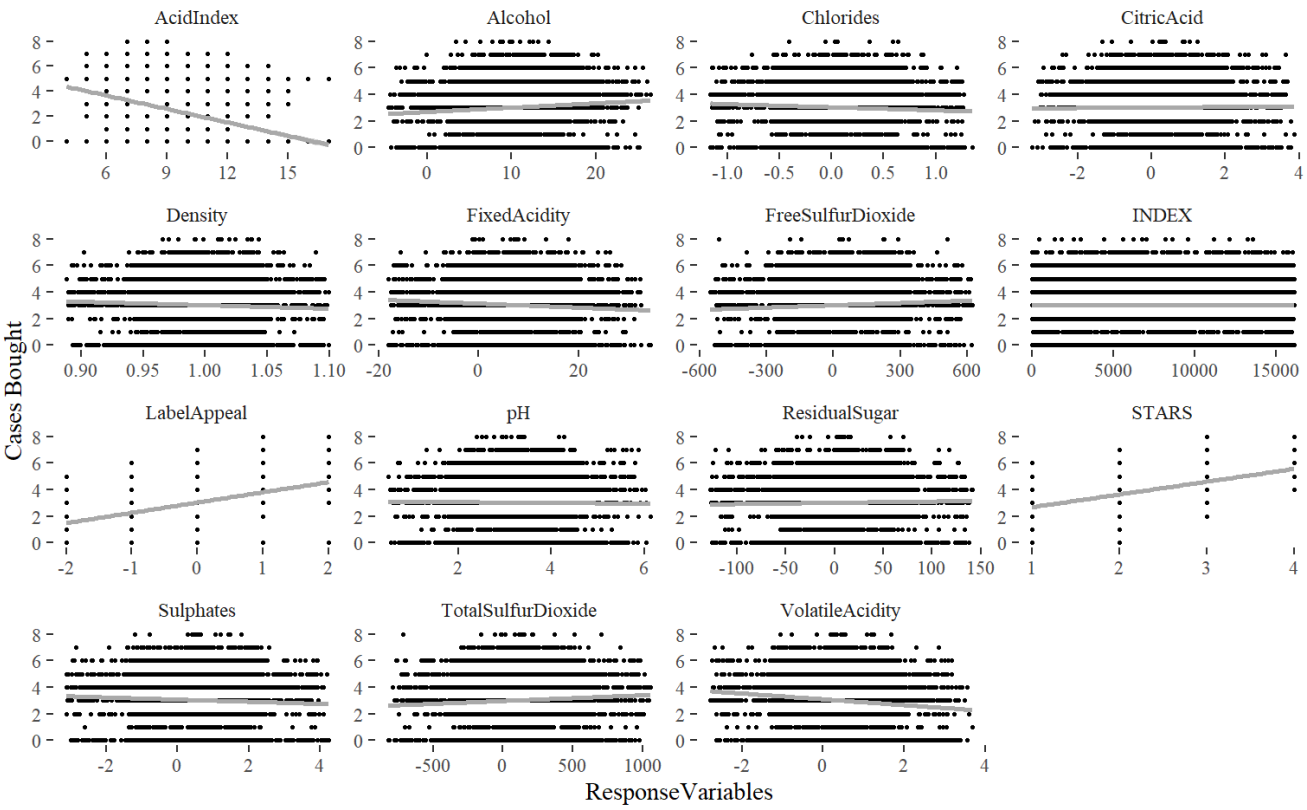




The correlation matrix below shows that the response variable **TARGET** has strong positive relationship (>=0.6) with variables **FixedAcidity**,**CitricAcid**,**ResidualSugar**,**Density**,**Alcohol**.



Scatter plots against **TARGET**:



There don't seem to be any crazy patterns here. It mostly looks linear which is a good sign for us. **`STARS`** and **`LableAppleal`** look like they have the greatest correlation.

Variable <chr>	Correlation_vs_Response <dbl>	FixedAcidity <dbl>	VolatileAcidity <dbl>	CitricAcid <dbl>
TARGET	1.000000000	-0.049010939	-0.08879321	0.008684633
FixedAcidity	-0.049010939	1.000000000	0.01237500	0.014240478
VolatileAcidity	-0.088793212	0.012375004	1.00000000	-0.016953371
CitricAcid	0.008684633	0.014240478	-0.01695337	1.000000000
ResidualSugar	NA	NA	NA	NA
Chlorides	NA	NA	NA	NA
FreeSulfurDioxide	NA	NA	NA	NA
TotalSulfurDioxide	NA	NA	NA	NA
Density	-0.035517502	0.006476528	0.01473492	-0.013952174
pH	NA	NA	NA	NA

1-10 of 15 rows | 1-5 of 16 columns

Previous 1 2 Next

Consolidated Data Dictionary

As a summary of the data exploration process, a data dictionary is created below:

Variable	Missing_Value	Mean	Median	Max	Min	SD	Correlation_vs_Response
TARGET	No	NA	NA	NA	NA	NA	1.00
INDEX	No	NA	NA	NA	NA	NA	0.00
FixedAcidity	No	7.08	6.90	34.40	-18.10	6.32	-0.05
VolatileAcidity	No	0.32	0.28	3.68	-2.79	0.78	-0.09
CitricAcid	No	0.31	0.31	3.86	-3.24	0.86	0.01
ResidualSugar	No	NA	NA	NA	NA	NaN	NA
Chlorides	No	NA	NA	NA	NA	NaN	NA
FreeSulfurDioxide	No	NA	NA	NA	NA	NaN	NA
TotalSulfurDioxide	No	NA	NA	NA	NA	NaN	NA
Density	No	0.99	0.99	1.10	0.89	0.03	-0.04
pH	No	NA	NA	NA	NA	NaN	NA
Sulphates	No	NA	NA	NA	NA	NaN	NA
Alcohol	No	NA	NA	NA	NA	NaN	NA
LabelAppeal	No	-0.01	0.00	2.00	-2.00	0.89	0.36
AcidIndex	No	7.77	8.00	17.00	4.00	1.32	-0.25
STARS	No	NA	NA	NA	NA	NaN	NA

DATA PREPARATION

Lets first split the data into training and test.

MICE (Multivariate Imputation by Chained Equations) package helps in inspecting, imputing, diagonise, analyze, pool the result, and generate simulated incomplete data

Given the low correlation between `AcidIndex` and `TARGET` it might not make a huge difference, however, we will log transform it to test.

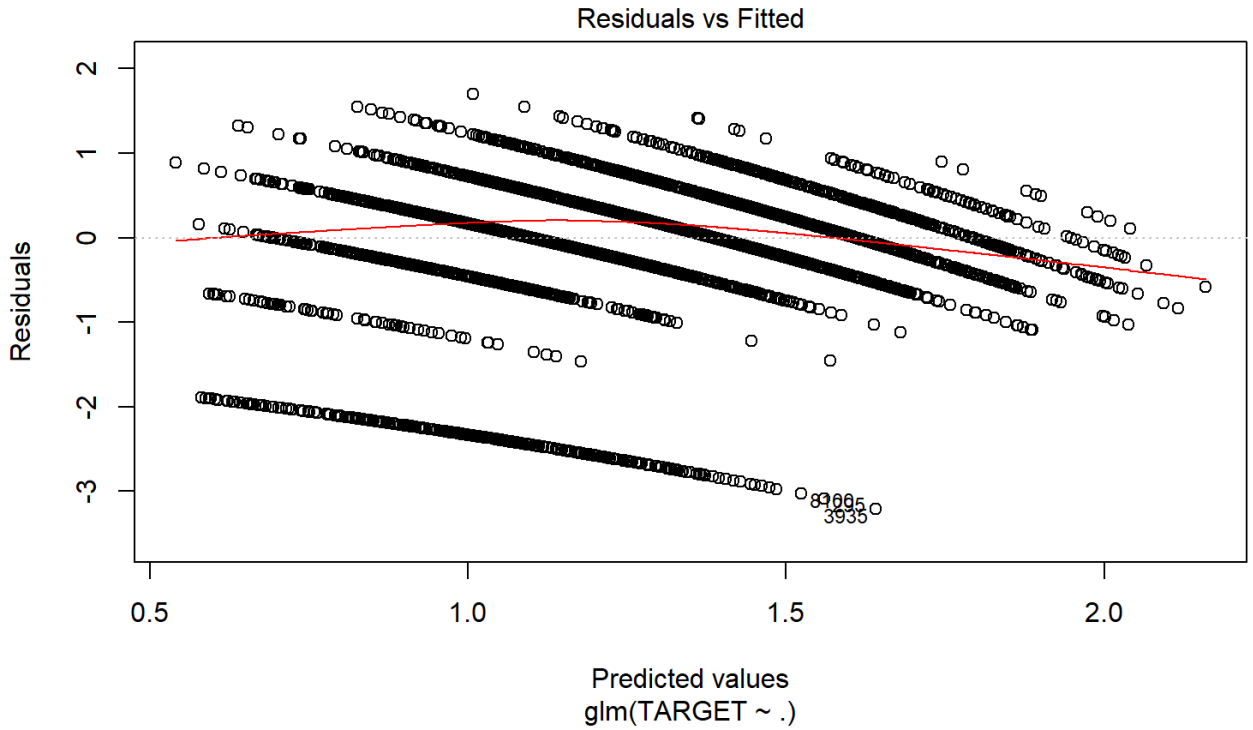
BUILD MODELS

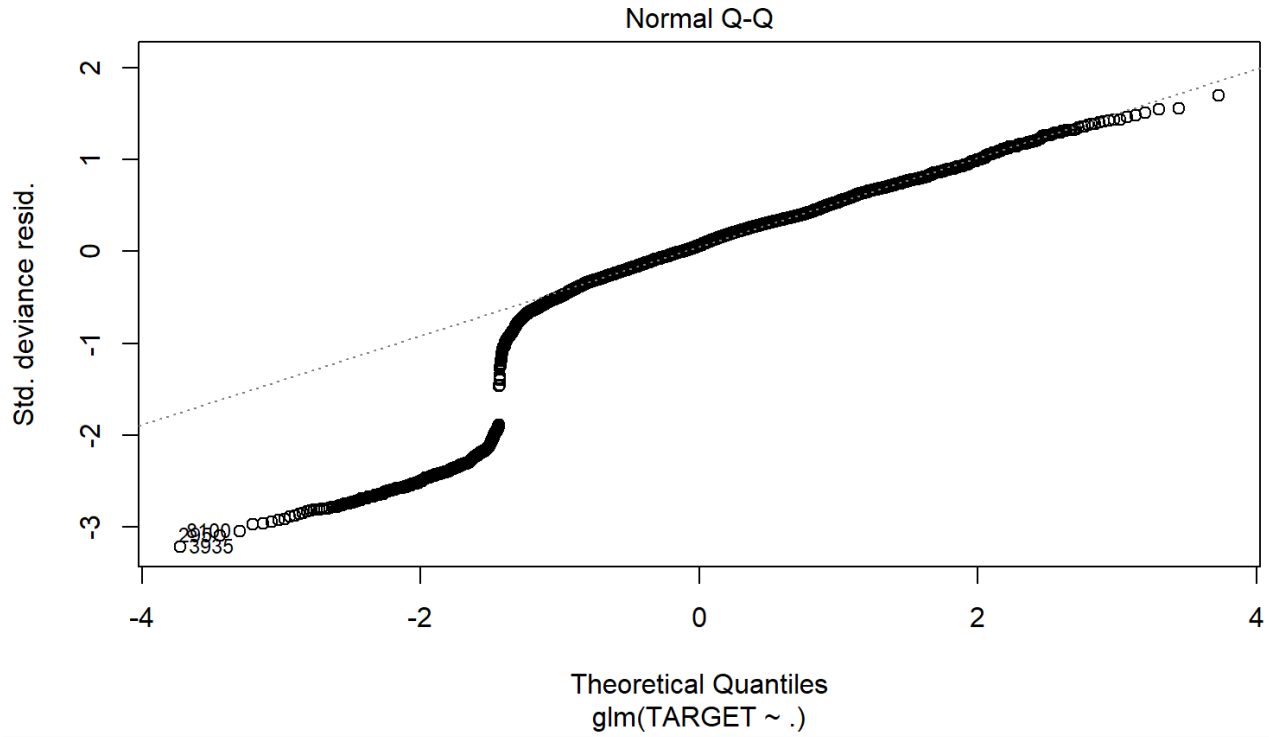
Model I: Poisson Model

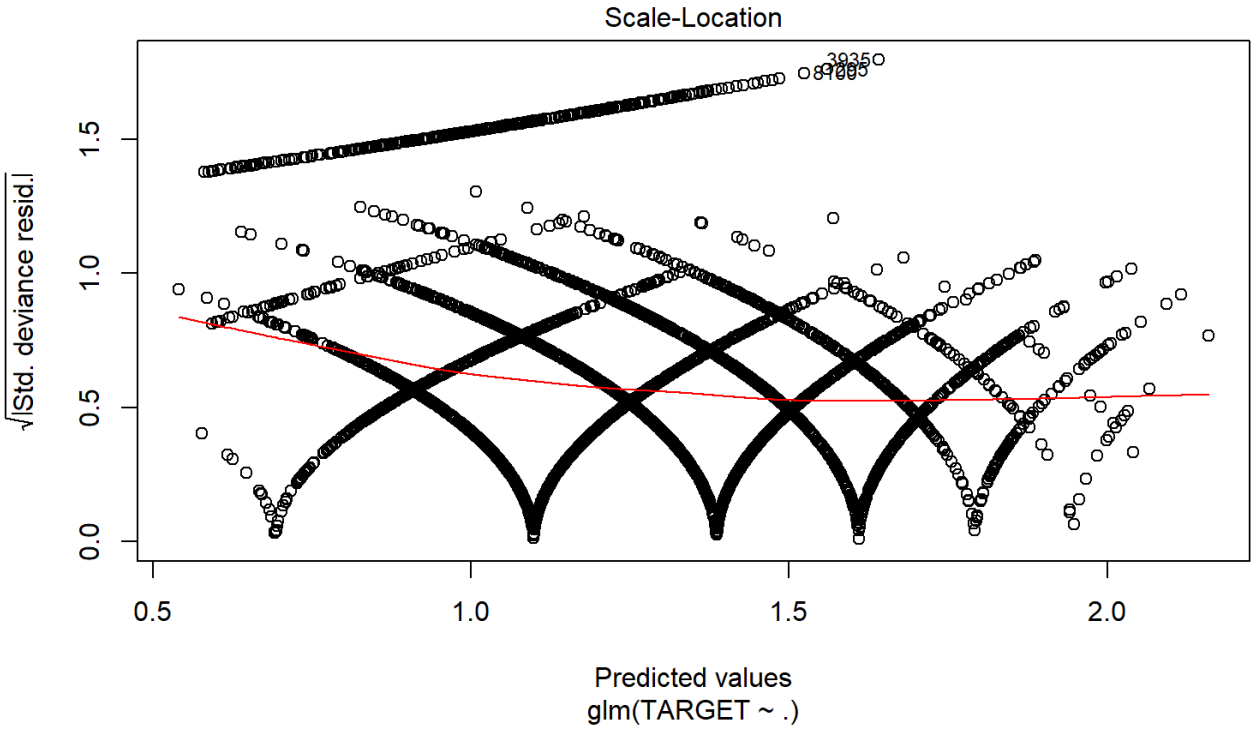
Model 1: Poisson Model without imputations

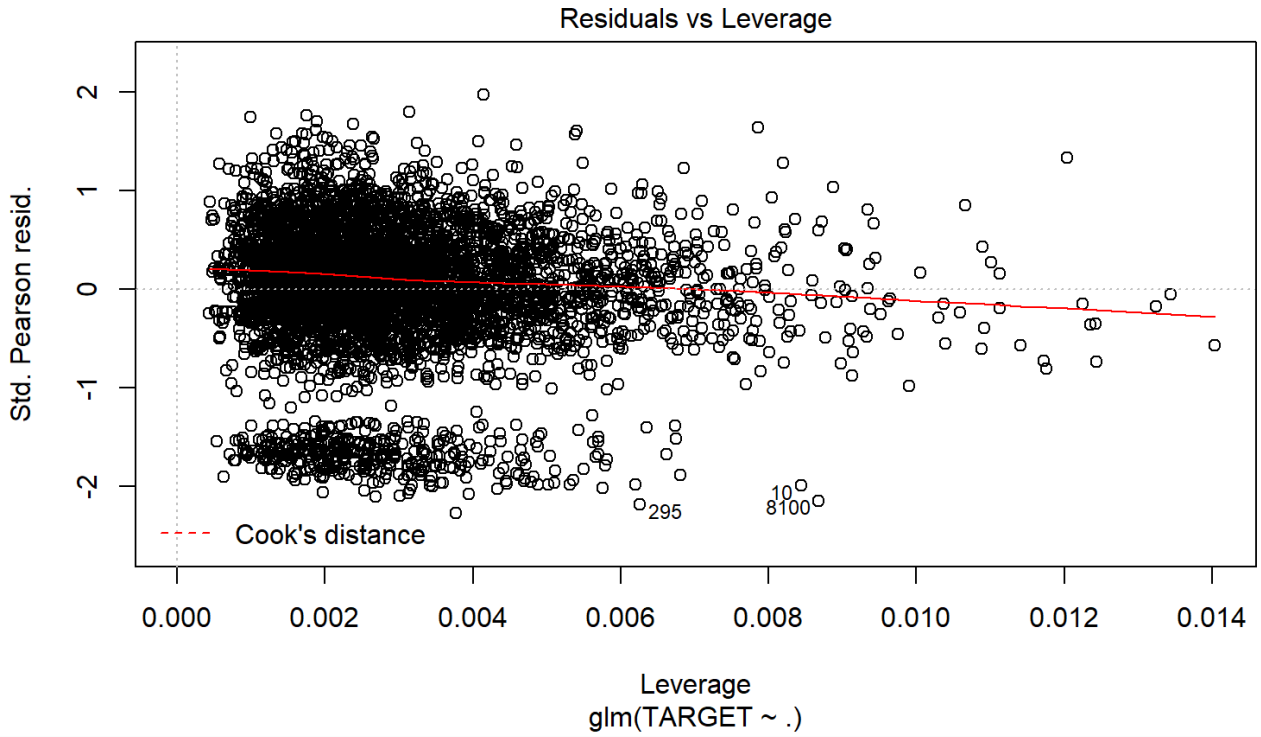
```
##
## Call:
## glm(formula = TARGET ~ ., family = poisson, data = wine_train1)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.2128  -0.2757   0.0647   0.3766   1.6981
##
## Coefficients:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       1.608e+00  2.796e-01   5.750 8.90e-09 ***
## FixedAcidity       6.705e-04  1.177e-03   0.570  0.56901
## VolatileAcidity   -2.750e-02  9.283e-03  -2.963  0.00305 **
## CitricAcid        -3.835e-03  8.519e-03  -0.450  0.65259
## ResidualSugar      1.828e-05  2.152e-04   0.085  0.93232
## Chlorides         -3.764e-02  2.314e-02  -1.627  0.10377
## FreeSulfurDioxide  5.671e-05  4.892e-05   1.159  0.24630
## TotalSulfurDioxide 2.230e-05  3.177e-05   0.702  0.48274
## Density           -4.025e-01  2.749e-01  -1.464  0.14326
## pH                 2.307e-04  1.085e-02   0.021  0.98303
## Sulphates         -5.984e-03  7.973e-03  -0.751  0.45293
## Alcohol            3.262e-03  2.004e-03   1.628  0.10360
## LabelAppeal        1.730e-01  8.858e-03  19.530  < 2e-16 ***
## AcidIndex         -4.967e-02  6.666e-03  -7.451 9.28e-14 ***
## STARS              1.929e-01  8.328e-03  23.160  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 4720.5  on 5143  degrees of freedom
## Residual deviance: 3242.8  on 5129  degrees of freedom
##   (5093 observations deleted due to missingness)
```

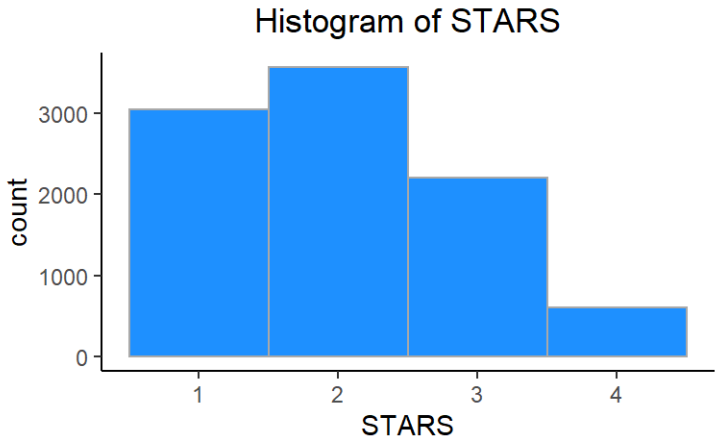
```
## AIC: 18545
##
## Number of Fisher Scoring iterations: 5
```

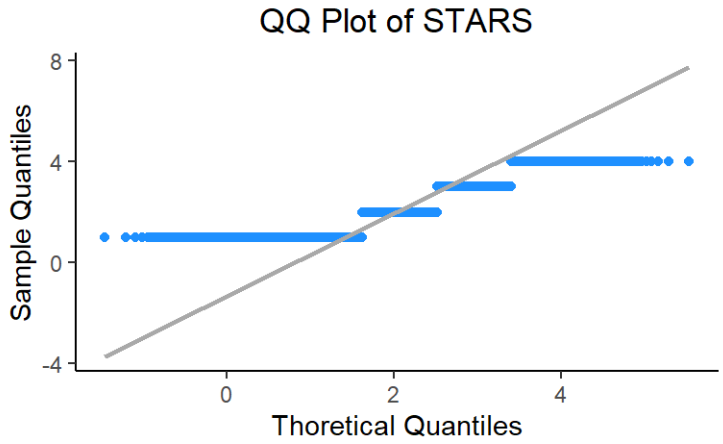


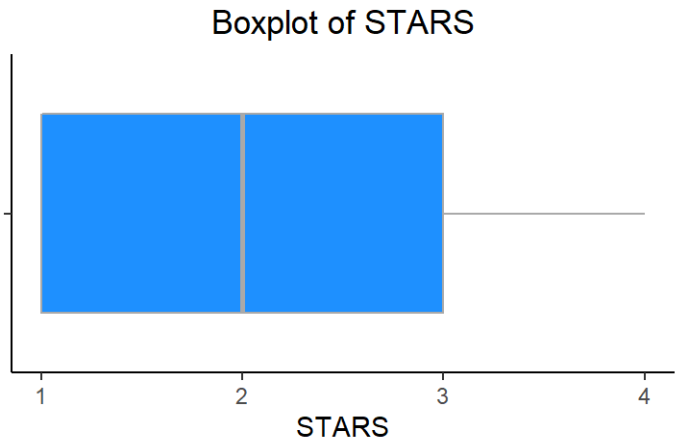

Normal Q-Q
Std. deviance resid.
Theoretical Quantiles
glm(TARGET ~ .)

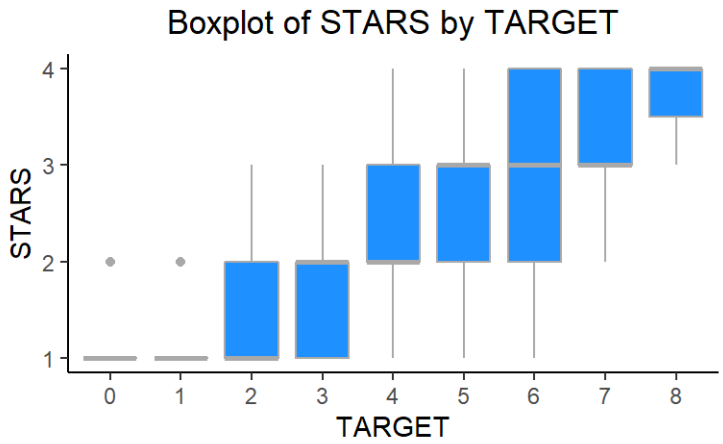

Scale-Location
√|Std. deviance resid.|
Predicted values
glm(TARGET ~ .)


Residuals vs Leverage
Std. Pearson resid.
2
1
0
-1
-2
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
295
10
8100
Cook's distance
Leverage
glm(TARGET ~ .)





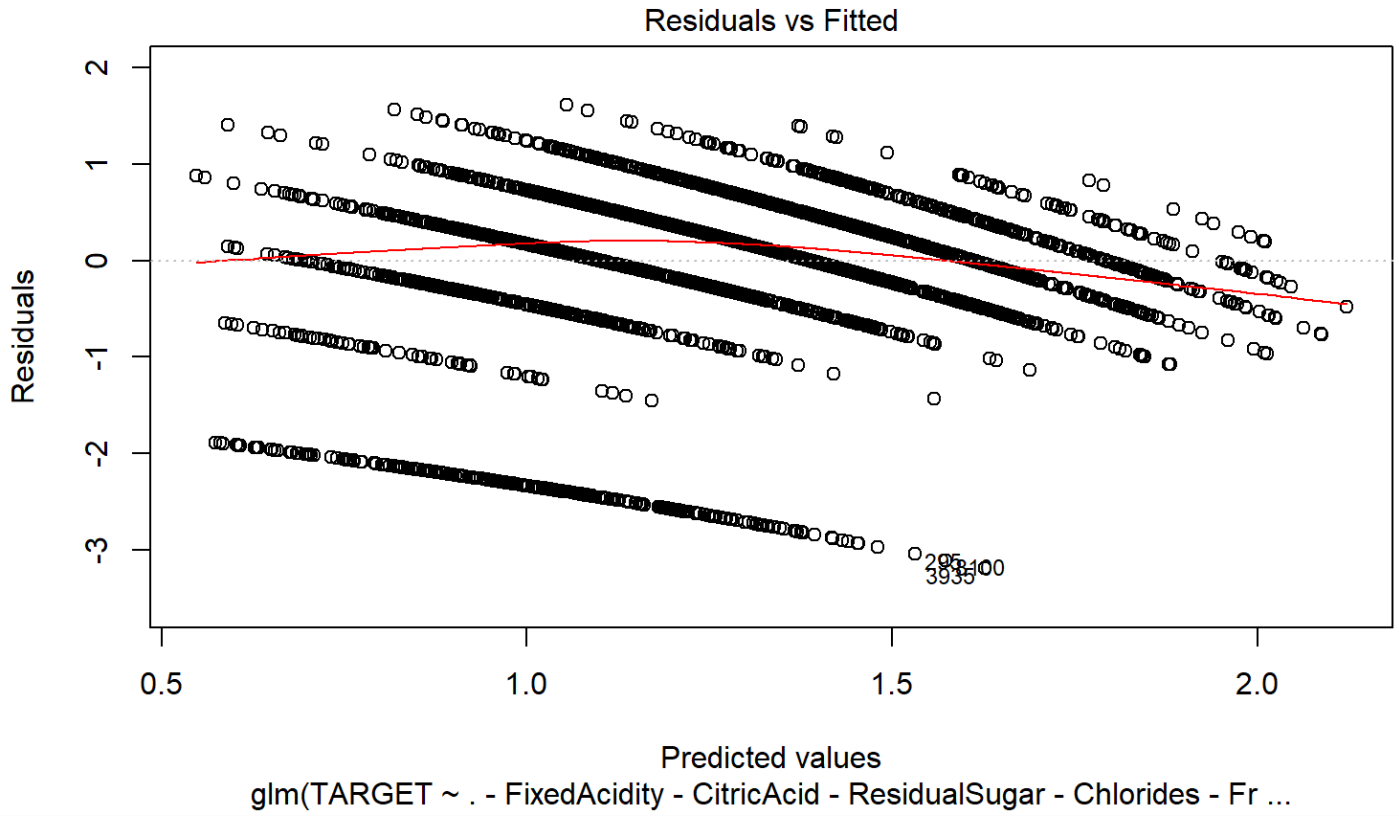


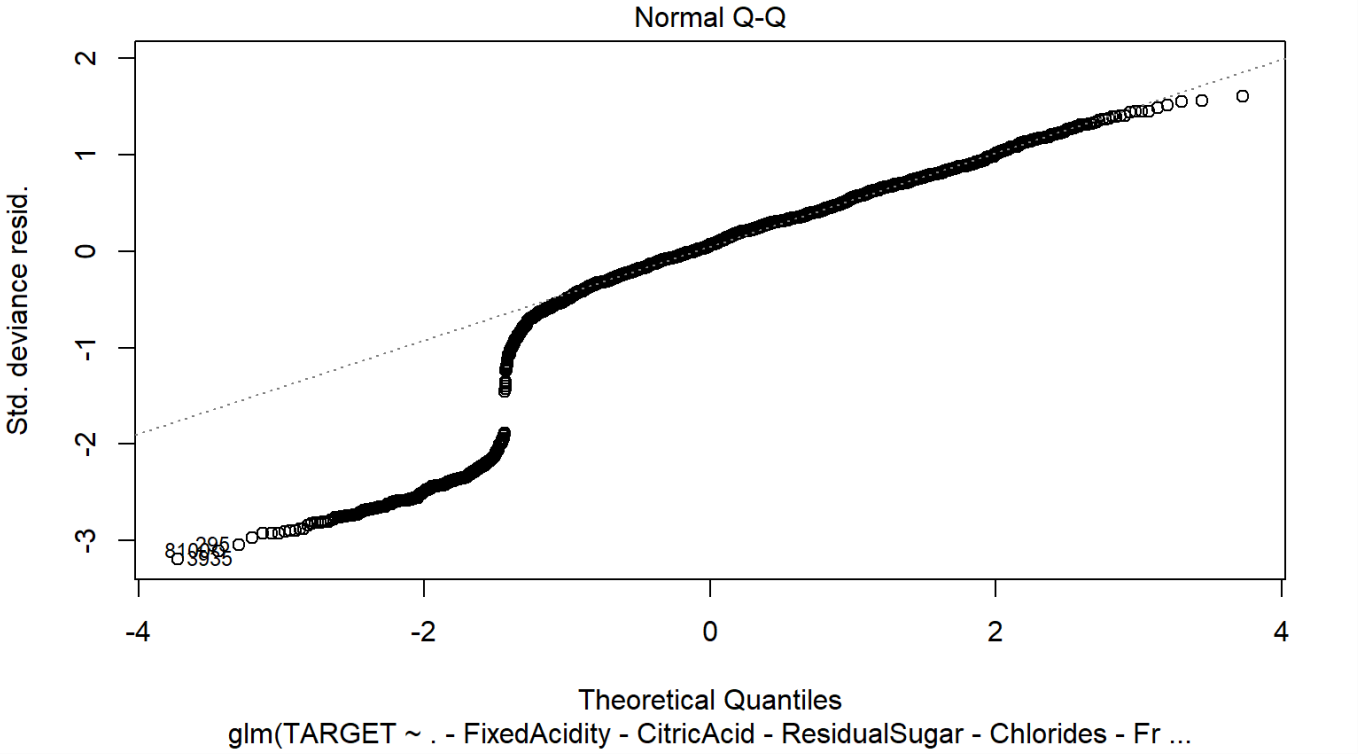


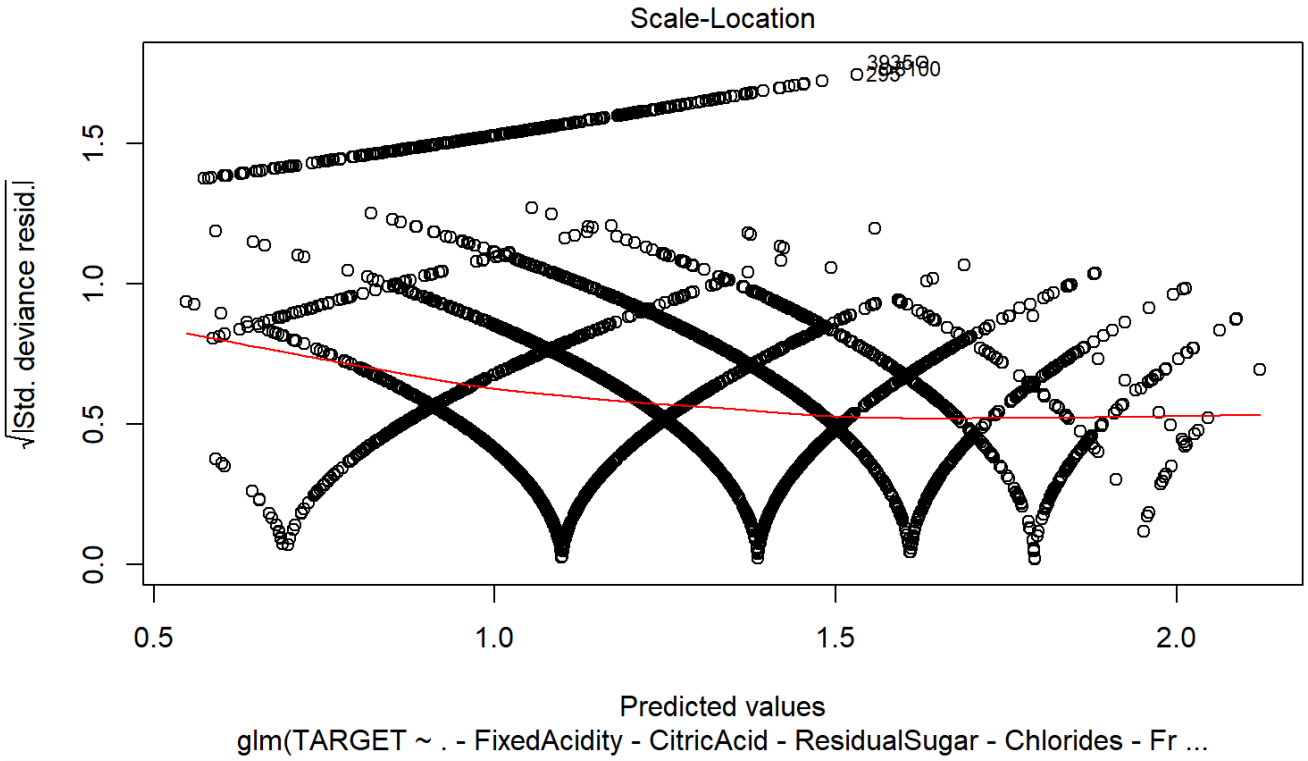
Model 2: Poisson Model without imputations and only significant variables

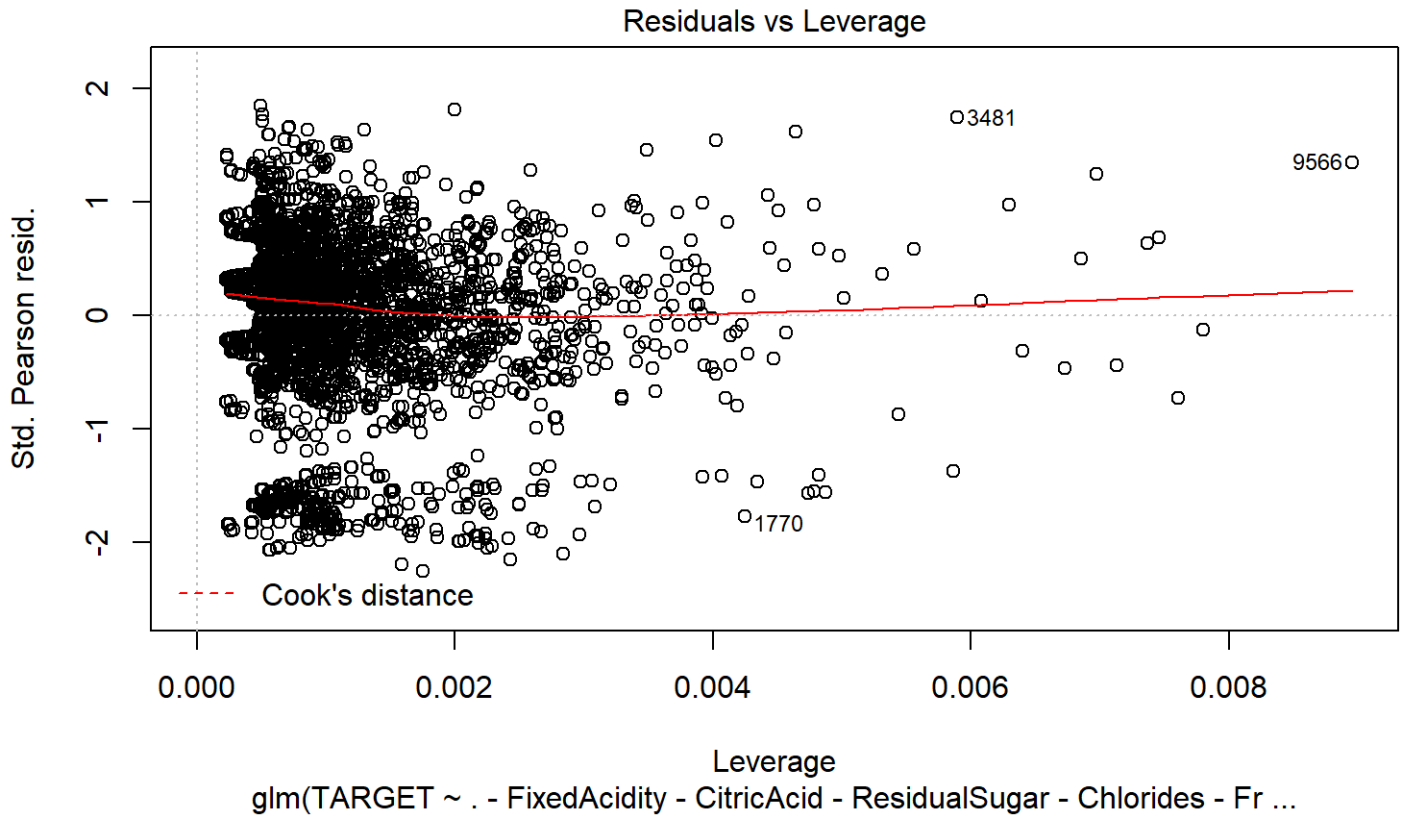
```
##
## Call:
## glm(formula = TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar -
##     Chlorides - FreeSulfurDioxide - TotalSulfurDioxide - Density -
##     pH - Sulphates - Alcohol, family = poisson, data = wine_train1)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.1898  -0.2777   0.0622   0.3764   1.6086
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept)     1.251442   0.054724  22.868  < 2e-16 ***
## VolatileAcidity -0.027581   0.009278  -2.973  0.00295 **
## LabelAppeal      0.173177   0.008853  19.562  < 2e-16 ***
## AcidIndex       -0.050616   0.006553  -7.724 1.13e-14 ***
## STARS           0.194208   0.008292  23.421  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 4720.5  on 5143  degrees of freedom
```

```
## Residual deviance: 3253.1  on 5139  degrees of freedom
##   (5093 observations deleted due to missingness)
## AIC: 18535
##
## Number of Fisher Scoring iterations: 5
```




Normal Q-Q
Std. deviance resid.
2
1
0
-1
-2
-3
-4
-2
0
2
4
Theoretical Quantiles
glm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Chlorides - Fr ...

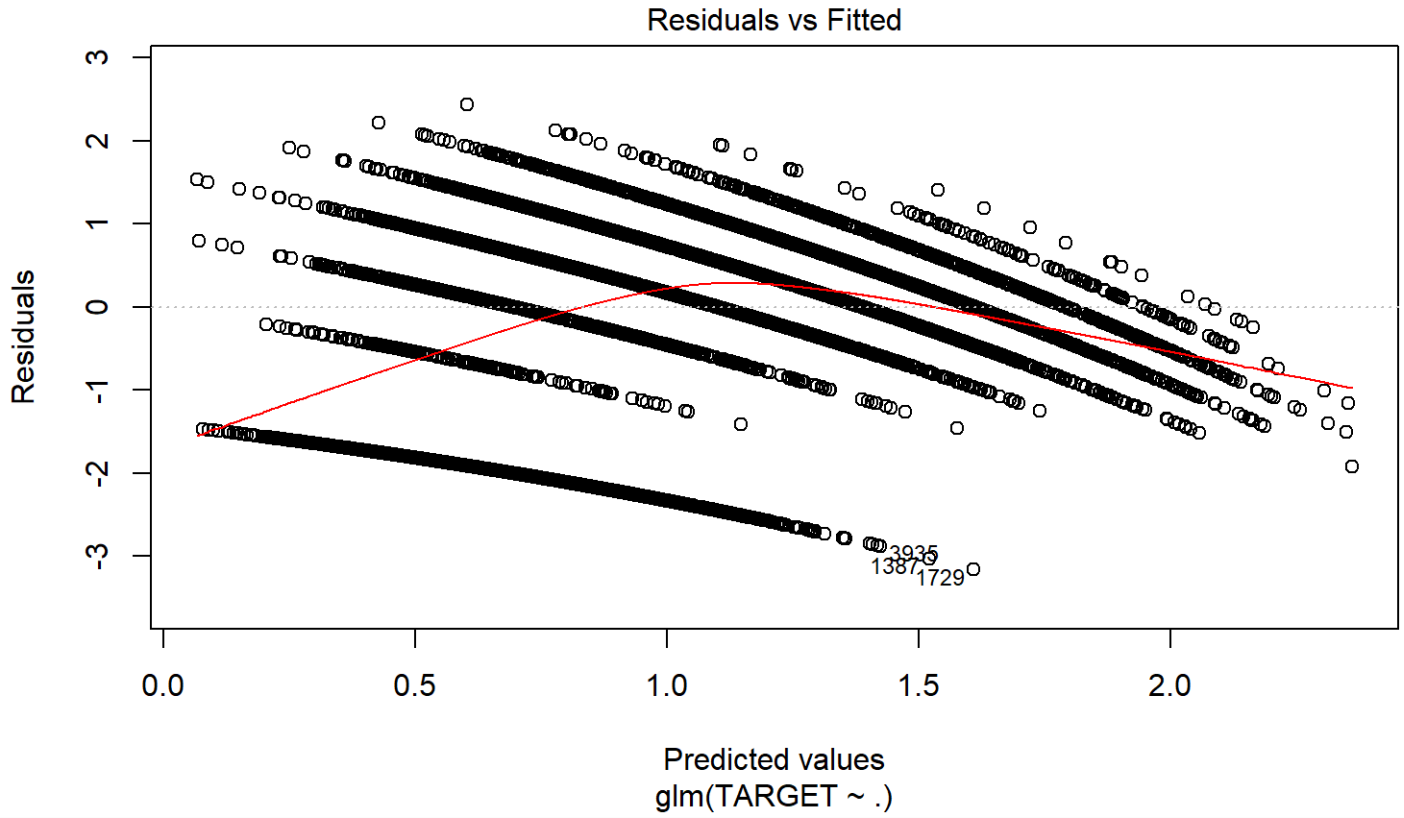

Scale-Location
√|Std. deviance resid.|
0.0
0.5
1.0
1.5
0.5
1.0
1.5
2.0
Predicted values
glm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Chlorides - Fr ...

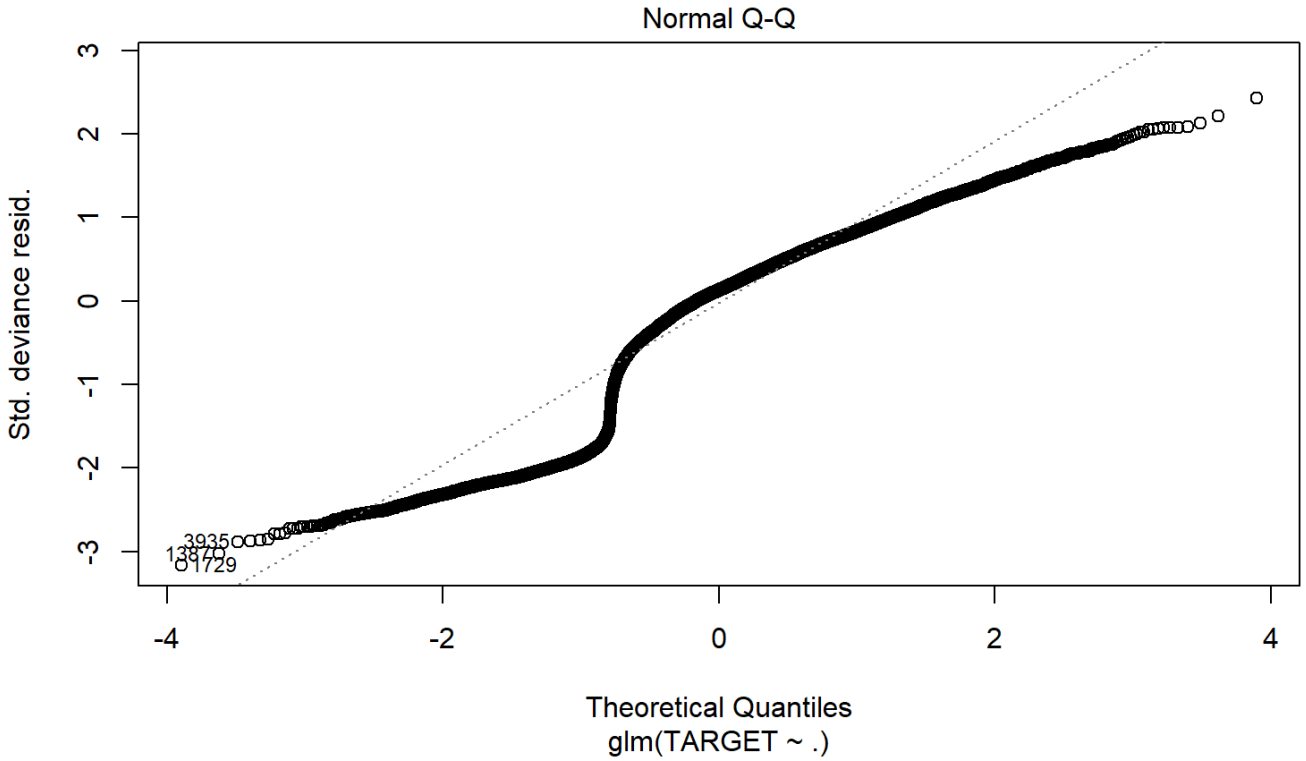


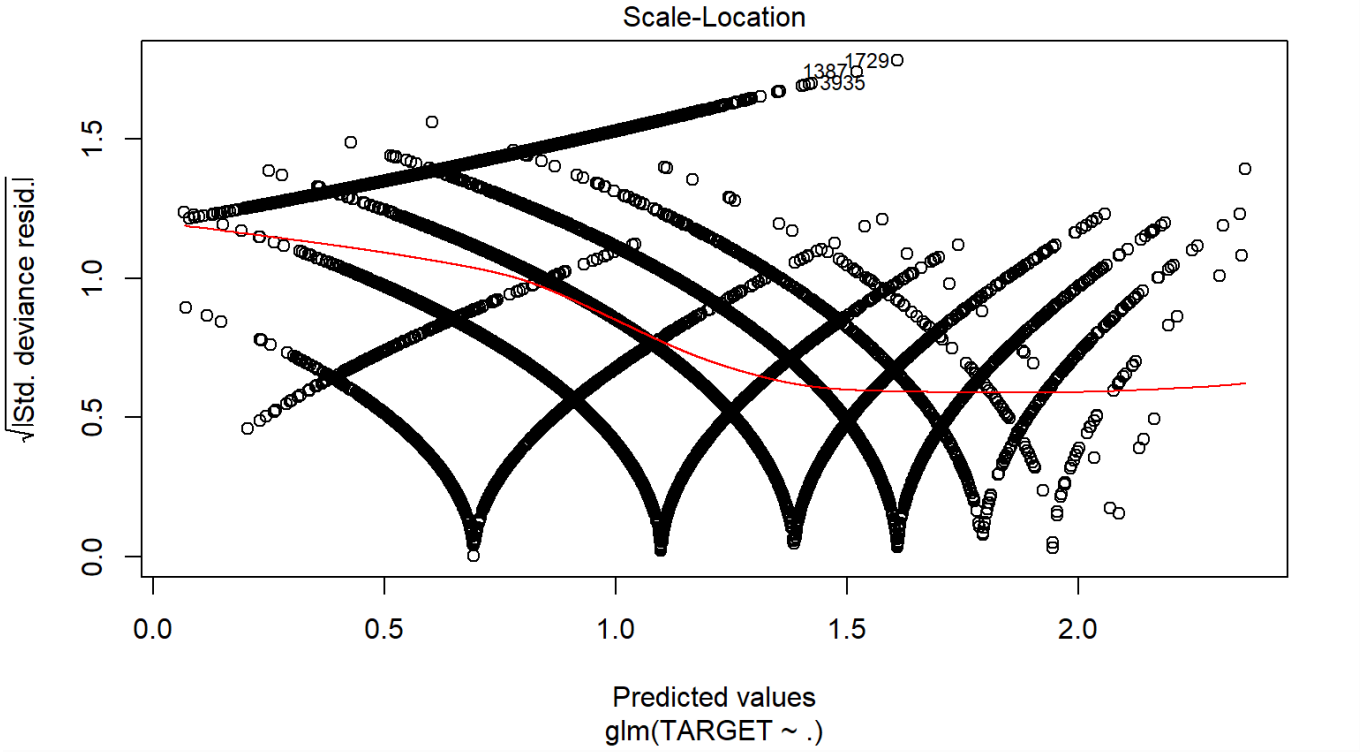
Model 3: Poisson Model with imputations

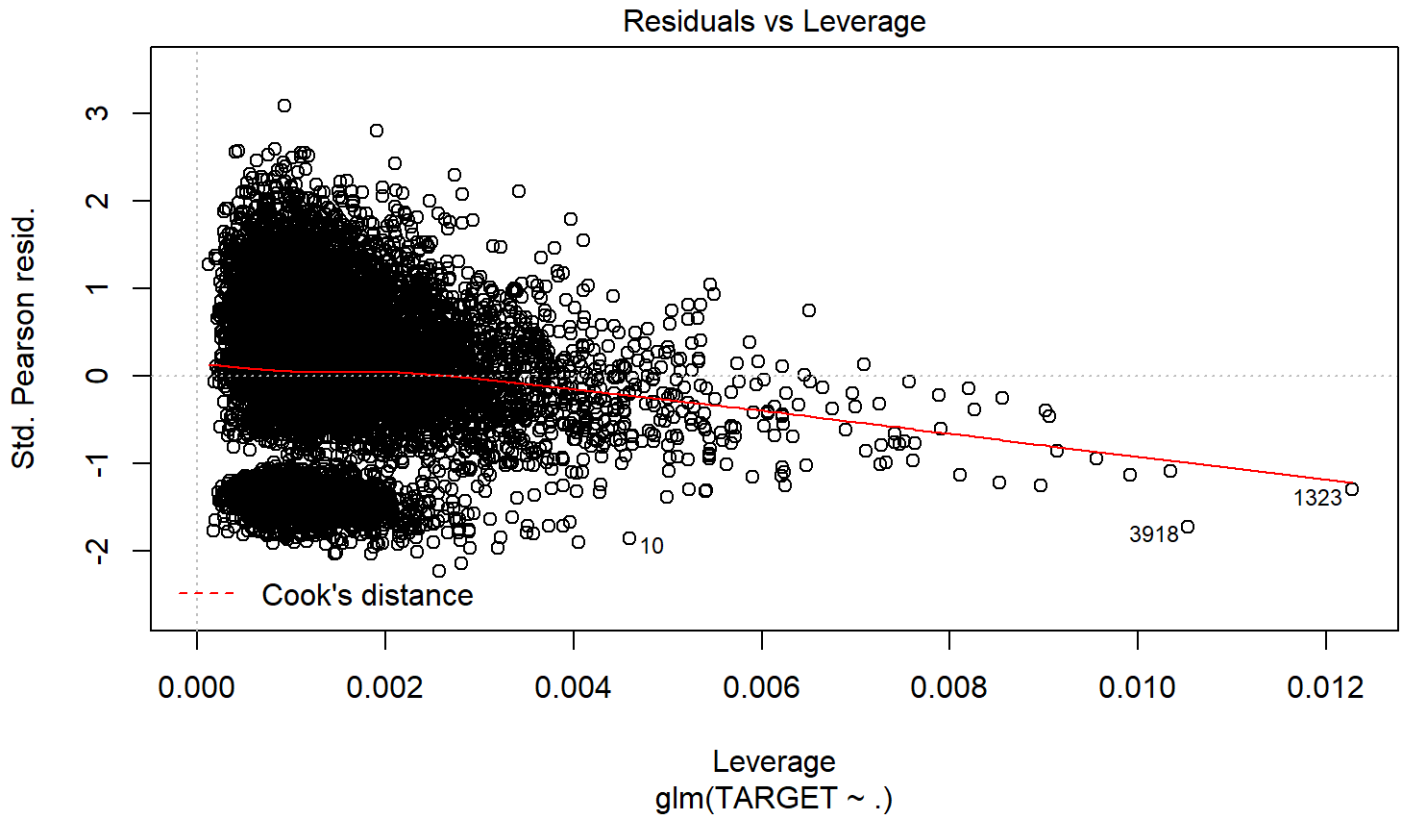
```
##
## Call:
## glm(formula = TARGET ~ ., family = poisson, data = wine_train2)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.1630  -0.6739   0.1305   0.6337   2.4320
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)         2.337e+00  2.281e-01  10.242  < 2e-16 ***
## FixedAcidity        2.250e-04  9.190e-04   0.245 0.806610
## VolatileAcidity    -4.313e-02  7.286e-03  -5.919 3.23e-09 ***
## CitricAcid          8.534e-03  6.573e-03   1.298 0.194168
## ResidualSugar       1.271e-04  1.675e-04   0.759 0.448033
## Chlorides          -6.572e-02  1.790e-02  -3.673 0.000240 ***
## FreeSulfurDioxide   1.336e-04  3.804e-05   3.512 0.000444 ***
## TotalSulfurDioxide  9.235e-05  2.460e-05   3.754 0.000174 ***
## Density            -3.404e-01  2.144e-01  -1.588 0.112379
## pH                 -1.962e-02  8.417e-03  -2.331 0.019744 *
## Sulphates          -1.569e-02  6.157e-03  -2.549 0.010805 *
## Alcohol             2.951e-03  1.554e-03   1.898 0.057632 .
## LabelAppeal         1.409e-01  6.798e-03  20.724  < 2e-16 ***
```

```
## AcidIndex         -7.709e-01  3.998e-02 -19.280  < 2e-16 ***
## STARS              3.407e-01  6.270e-03  54.337  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 18291  on 10236  degrees of freedom
## Residual deviance: 12829  on 10222  degrees of freedom
## AIC: 38417
##
## Number of Fisher Scoring iterations: 5
```




Normal Q-Q
Std. deviance resid.
3
2
1
0
-1
-2
-3
3935
13870
1729
-4
-2
0
2
4
Theoretical Quantiles
glm(TARGET ~ .)

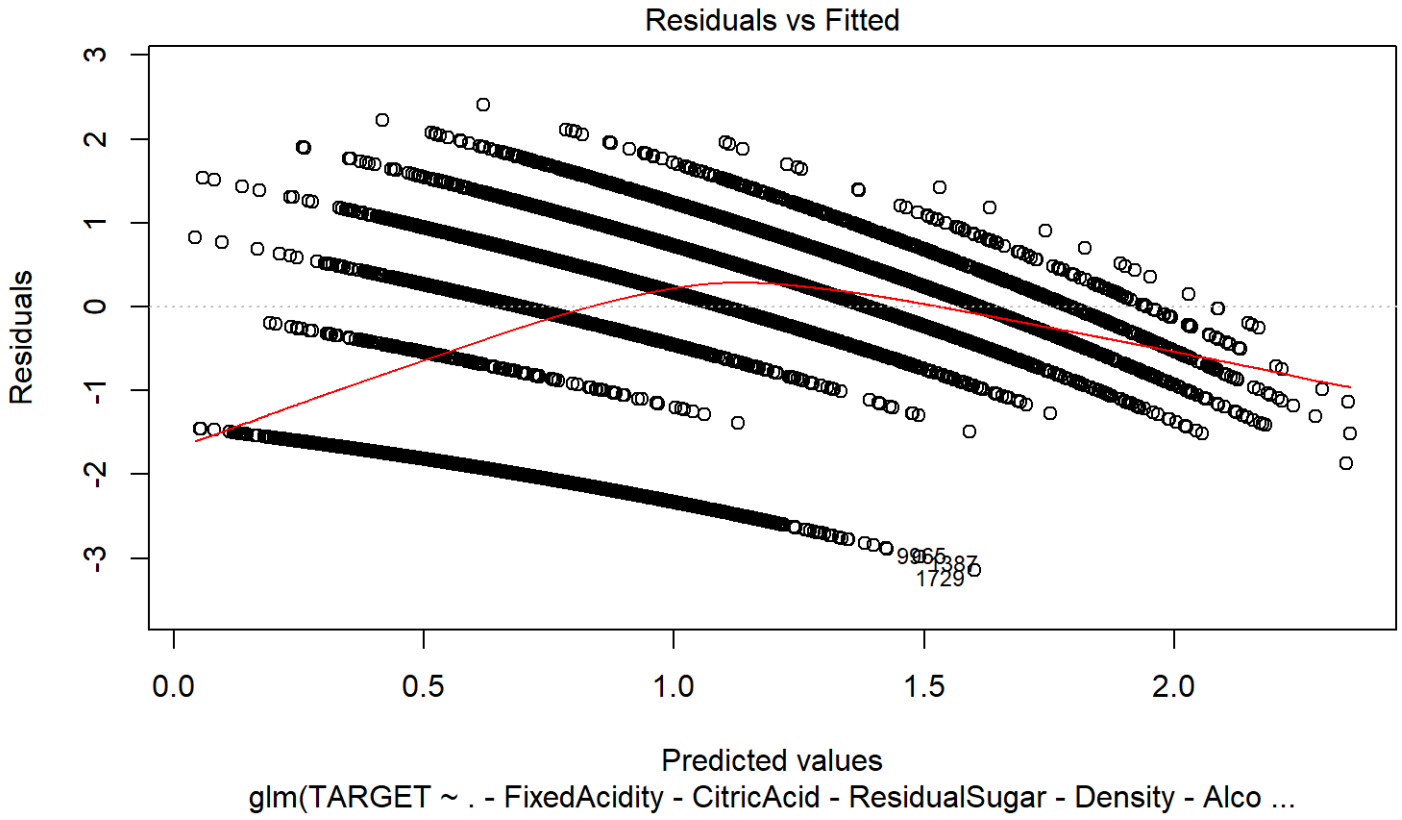

Scale-Location
√|Std. deviance resid.|
1729
13870
3935
0.0
0.5
1.0
1.5
2.0
Predicted values
glm(TARGET ~ .)

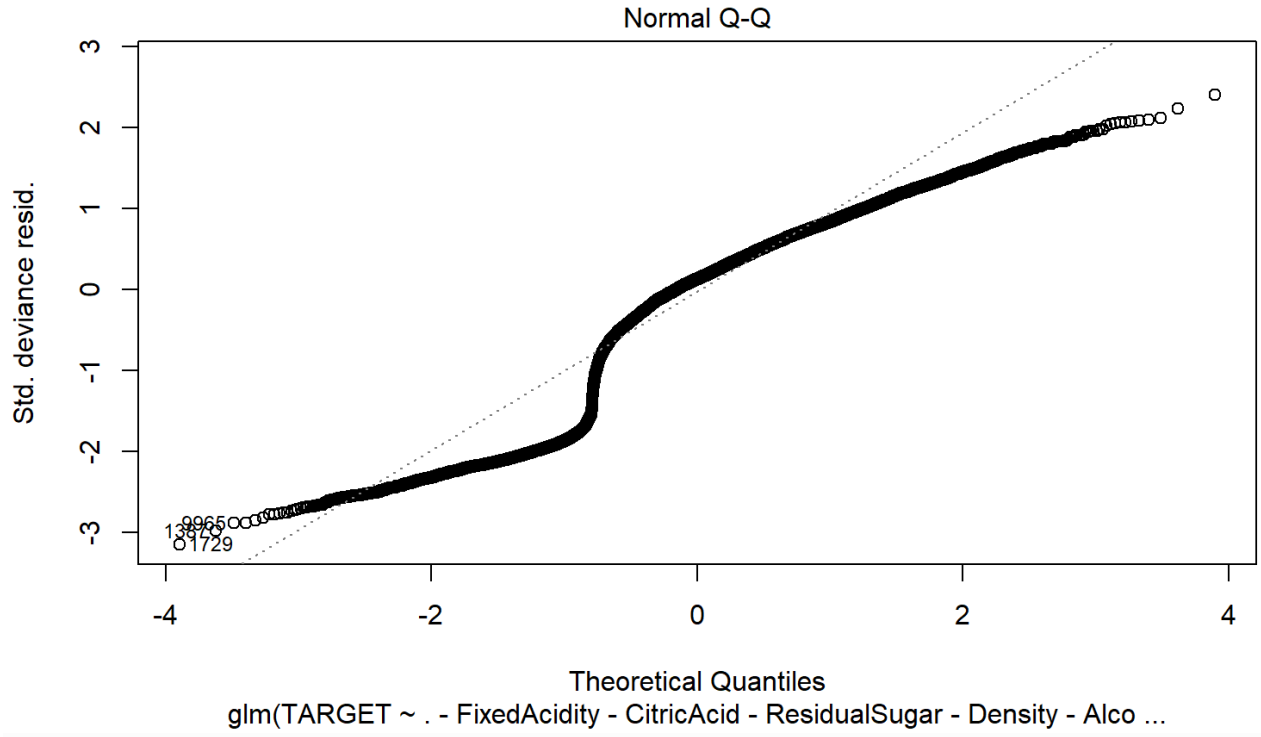


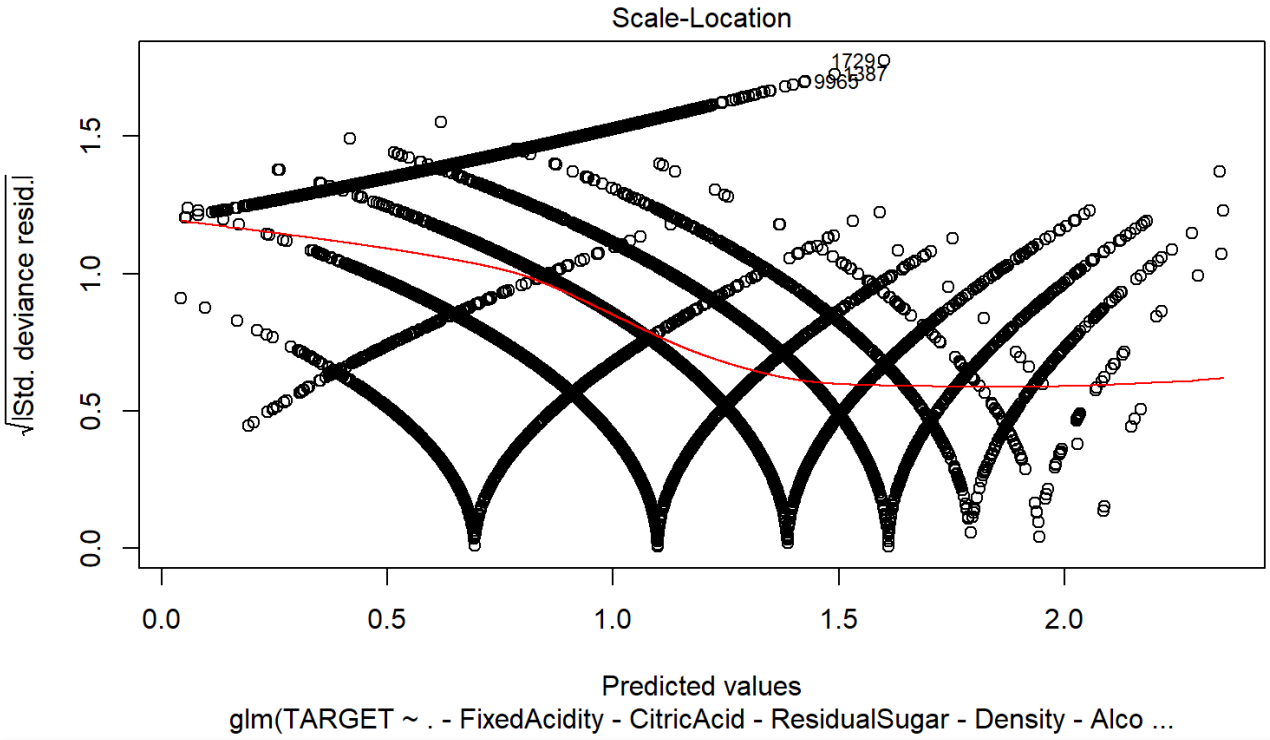
Model 4: Poisson Model with imputations and only significant variables

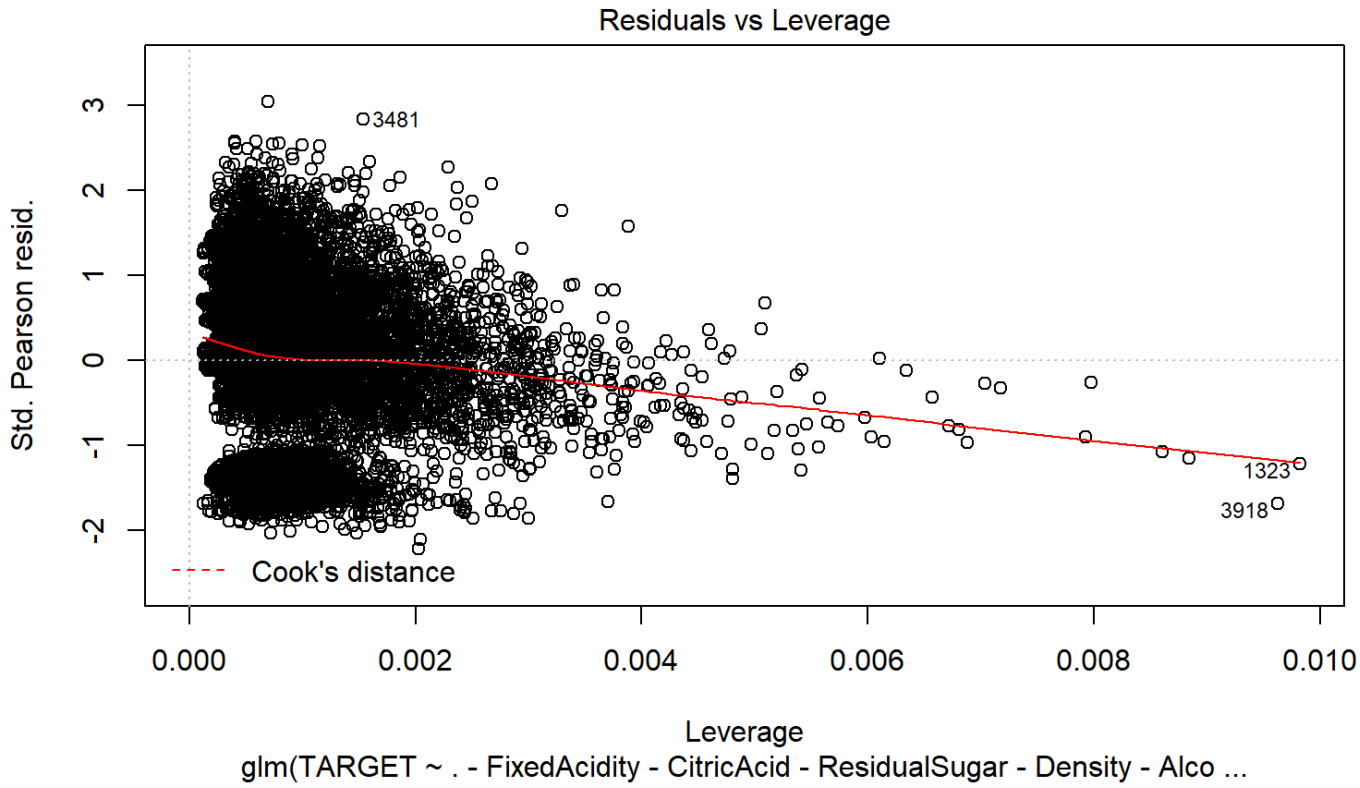
```
##
## Call:
## glm(formula = TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar -
##     Density - Alcohol, family = poisson, data = wine_train2)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.1469  -0.6828   0.1295   0.6379   2.4054
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)       2.038e+00  8.840e-02  23.052  < 2e-16 ***
## VolatileAcidity  -4.348e-02  7.284e-03  -5.969 2.39e-09 ***
## Chlorides        -6.725e-02  1.789e-02  -3.760 0.000170 ***
## FreeSulfurDioxide  1.316e-04  3.801e-05   3.461 0.000537 ***
## TotalSulfurDioxide  9.150e-05  2.458e-05   3.723 0.000197 ***
## pH               -1.991e-02  8.415e-03  -2.366 0.018003 *
## Sulphates        -1.563e-02  6.153e-03  -2.540 0.011086 *
## LabelAppeal       1.409e-01  6.798e-03  20.727  < 2e-16 ***
## AcidIndex        -7.729e-01  3.936e-02 -19.636  < 2e-16 ***
## STARS             3.417e-01  6.255e-03  54.634  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 18291  on 10236  degrees of freedom
## Residual deviance: 12837  on 10227  degrees of freedom
## AIC: 38415
##
## Number of Fisher Scoring iterations: 5
```




Normal Q-Q
Std. deviance resid.
3
2
1
0
-1
-2
-3
9965
13729
1729
-4
-2
0
2
4
Theoretical Quantiles
glm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Density - Alco ...


Scale-Location
√|Std. deviance resid.|
17299
11587
9965
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
Predicted values
glm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Density - Alco ...

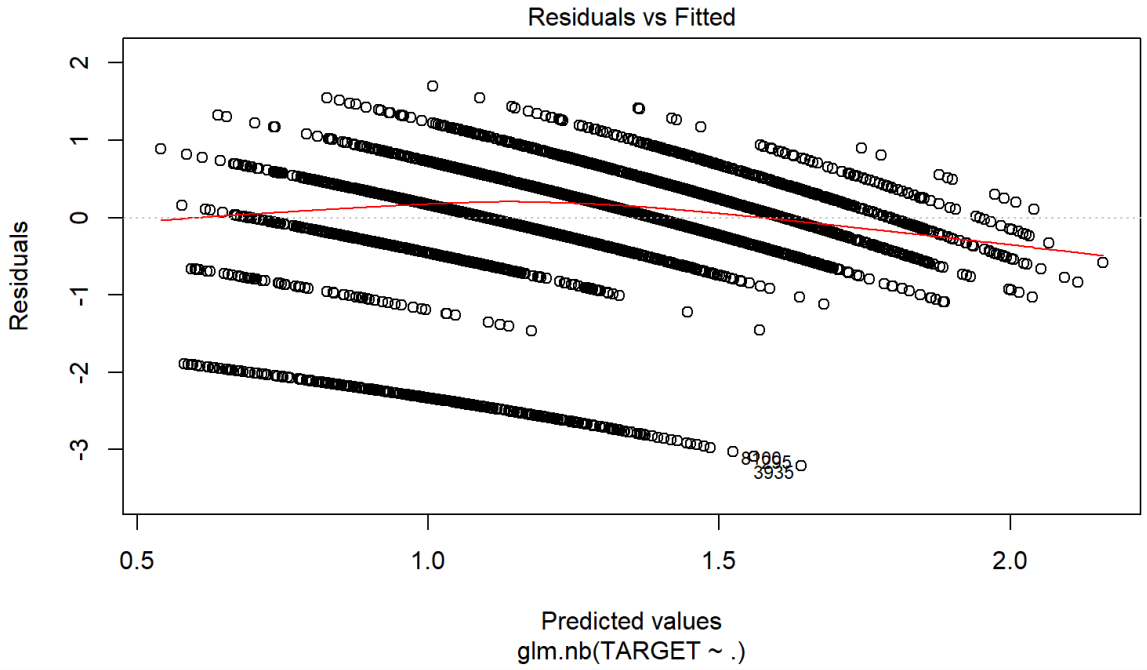


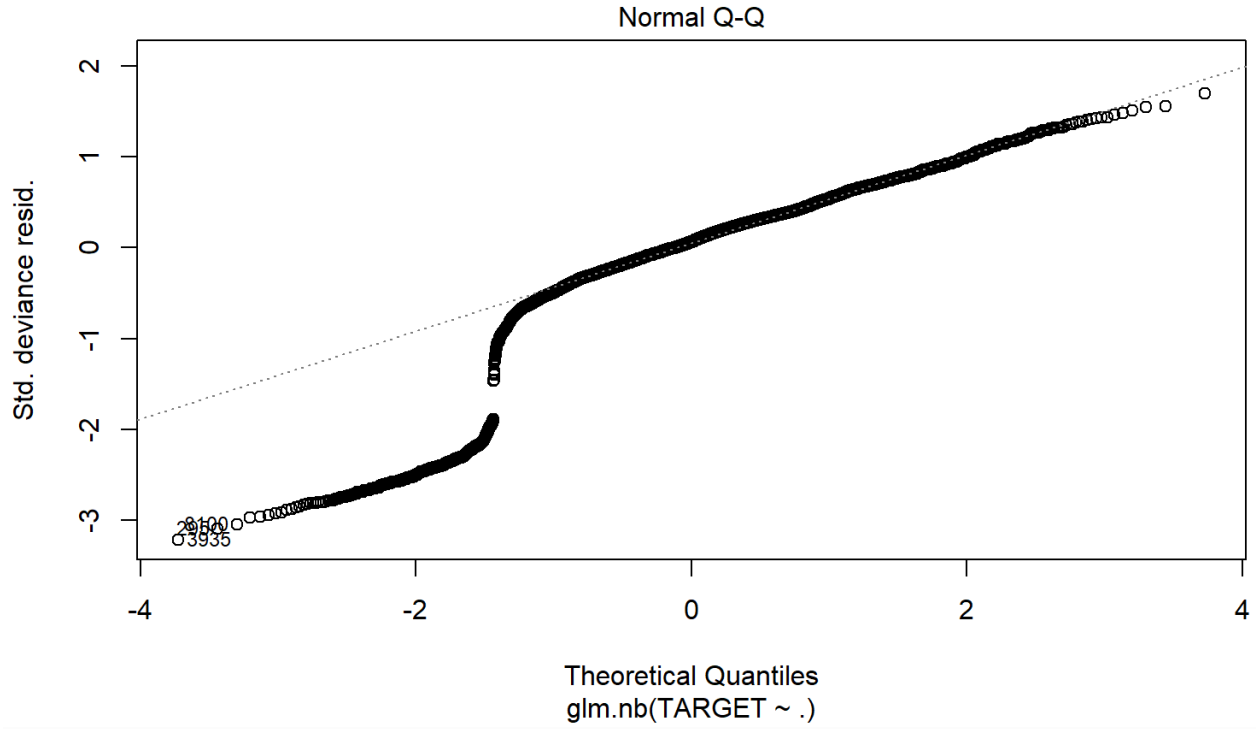
Model II: Negative Binomial

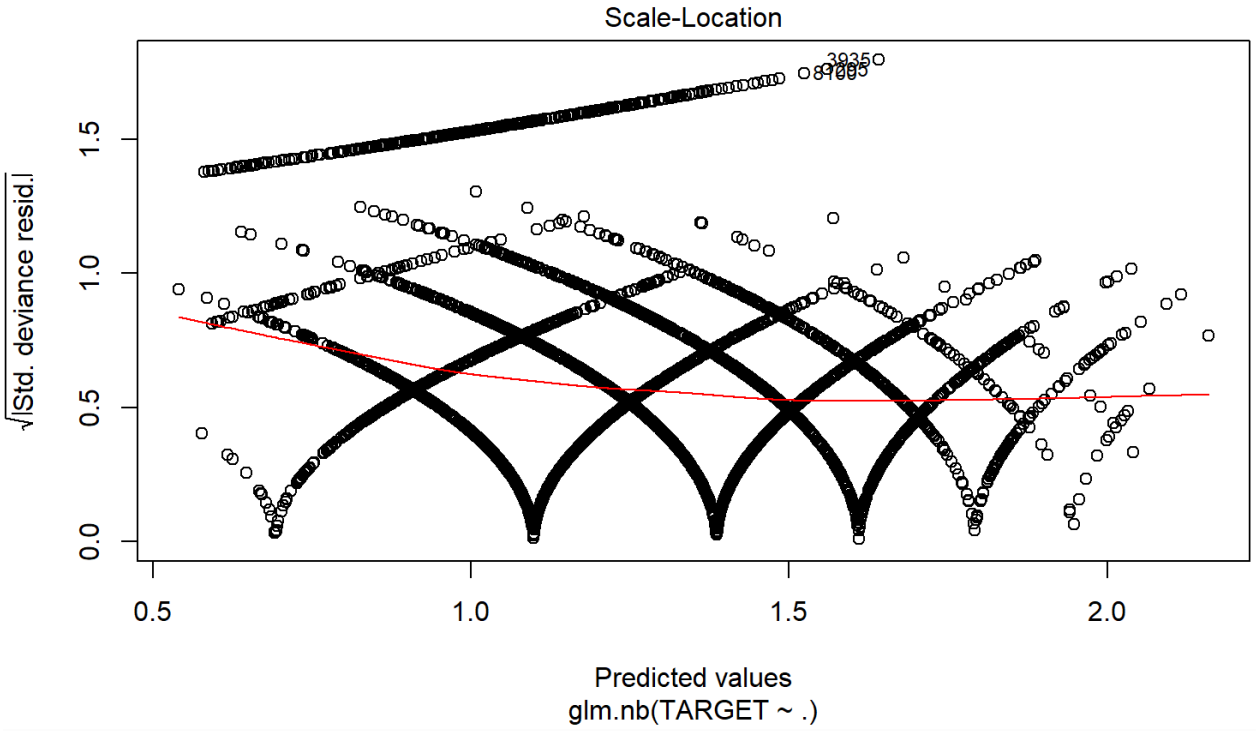
Model 5 : Negative Binomial without imputations

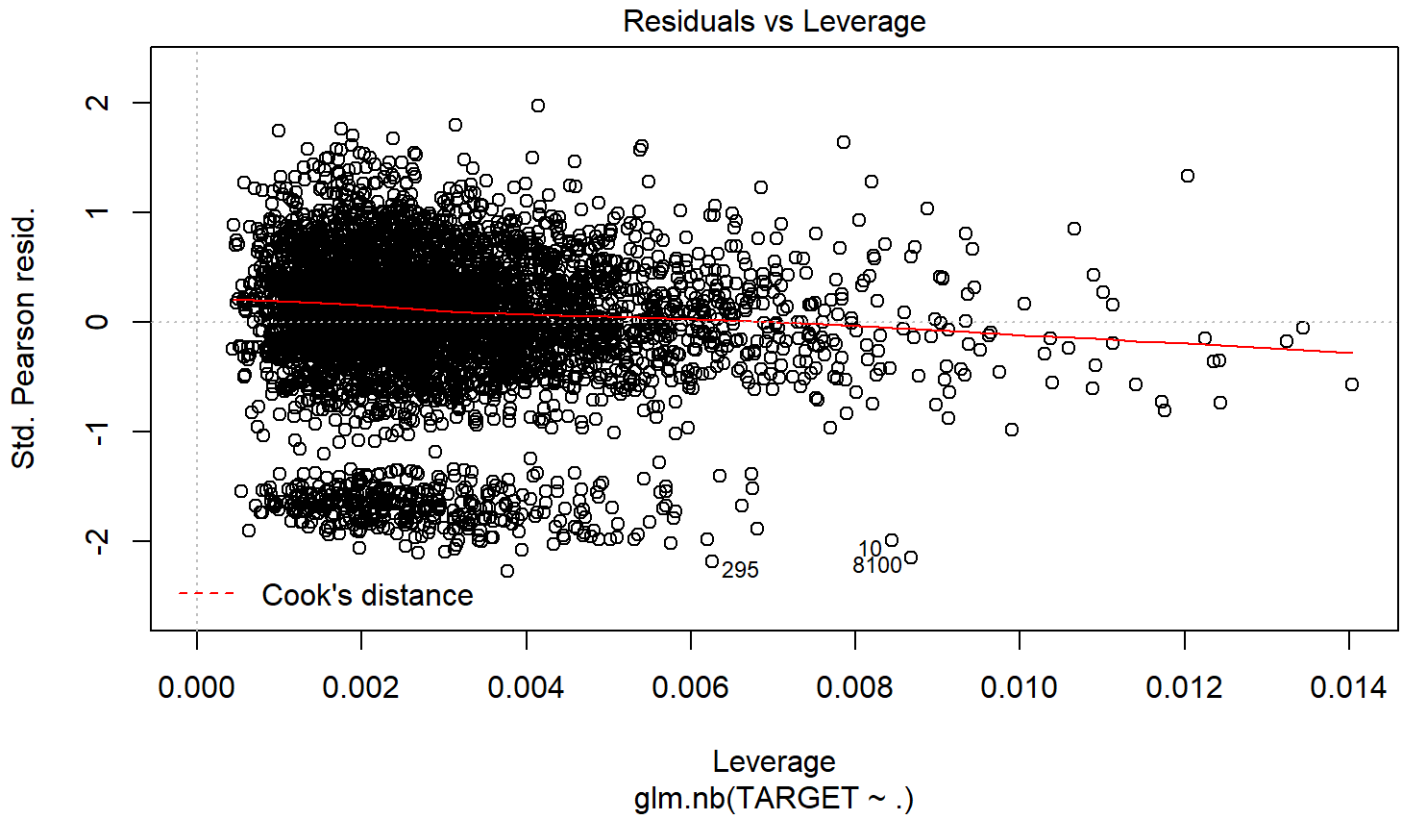
```
##
## Call:
## glm.nb(formula = TARGET ~ ., data = wine_train1, init.theta = 138898.9107,
##     link = log)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.2127  -0.2757   0.0647   0.3766   1.6981
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)         1.608e+00  2.796e-01   5.750 8.91e-09 ***
## FixedAcidity        6.705e-04  1.177e-03   0.570  0.56900
## VolatileAcidity    -2.750e-02  9.283e-03  -2.963  0.00305 **
## CitricAcid         -3.835e-03  8.519e-03  -0.450  0.65259
## ResidualSugar       1.828e-05  2.152e-04   0.085  0.93231
## Chlorides          -3.764e-02  2.314e-02  -1.627  0.10378
## FreeSulfurDioxide   5.671e-05  4.892e-05   1.159  0.24630
## TotalSulfurDioxide  2.230e-05  3.177e-05   0.702  0.48275
## Density            -4.025e-01  2.750e-01  -1.464  0.14326
## pH                  2.307e-04  1.085e-02   0.021  0.98303
```

```
## Sulphates         -5.984e-03  7.973e-03  -0.751  0.45293
## Alcohol           3.262e-03  2.004e-03   1.628  0.10360
## LabelAppeal         1.730e-01  8.858e-03  19.529  < 2e-16 ***
## AcidIndex         -4.967e-02  6.666e-03  -7.451 9.28e-14 ***
## STARS             1.929e-01  8.328e-03  23.160  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for Negative Binomial(138898.9) family taken to be 1)
##
##     Null deviance: 4720.4  on 5143  degrees of freedom
## Residual deviance: 3242.7  on 5129  degrees of freedom
##   (5093 observations deleted due to missingness)
## AIC: 18547
##
## Number of Fisher Scoring iterations: 1
##
##
##               Theta:  138899
##           Std. Err.:  259921
## Warning while fitting theta: iteration limit reached
##
##  2 x log-likelihood:  -18515.07
```




Normal Q-Q
Std. deviance resid.
-4
-2
0
2
4
-3
-2
-1
0
1
2
3935
Theoretical Quantiles
glm.nb(TARGET ~ .)

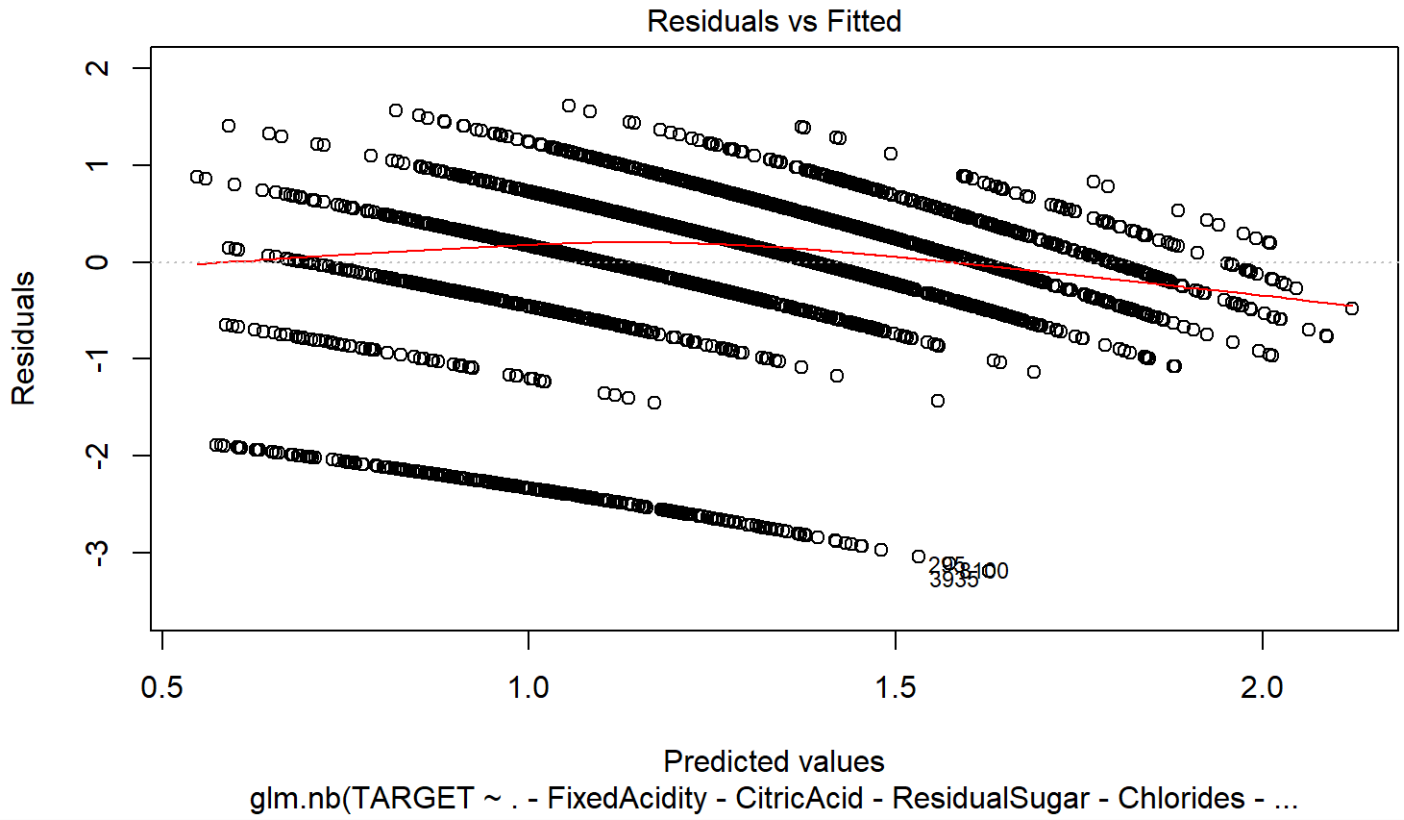

Scale-Location
√|Std. deviance resid.|
0.5
1.0
1.5
2.0
0.0
0.5
1.0
1.5
3935
Predicted values
glm.nb(TARGET ~ .)

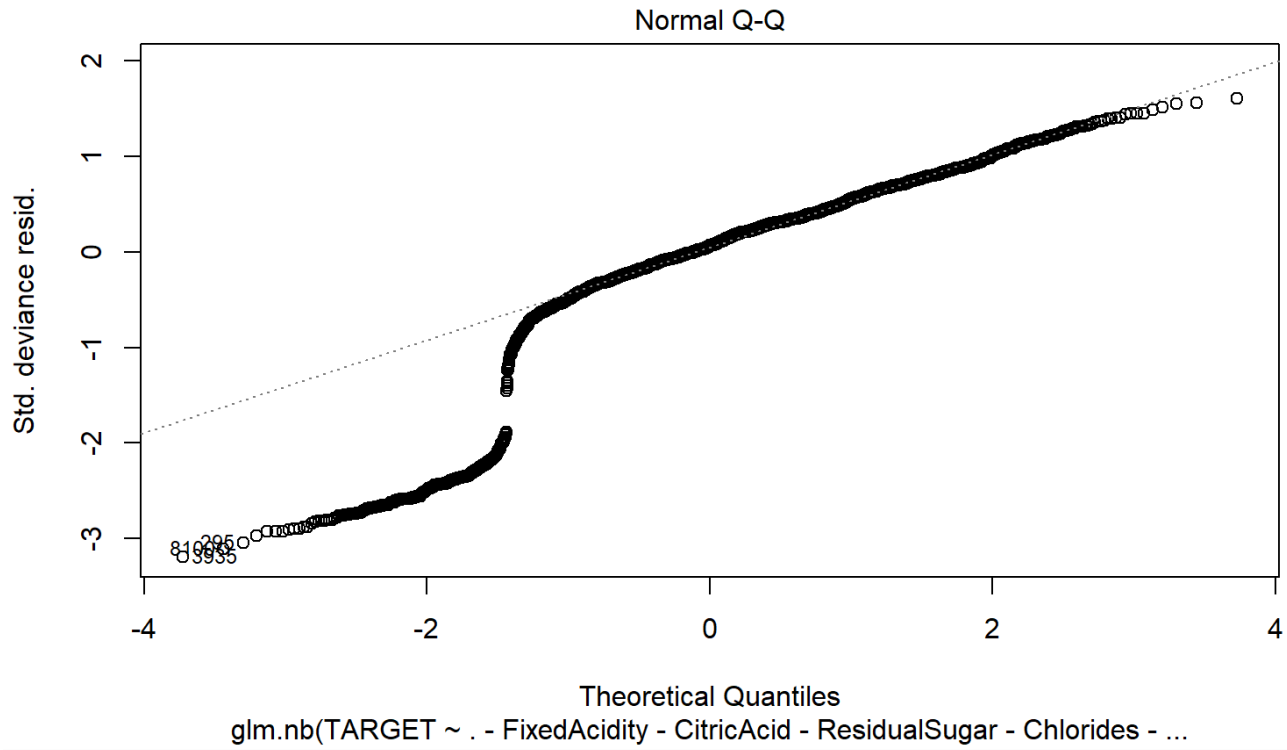


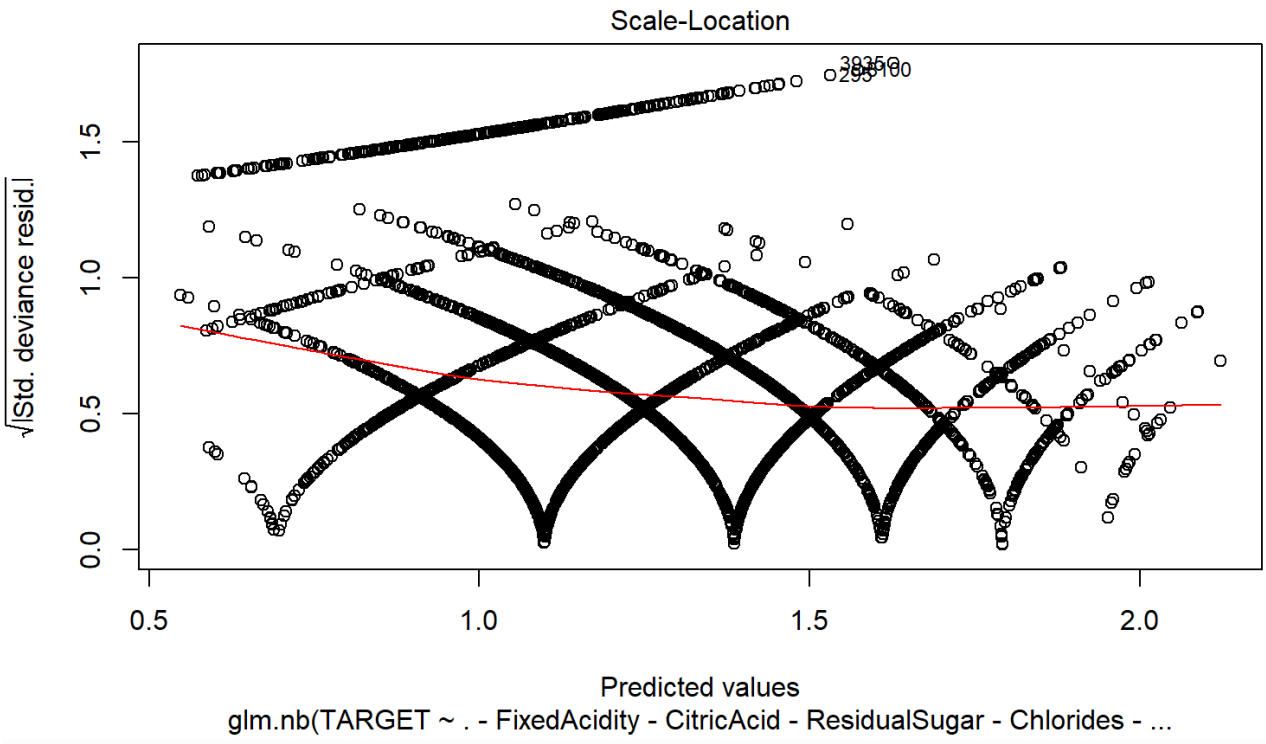
Model 6 : Negative Binomial without imputations and only significant variables

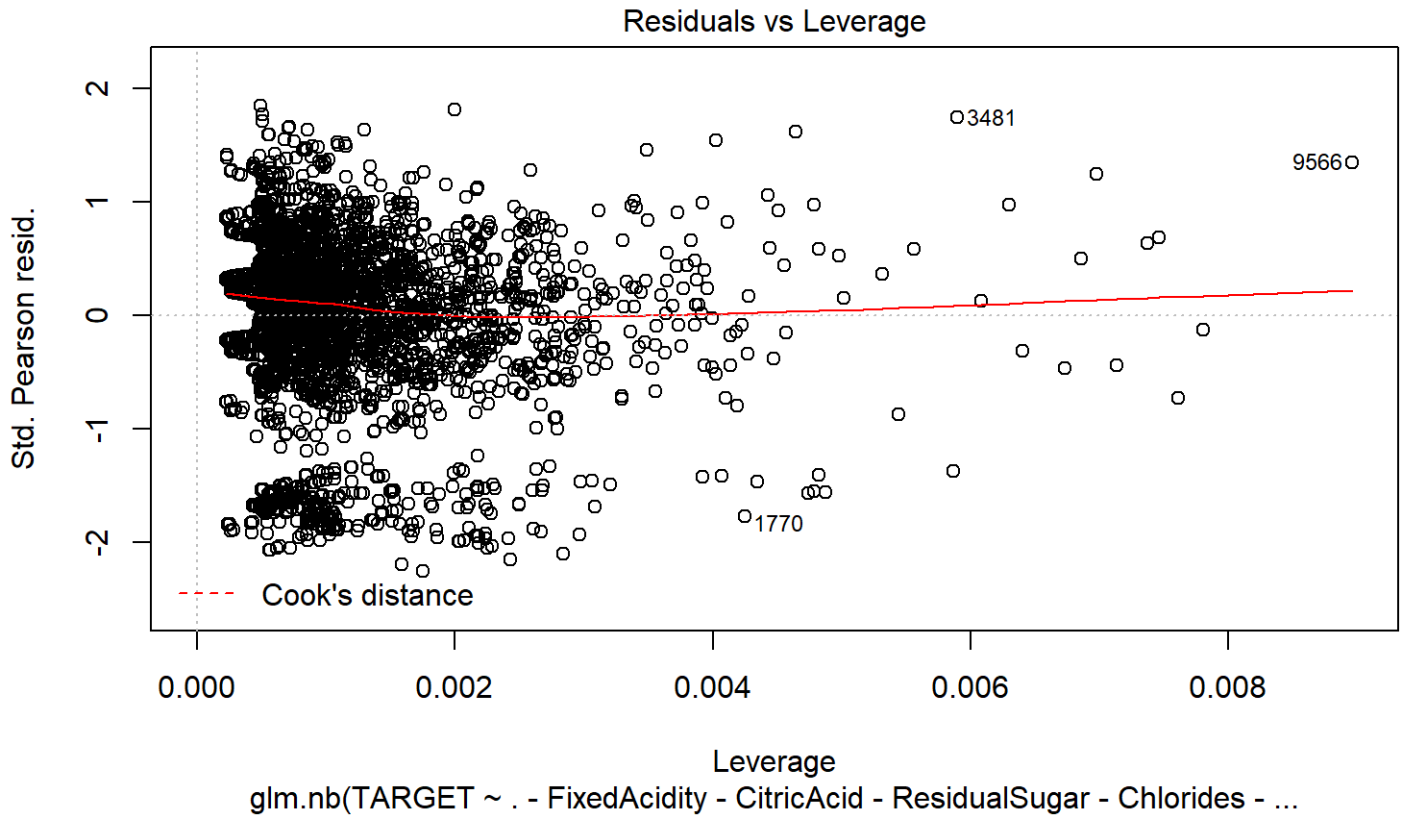
```
##
## Call:
## glm.nb(formula = TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar -
##     Chlorides - FreeSulfurDioxide - TotalSulfurDioxide - Density -
##     pH - Sulphates - Alcohol, data = wine_train1, init.theta = 138402.5261,
##     link = log)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.1898  -0.2777   0.0622   0.3764   1.6086
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept)     1.251443   0.054725  22.868  < 2e-16 ***
## VolatileAcidity -0.027581   0.009279  -2.973  0.00295 **
## LabelAppeal      0.173177   0.008853  19.562  < 2e-16 ***
## AcidIndex       -0.050616   0.006553  -7.724 1.13e-14 ***
## STARS           0.194209   0.008292  23.421  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for Negative Binomial(138402.5) family taken to be 1)
##
```

```
##     Null deviance: 4720.4  on 5143  degrees of freedom
## Residual deviance: 3253.0  on 5139  degrees of freedom
##   (5093 observations deleted due to missingness)
## AIC: 18537
##
## Number of Fisher Scoring iterations: 1
##
##
##              Theta:  138403
##          Std. Err.:  258834
## Warning while fitting theta: iteration limit reached
##
##  2 x log-likelihood:  -18525.37
```




Normal Q-Q
Std. deviance resid.
2
1
0
-1
-2
-3
-4
-2
0
2
4
Theoretical Quantiles
glm.nb(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Chlorides - ...

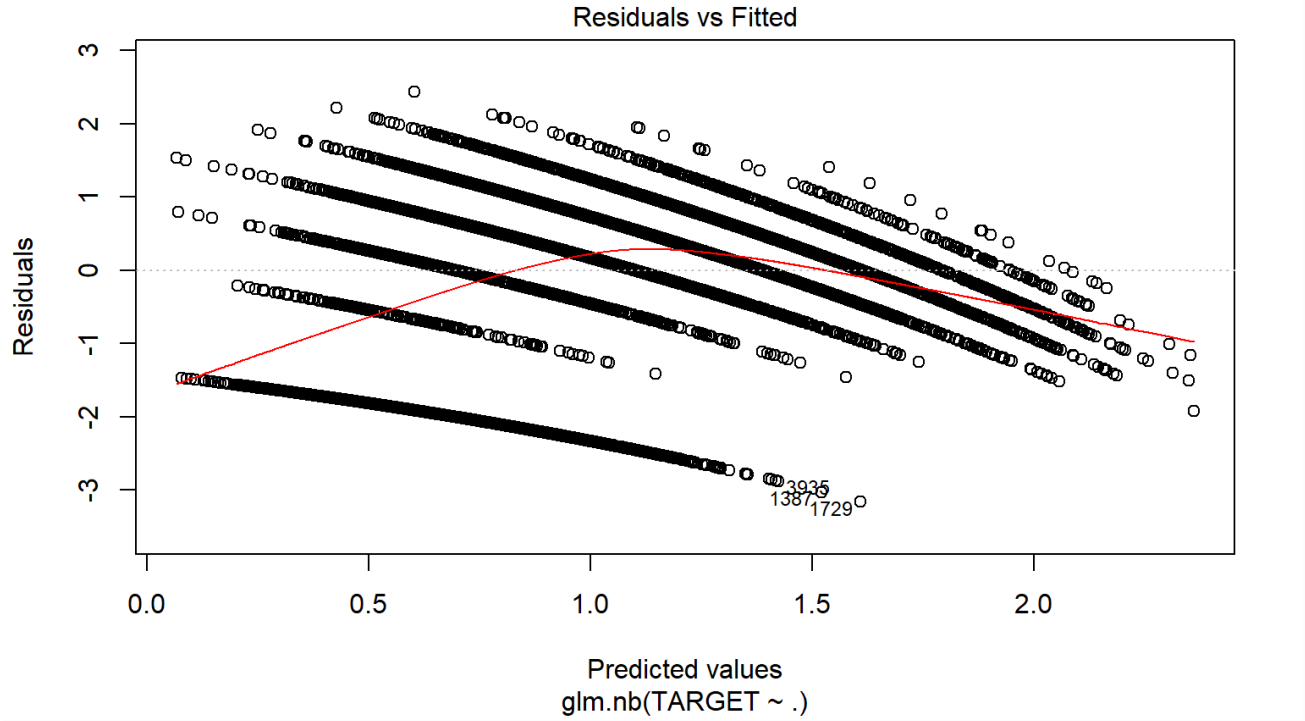

Scale-Location
√|Std. deviance resid.|
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
Predicted values
glm.nb(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Chlorides - ...

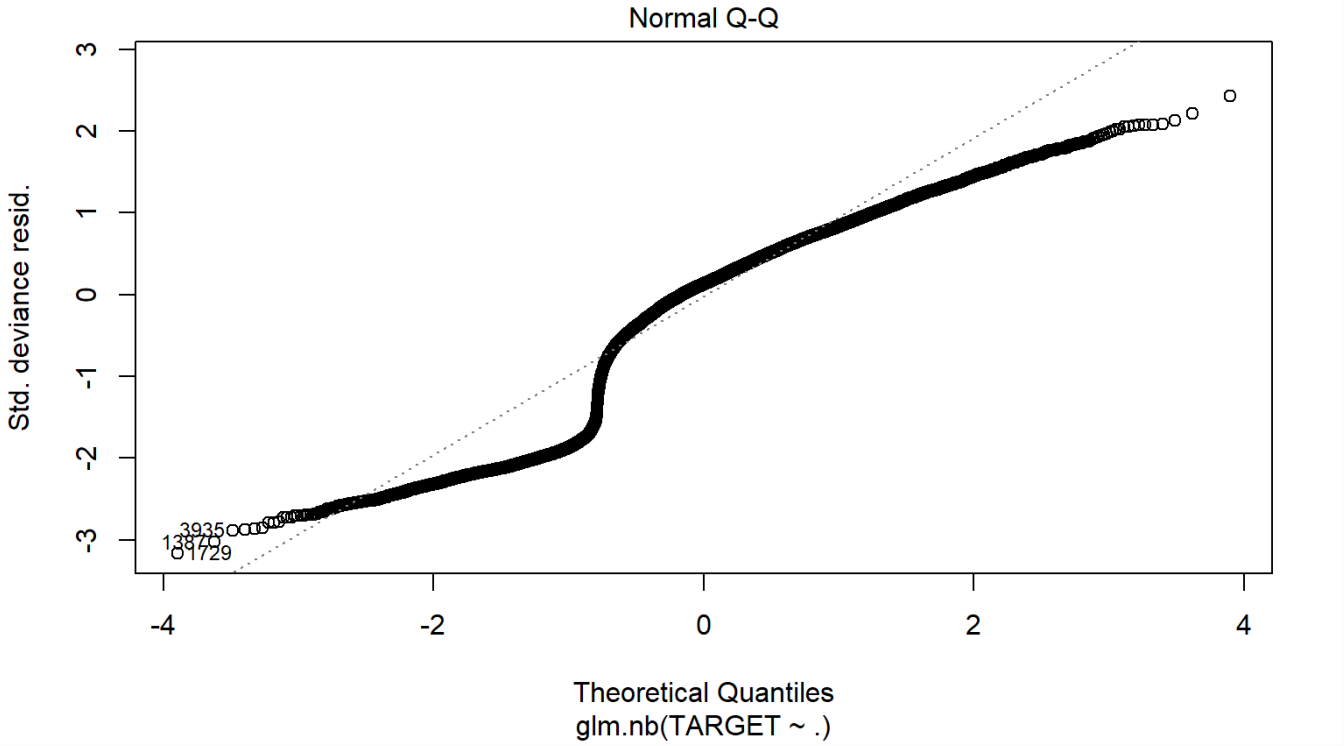


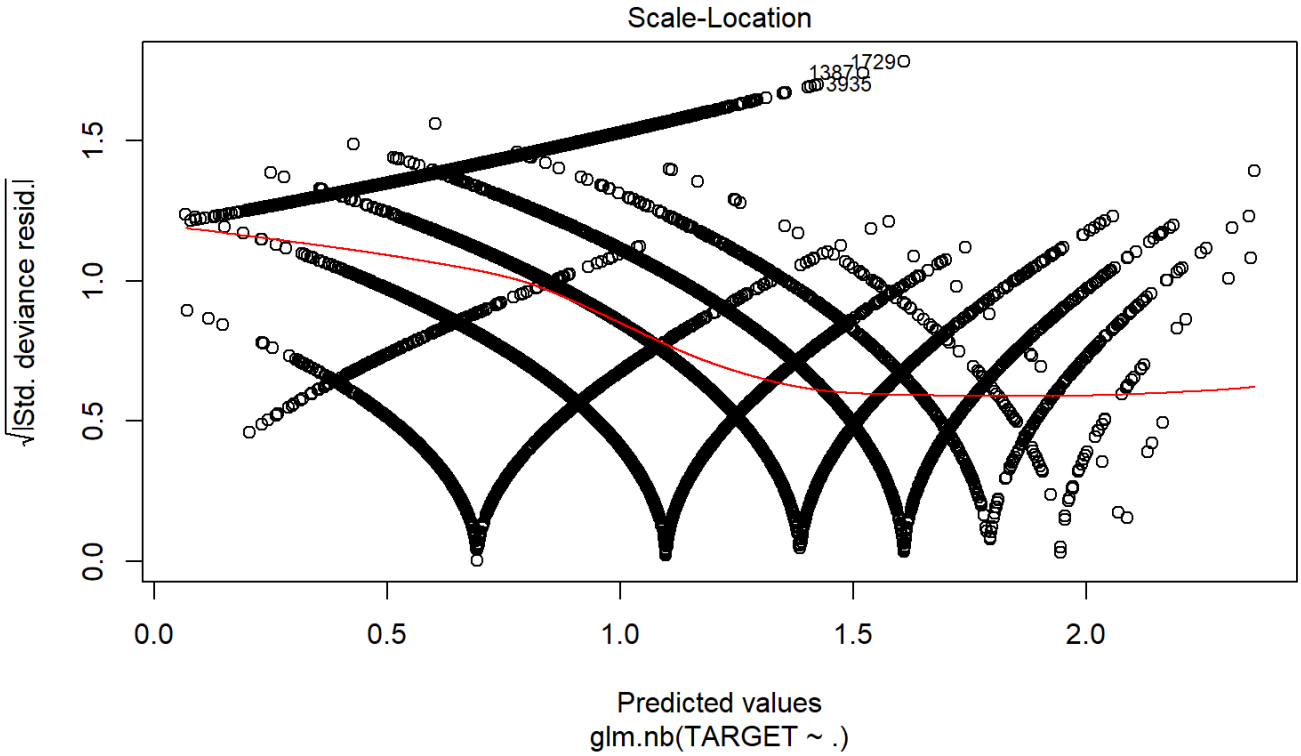
Model 7 : Negative Binomial with imputations

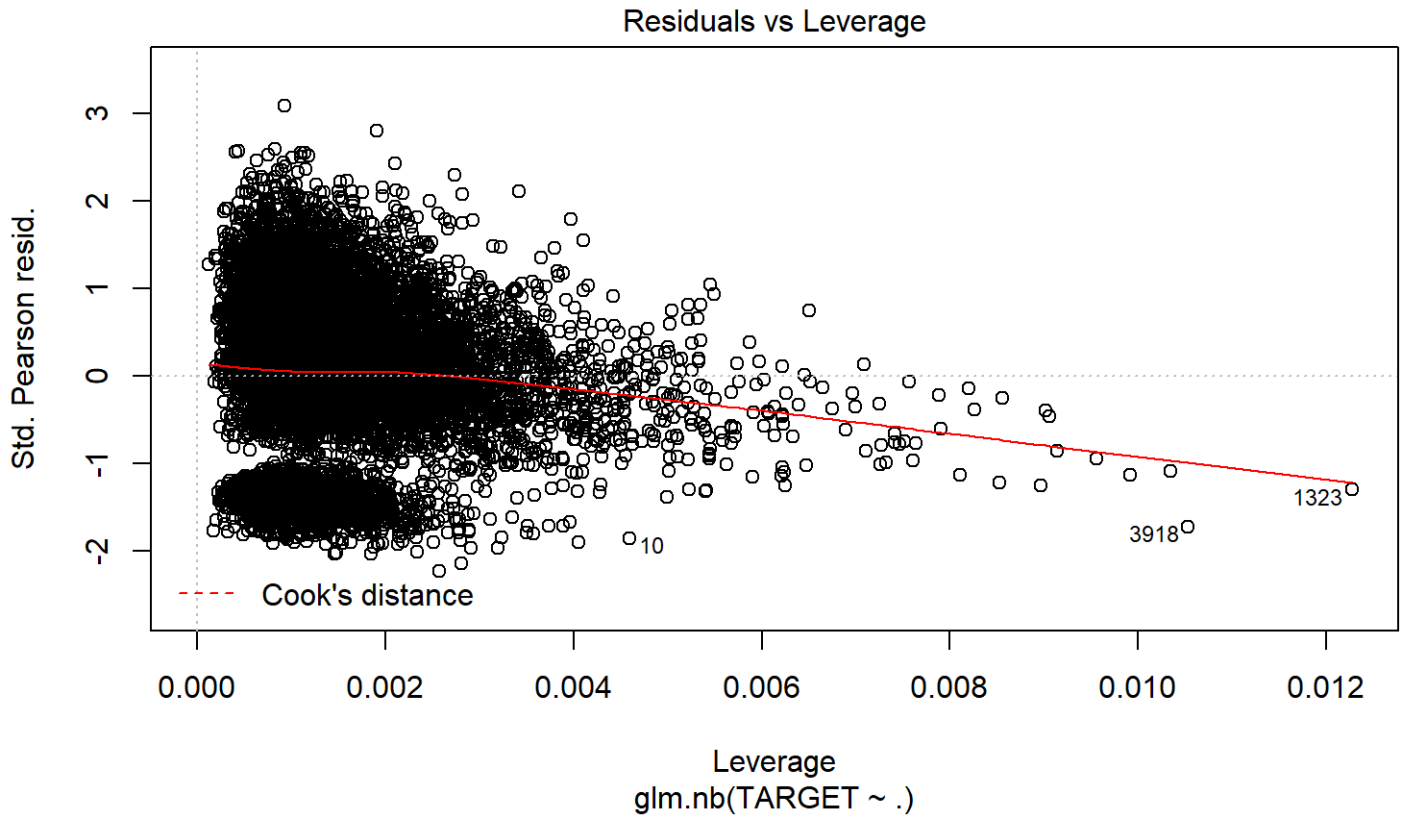
```
##
## Call:
## glm.nb(formula = TARGET ~ ., data = wine_train2, init.theta = 49078.50992,
##     link = log)
##
## Deviance Residuals:
##        Min       1Q   Median       3Q      Max
## -3.1629  -0.6739   0.1305   0.6337   2.4320
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)         2.337e+00  2.281e-01  10.242  < 2e-16 ***
## FixedAcidity         2.250e-04  9.190e-04   0.245 0.806608
## VolatileAcidity     -4.313e-02  7.286e-03  -5.919 3.23e-09 ***
## CitricAcid           8.534e-03  6.573e-03   1.298 0.194177
## ResidualSugar        1.271e-04  1.675e-04   0.759 0.448021
## Chlorides           -6.573e-02  1.790e-02  -3.673 0.000240 ***
## FreeSulfurDioxide    1.336e-04  3.804e-05   3.512 0.000444 ***
## TotalSulfurDioxide   9.235e-05  2.460e-05   3.754 0.000174 ***
## Density             -3.404e-01  2.144e-01  -1.588 0.112389
## pH                  -1.962e-02  8.418e-03  -2.331 0.019745 *
## Sulphates           -1.569e-02  6.157e-03  -2.549 0.010806 *
## Alcohol              2.951e-03  1.554e-03   1.898 0.057642 .
```

```
## LabelAppeal        1.409e-01  6.798e-03  20.723  < 2e-16 ***
## AcidIndex         -7.709e-01  3.999e-02 -19.279  < 2e-16 ***
## STARS              3.407e-01  6.270e-03  54.335  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for Negative Binomial(49078.51) family taken to be 1)
##
##     Null deviance: 18290  on 10236  degrees of freedom
## Residual deviance: 12828  on 10222  degrees of freedom
## AIC: 38419
##
## Number of Fisher Scoring iterations: 1
##
##
##               Theta:  49079
##           Std. Err.:  63619
## Warning while fitting theta: iteration limit reached
##
##  2 x log-likelihood:  -38387.04
```




Normal Q-Q
Std. deviance resid.
3
2
1
0
-1
-2
-3
3935
13870
81729
-4
-2
0
2
4
Theoretical Quantiles
glm.nb(TARGET ~ .)

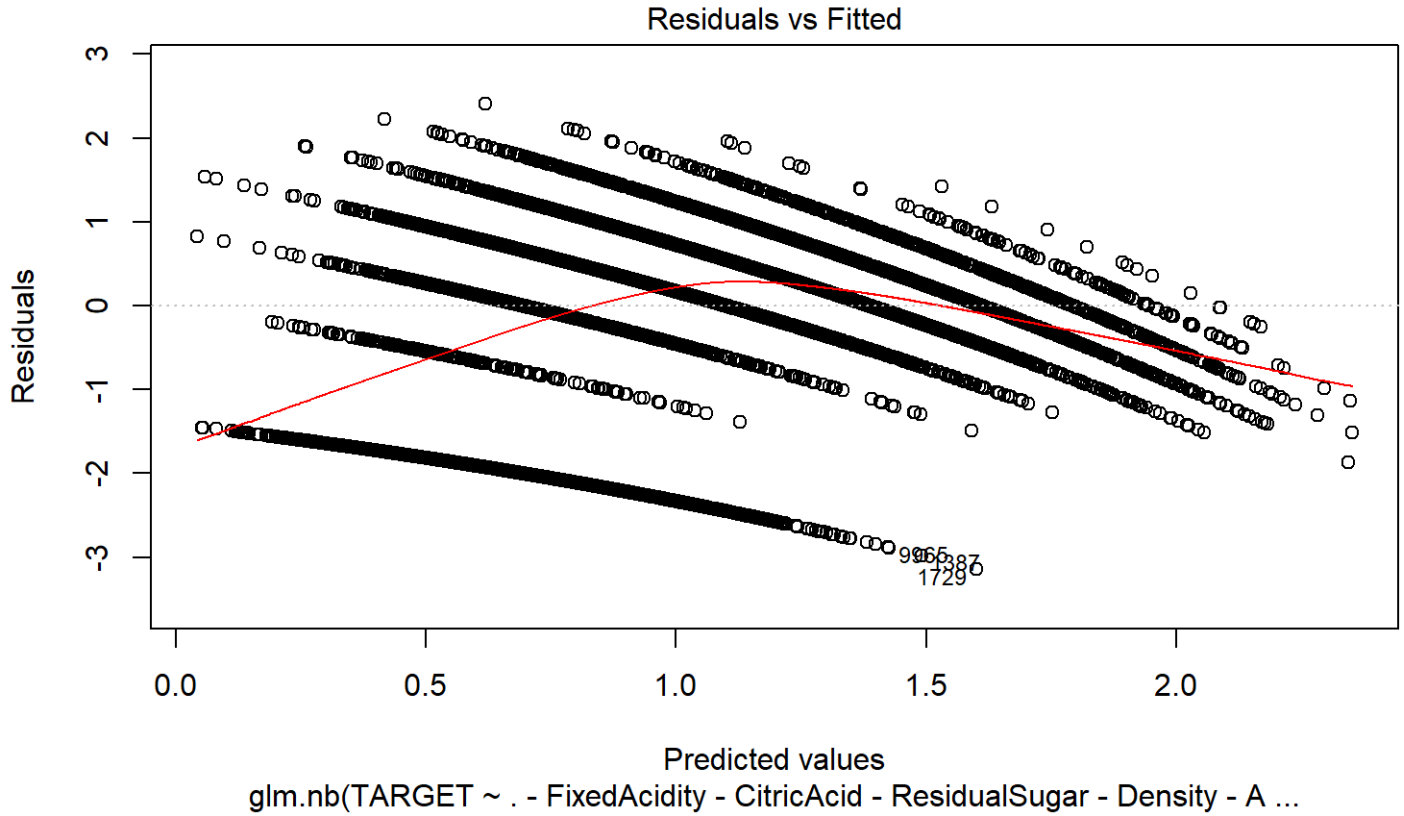

Scale-Location
17290
13870
3935
√|Std. deviance resid.|
0.0
0.5
1.0
1.5
0.0
0.5
1.0
1.5
2.0
Predicted values
glm.nb(TARGET ~ .)

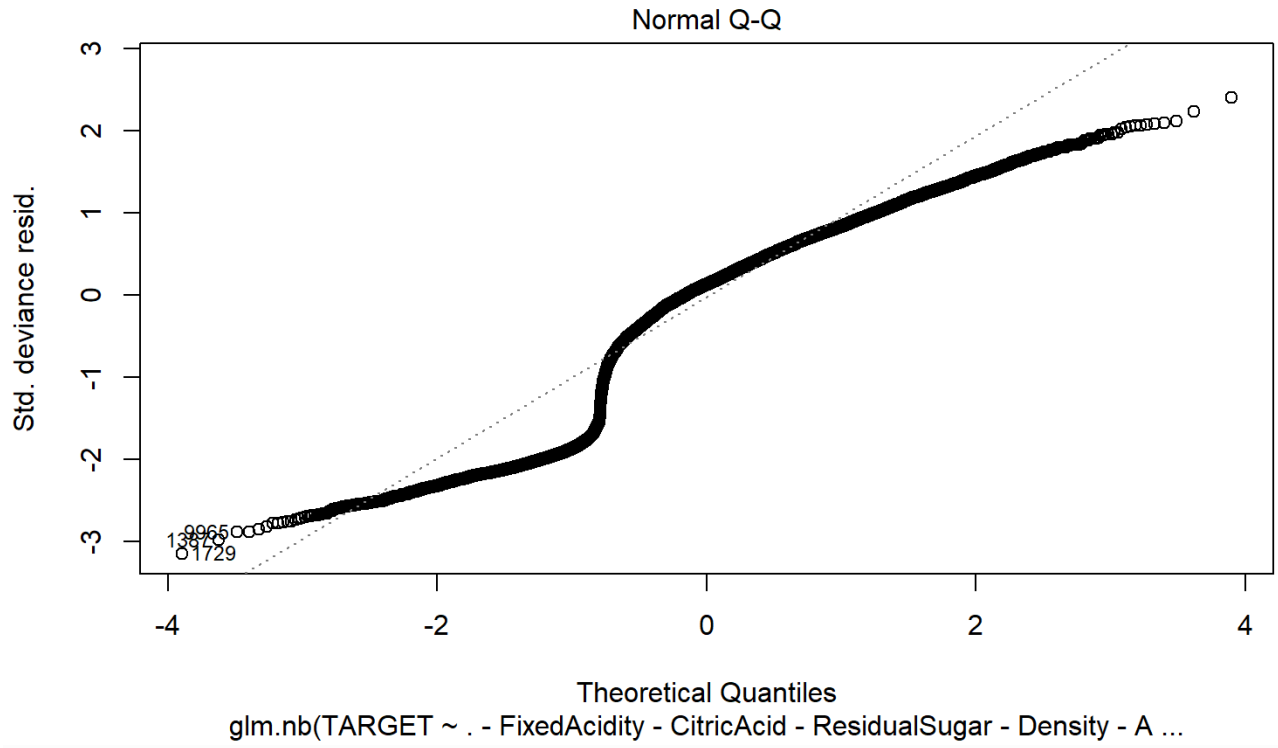


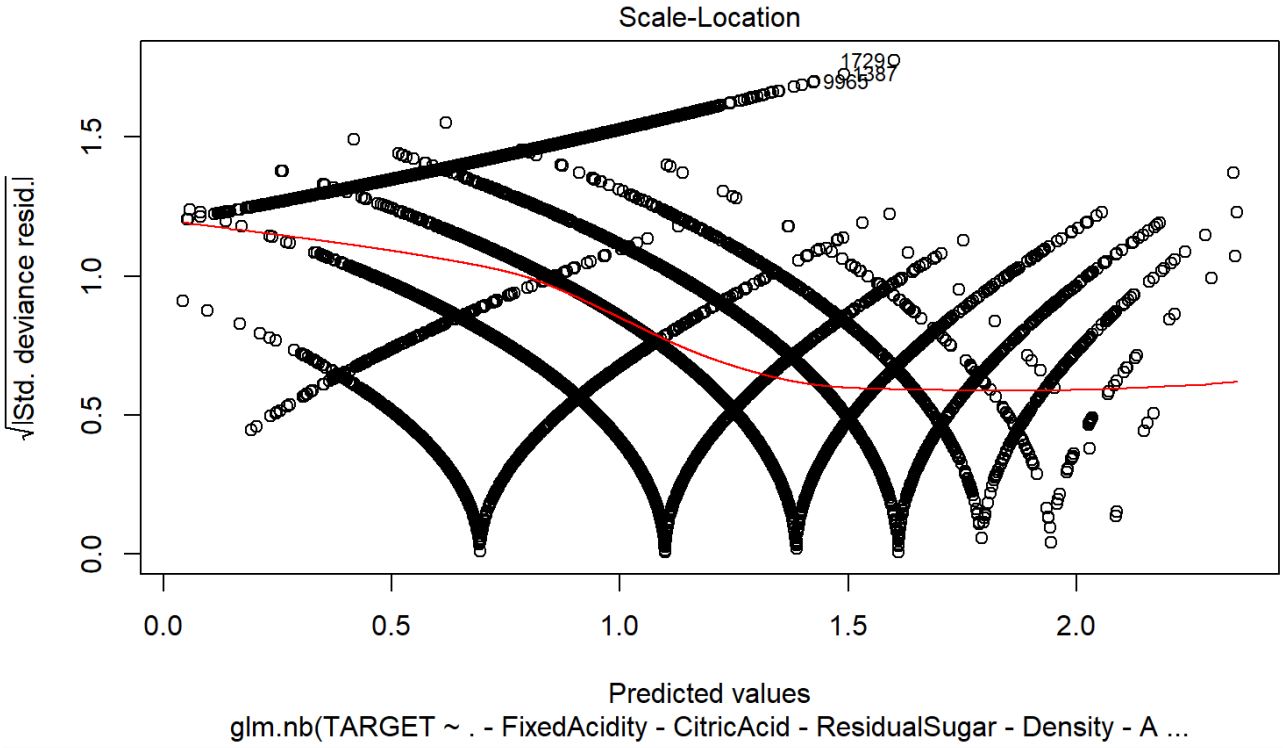
Model 8 : Negative Binomial with imputations and only significant variables

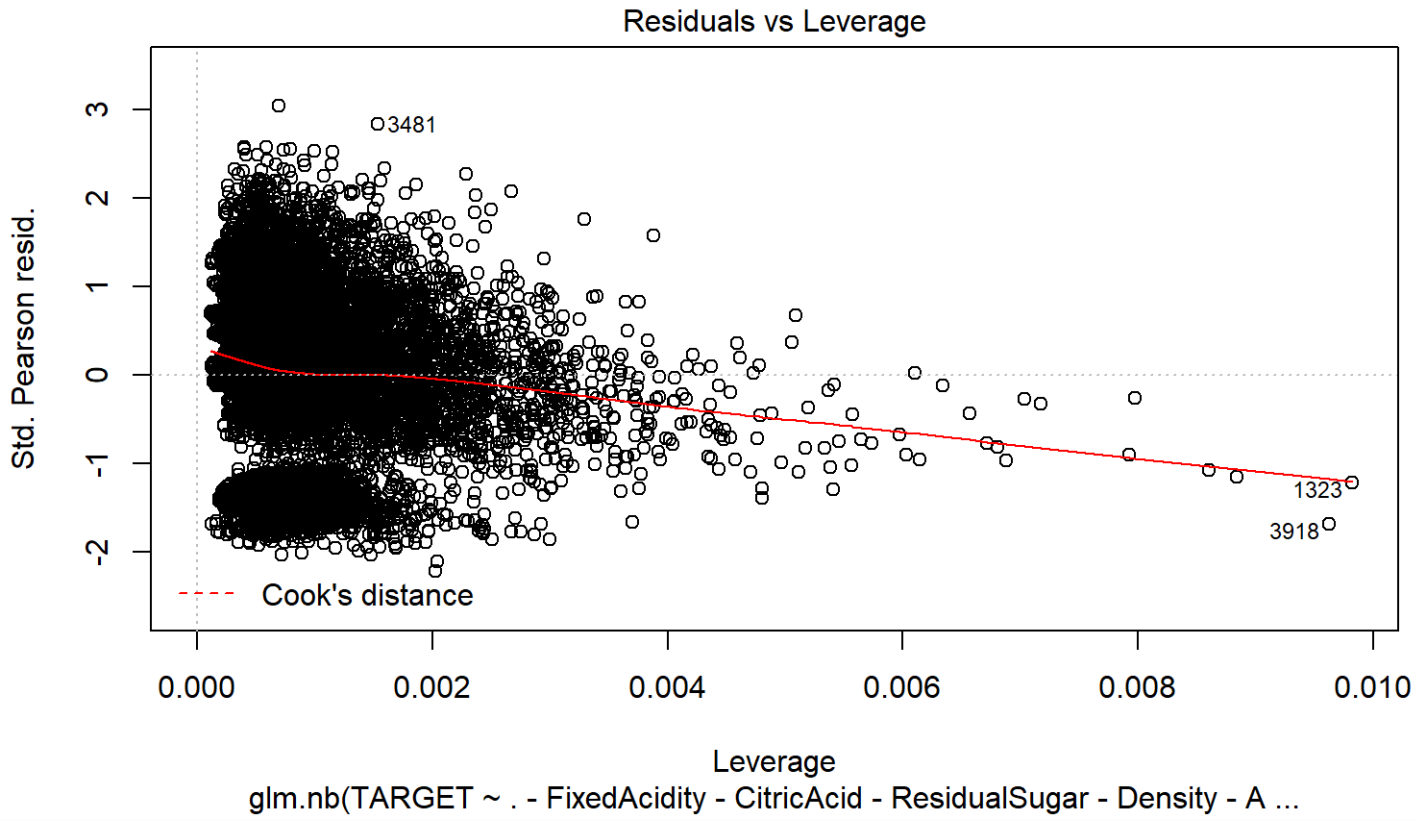
```
##
## Call:
## glm.nb(formula = TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar -
##       Density - Alcohol, data = wine_train2, init.theta = 48992.35936,
##     link = log)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -3.1469  -0.6828   0.1295   0.6379   2.4053
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)          2.038e+00  8.840e-02  23.052  < 2e-16 ***
## VolatileAcidity     -4.348e-02  7.284e-03  -5.969 2.39e-09 ***
## Chlorides           -6.726e-02  1.789e-02  -3.760 0.000170 ***
## FreeSulfurDioxide    1.316e-04  3.801e-05   3.461 0.000537 ***
## TotalSulfurDioxide   9.150e-05  2.458e-05   3.723 0.000197 ***
## pH                  -1.991e-02  8.415e-03  -2.366 0.018004 *
## Sulphates           -1.563e-02  6.153e-03  -2.540 0.011087 *
## LabelAppeal          1.409e-01  6.798e-03  20.726  < 2e-16 ***
## AcidIndex           -7.730e-01  3.936e-02 -19.636  < 2e-16 ***
## STARS                3.417e-01  6.255e-03  54.632  < 2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for Negative Binomial(48992.36) family taken to be 1)
##
##     Null deviance: 18290  on 10236  degrees of freedom
## Residual deviance: 12837  on 10227  degrees of freedom
## AIC: 38418
##
## Number of Fisher Scoring iterations: 1
##
##
##               Theta:  48992
##           Std. Err.:  63531
## Warning while fitting theta: iteration limit reached
##
##  2 x log-likelihood:  -38395.56
```




Normal Q-Q
Std. deviance resid.
3
2
1
0
-1
-2
-3
9965
13879
1729
-4
-2
0
2
4
Theoretical Quantiles
glm.nb(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Density - A ...


Scale-Location
√|Std. deviance resid.|
1.5
1.0
0.5
0.0
1729
9965
13879
0.0
0.5
1.0
1.5
2.0
Predicted values
glm.nb(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar - Density - A ...



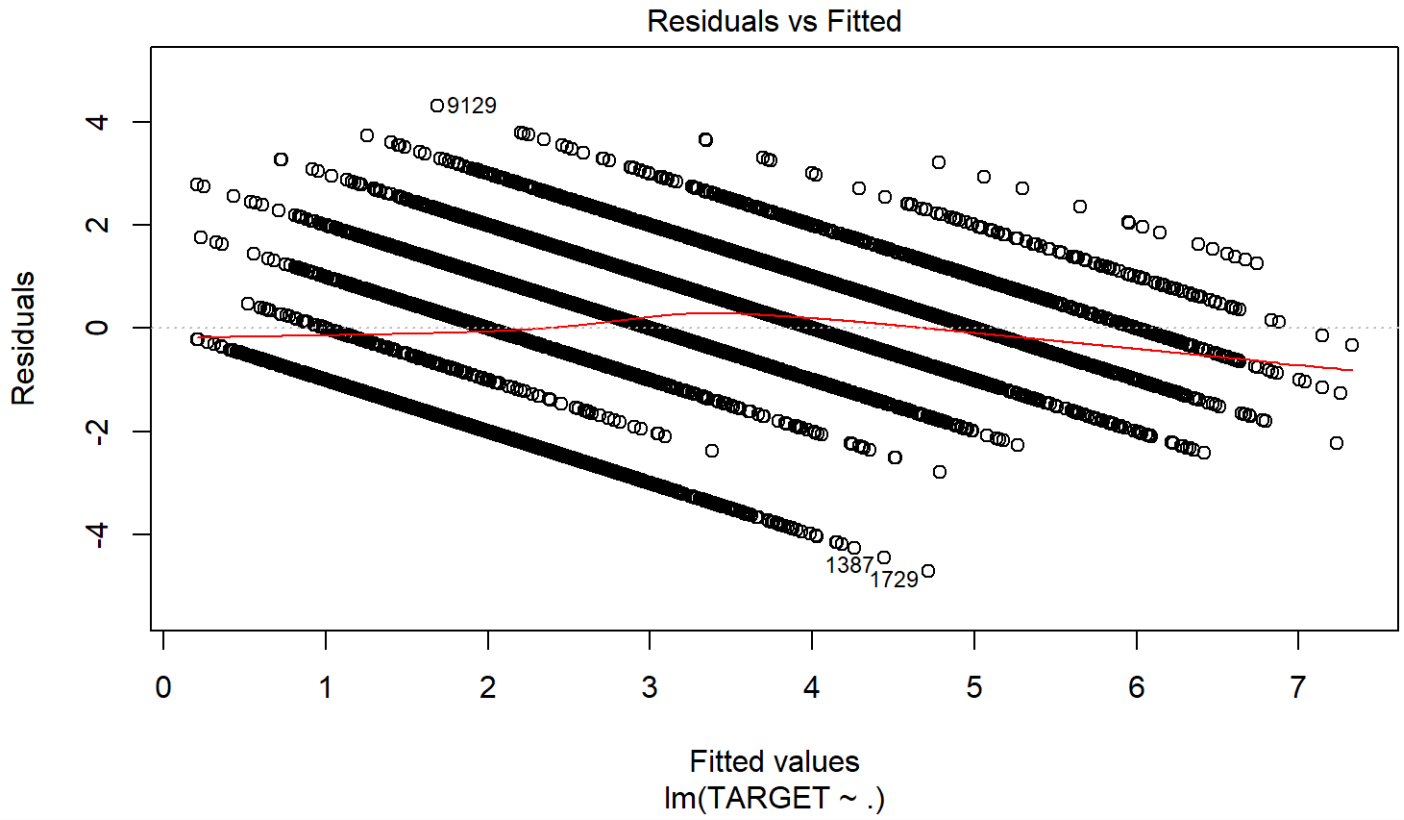
Model III: Linear Model

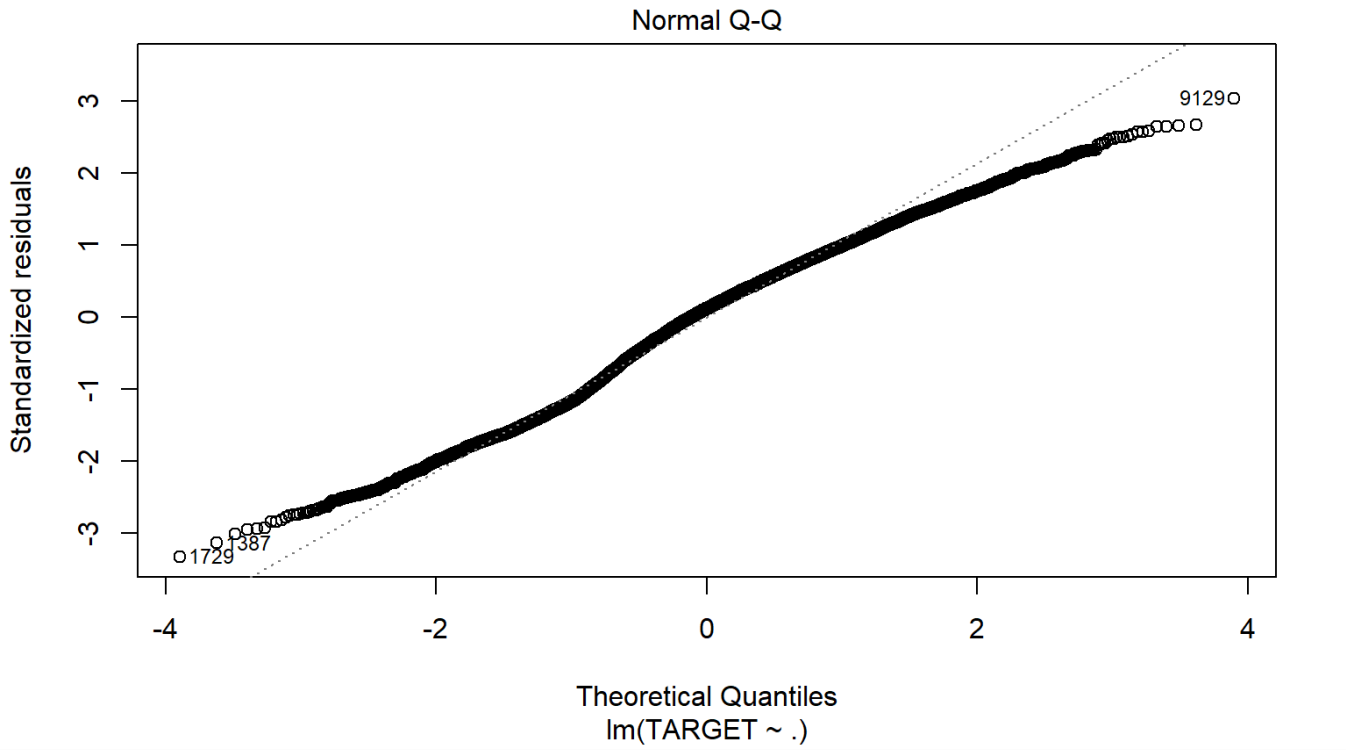
Model 9 : Linear Model with imputations

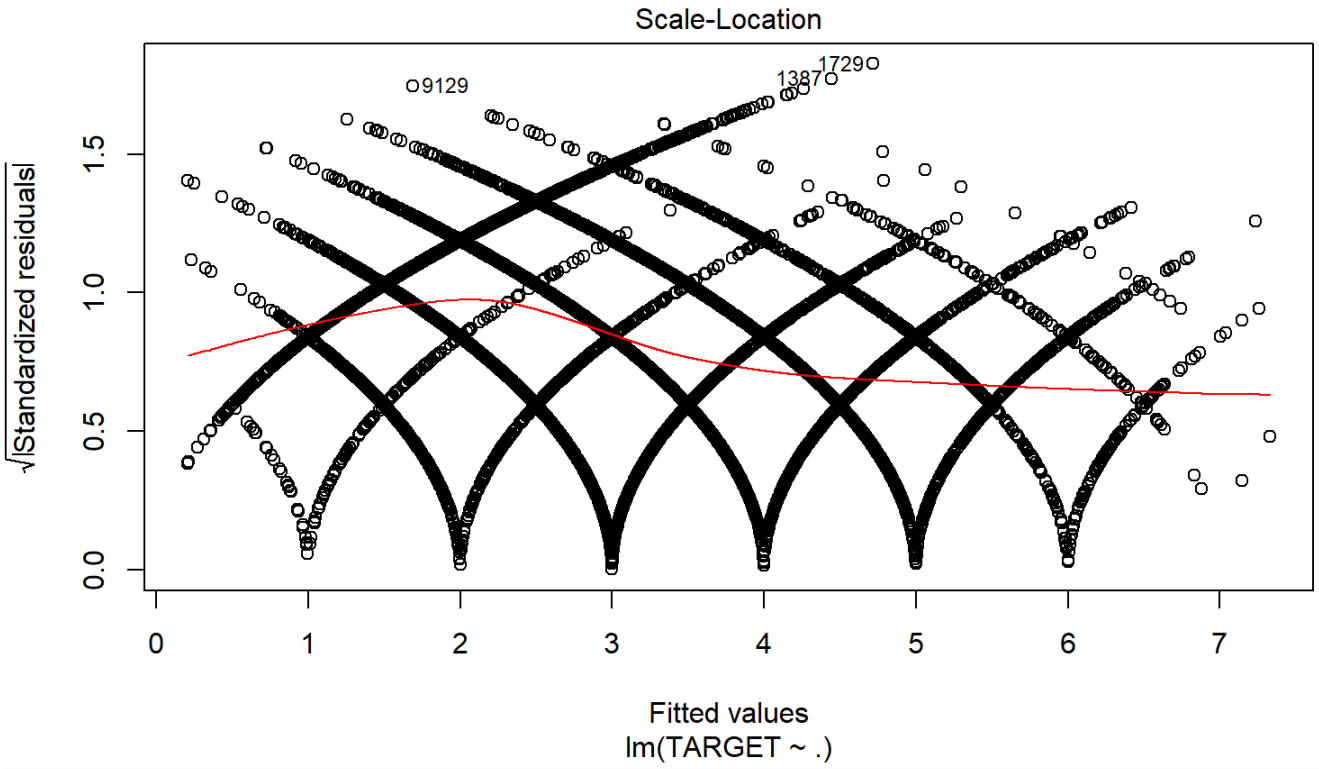
Using Linear Regression Model on imputed training data.

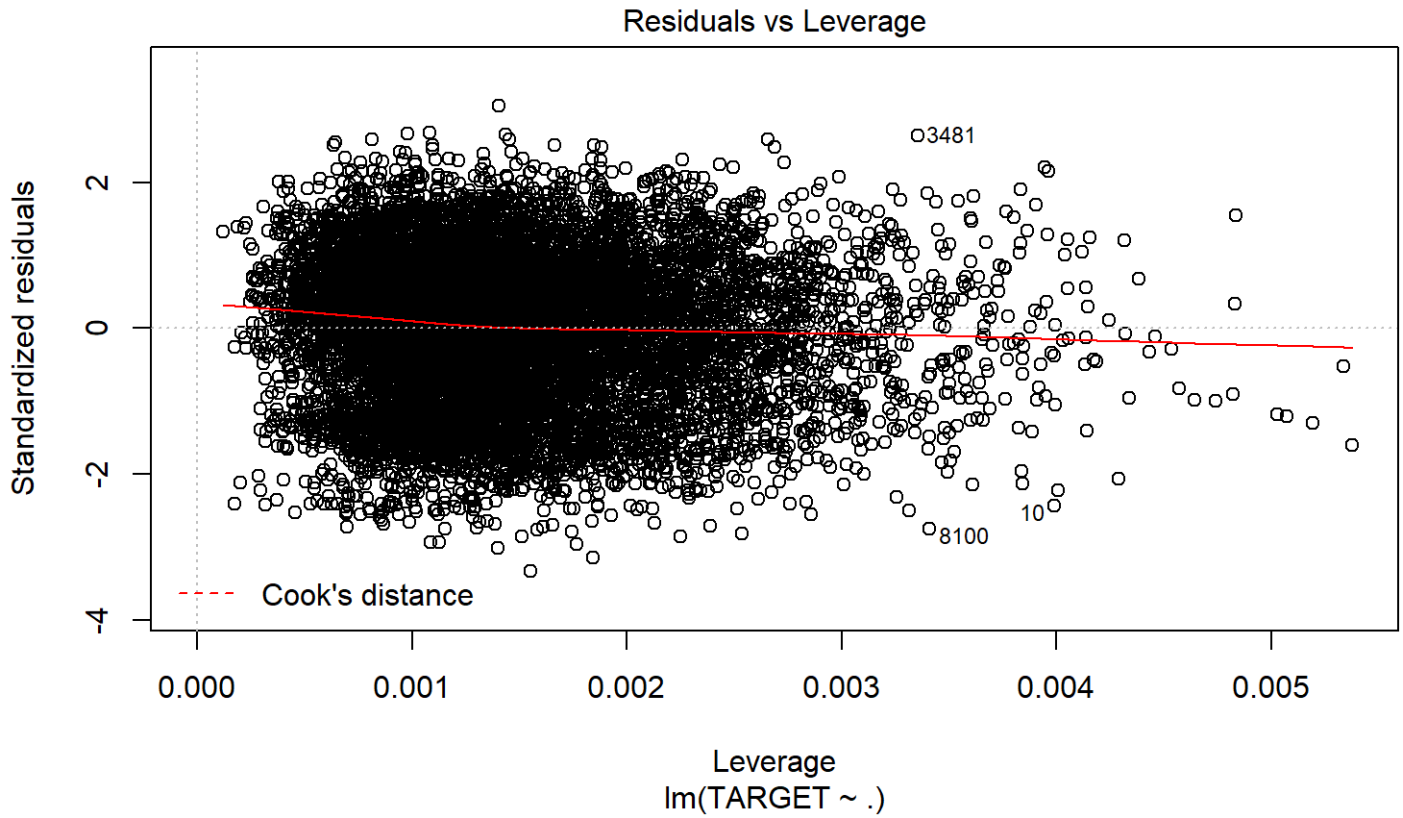
```
##
## Call:
## lm(formula = TARGET ~ ., data = wine_train2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.7147 -1.0144  0.1737  1.0276  4.3109
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)         5.968e+00  5.567e-01  10.719  < 2e-16 ***
## FixedAcidity        1.297e-03  2.253e-03   0.576 0.564897
## VolatileAcidity    -1.269e-01  1.791e-02  -7.085 1.48e-12 ***
## CitricAcid          2.625e-02  1.629e-02   1.611 0.107133
## ResidualSugar       4.231e-04  4.132e-04   1.024 0.305939
## Chlorides          -2.023e-01  4.391e-02  -4.606 4.15e-06 ***
## FreeSulfurDioxide   3.635e-04  9.387e-05   3.873 0.000108 ***
```

```
## TotalSulfurDioxide  2.432e-04  6.023e-05   4.038 5.42e-05 ***
## Density            -8.659e-01  5.260e-01  -1.646 0.099740 .
## pH                 -4.730e-02  2.072e-02  -2.283 0.022424 *
## Sulphates          -4.212e-02  1.512e-02  -2.786 0.005346 **
## Alcohol             1.251e-02  3.807e-03   3.285 0.001025 **
## LabelAppeal         4.311e-01  1.646e-02  26.191  < 2e-16 ***
## AcidIndex          -2.068e+00  9.237e-02 -22.392  < 2e-16 ***
## STARS               1.167e+00  1.671e-02  69.805  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.416 on 10222 degrees of freedom
## Multiple R-squared:  0.4605, Adjusted R-squared:  0.4598
## F-statistic: 623.3 on 14 and 10222 DF,  p-value: < 2.2e-16
```




Normal Q-Q
Standardized residuals
3
2
1
0
-1
-2
-3
9129
1387
1729
-4
-2
0
2
4
Theoretical Quantiles
lm(TARGET ~ .)


Scale-Location
9129
13870
17290
√|Standardized residuals|
0.0
0.5
1.0
1.5
0
1
2
3
4
5
6
7
Fitted values
lm(TARGET ~ .)

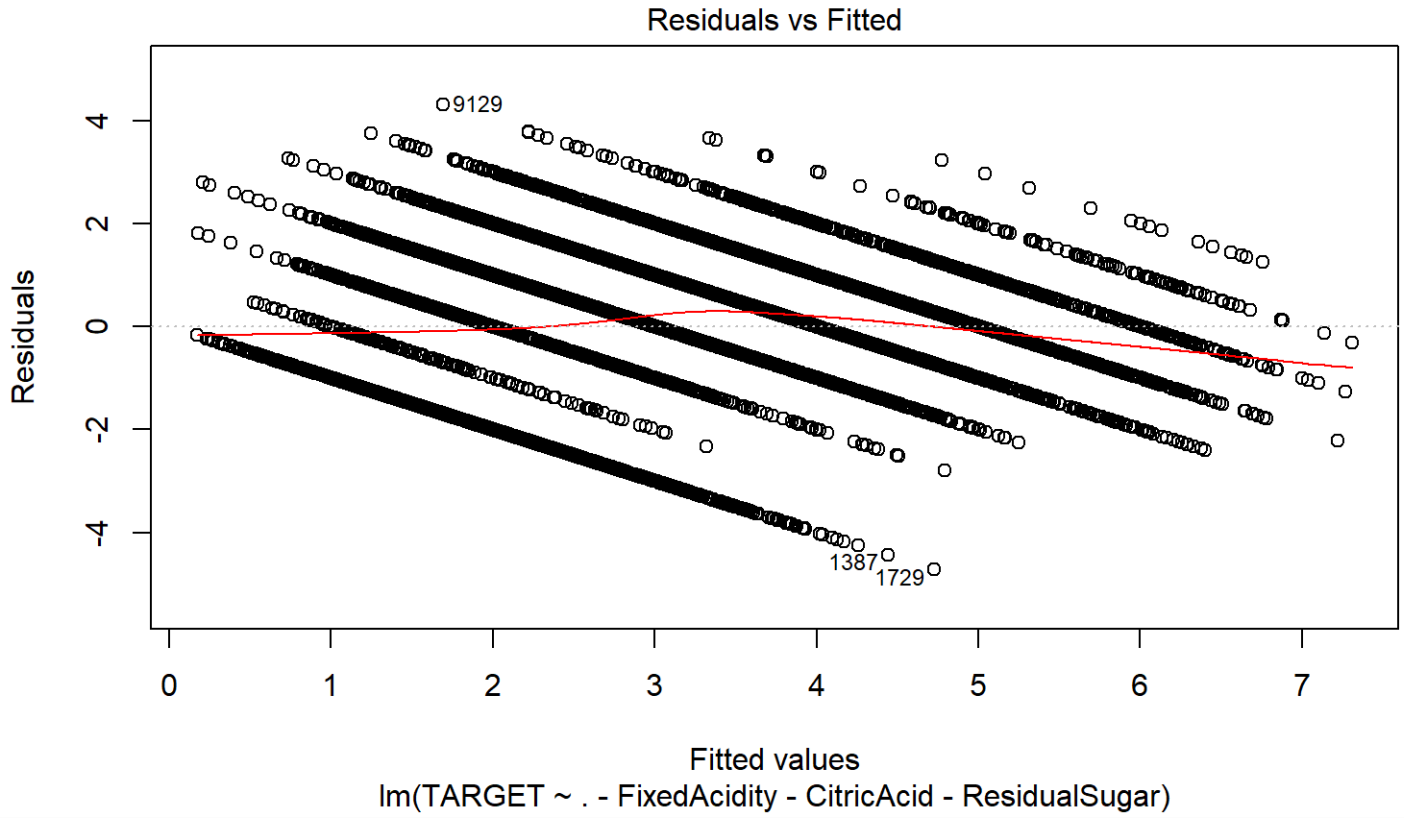


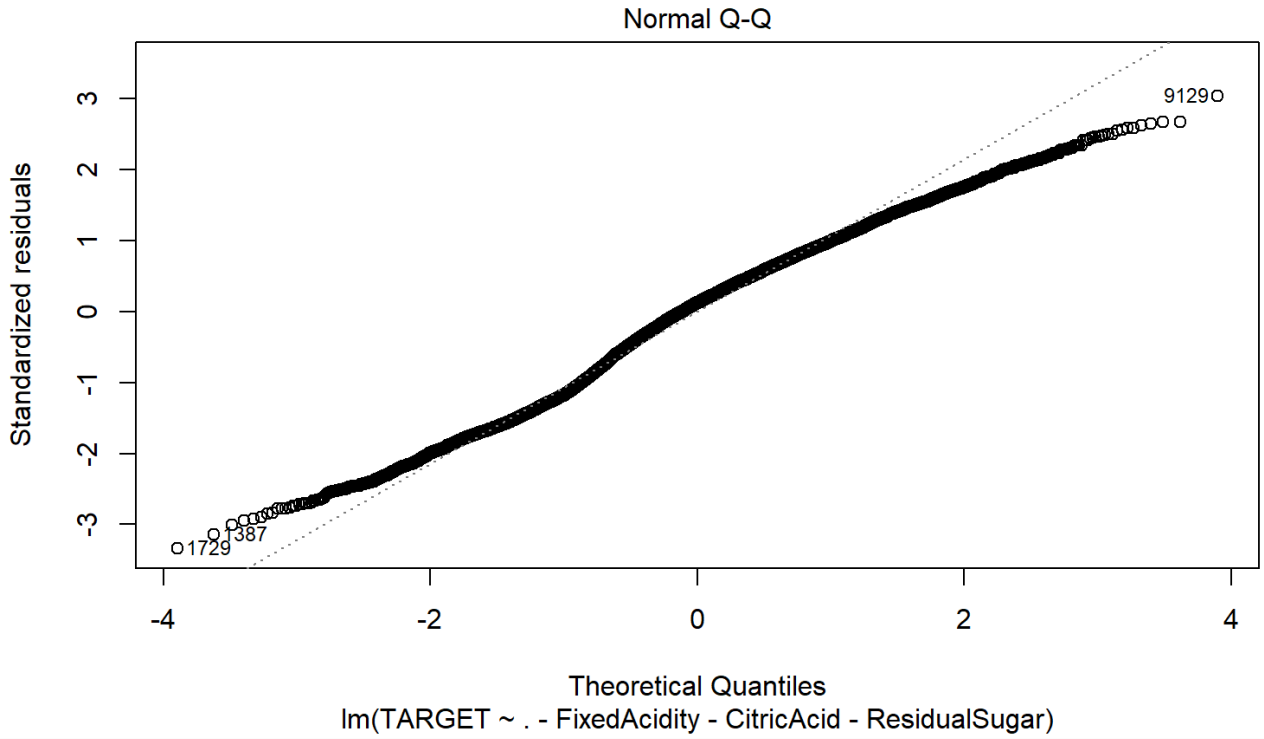
Model 10 : Linear Model with imputations and only significant variables.

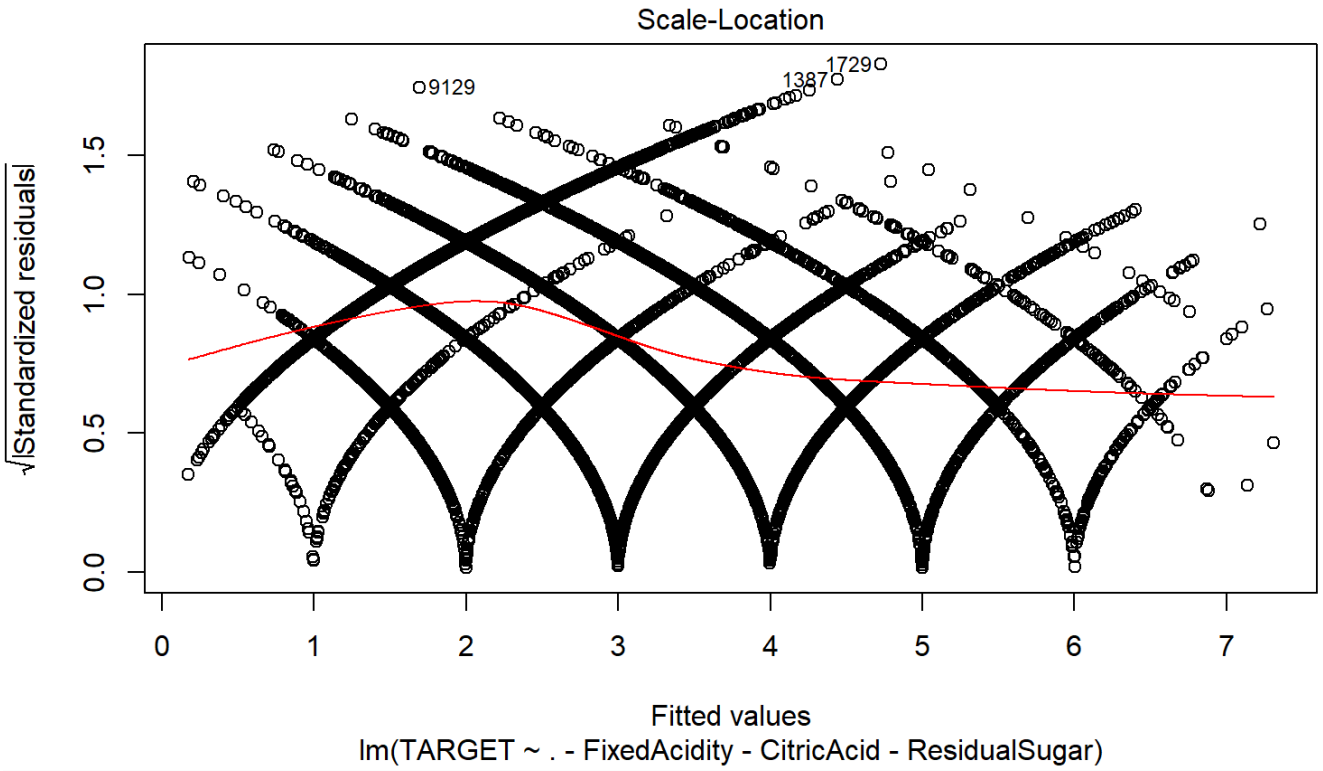
As we know the significant variables are `FixedAcidity`, `CitricAcid` and `ResidualSugar`, so using the same in the Linear Regression Model and applying the same of imputed training data.

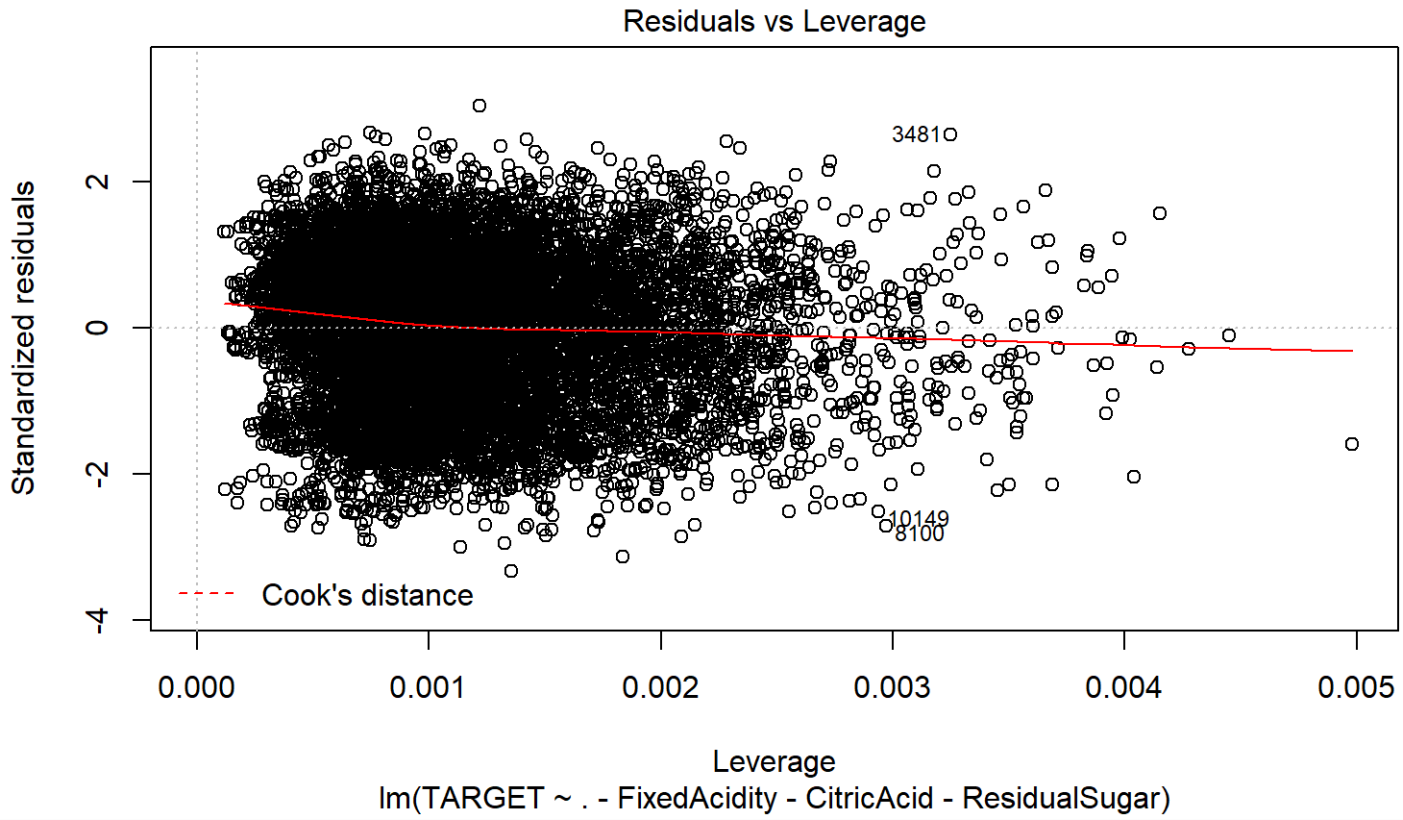
```
##
## Call:
## lm(formula = TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar,
##     data = wine_train2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.7242 -1.0131  0.1728  1.0331  4.3050
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)         5.951e+00  5.566e-01  10.691  < 2e-16 ***
## VolatileAcidity    -1.278e-01  1.791e-02  -7.138 1.01e-12 ***
## Chlorides          -2.032e-01  4.391e-02  -4.627 3.75e-06 ***
## FreeSulfurDioxide   3.660e-04  9.386e-05   3.899 9.71e-05 ***
## TotalSulfurDioxide  2.454e-04  6.021e-05   4.075 4.63e-05 ***
## Density            -8.712e-01  5.260e-01  -1.656  0.09768 .
```

```
## pH              -4.728e-02  2.071e-02  -2.282  0.02249 *
## Sulphates         -4.236e-02  1.511e-02  -2.803  0.00507 **
## Alcohol           1.249e-02  3.807e-03   3.281  0.00104 **
## LabelAppeal         4.310e-01  1.646e-02  26.186  < 2e-16 ***
## AcidIndex         -2.048e+00  9.074e-02 -22.572  < 2e-16 ***
## STARS             1.167e+00  1.671e-02  69.833  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.416 on 10225 degrees of freedom
## Multiple R-squared:  0.4603, Adjusted R-squared:  0.4598
## F-statistic: 792.9 on 11 and 10225 DF,  p-value: < 2.2e-16
```




Normal Q-Q
Standardized residuals
3
2
1
0
-1
-2
-3
9129
1387
1729
-4
-2
0
2
4
Theoretical Quantiles
lm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar)


Scale-Location
9129
1387
1729
√|Standardized residuals|
0.0
0.5
1.0
1.5
0
1
2
3
4
5
6
7
Fitted values
lm(TARGET ~ . - FixedAcidity - CitricAcid - ResidualSugar)



Model 11 : Ordinal Logistic Regression

This regression uses ordered factors. I would expect this to be one of the top performers.

```
## Call:
## polr(formula = TARGET ~ ., data = polrDF, Hess = TRUE)
##
## Coefficients:
##                       Value Std. Error  t value
## FixedAcidity        0.0021819  0.0029055   0.7510
## VolatileAcidity    -0.1555960  0.0232760  -6.6848
## CitricAcid          0.0289713  0.0211212   1.3717
## ResidualSugar       0.0003196  0.0005320   0.6008
## Chlorides          -0.2627487  0.0566657  -4.6368
## FreeSulfurDioxide   0.0004607  0.0001216   3.7875
## TotalSulfurDioxide  0.0002716  0.0000783   3.4686
## Density            -1.2981402  0.1490930  -8.7069
## pH                 -0.0314095  0.0268078  -1.1717
## Sulphates          -0.0339150  0.0196712  -1.7241
## Alcohol             0.0269097  0.0048969   5.4953
## LabelAppeal         0.8256163  0.0237699  34.7337
## AcidIndex          -2.6646249  0.1250905 -21.3016
## STARS               1.4684471  0.0256683  57.2086
```

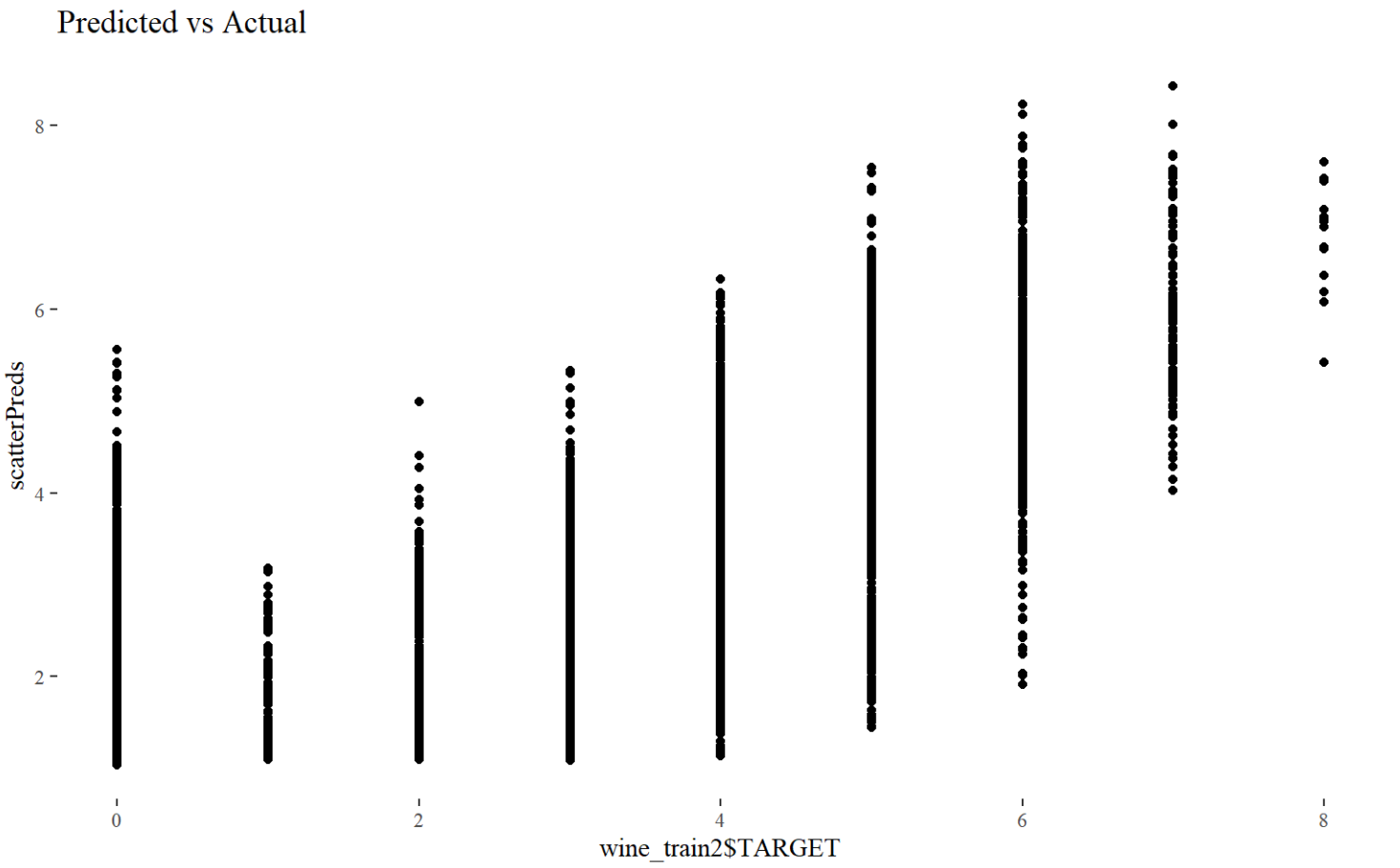
```
##
## Intercepts:
##     Value    Std. Error t value
## 0|1  -5.9211   0.1357   -43.6446
## 1|2  -5.7842   0.1355   -42.6743
## 2|3  -5.1811   0.1351   -38.3486
## 3|4  -3.8133   0.1350   -28.2556
## 4|5  -1.9656   0.1372   -14.3273
## 5|6   0.0034   0.1437     0.0237
## 6|7   2.2069   0.1675    13.1788
## 7|8   4.5480   0.3034    14.9895
##
## Residual Deviance: 30016.23
## AIC: 30060.23
```

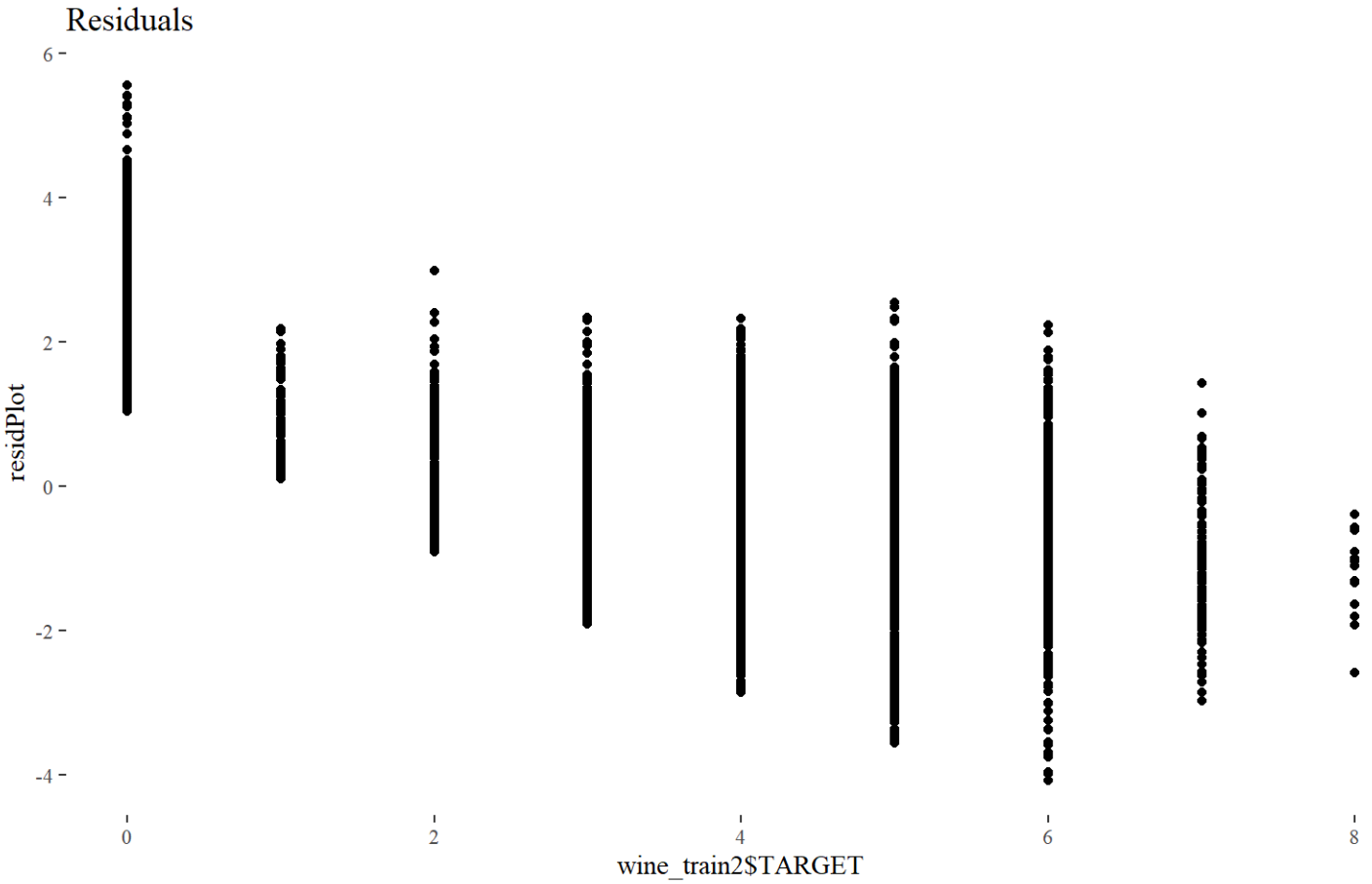
Model 12 : Zero inflation

Zero inflation understands that some Poisson distrobutions are dominated by many zeros. As such it corrects for this. This is one of the most promissing ones because as we saw in our data exploration, there were more zeros, and then normally distributed data after that.

```
##
## Call:
## zeroinfl(formula = TARGET ~ . | STARS, data = wine_train2, dist = "negbin")
##
## Pearson residuals:
##     Min      1Q  Median      3Q     Max
## -2.09180 -0.49650  0.07134  0.48208  2.08565
##
## Count model coefficients (negbin with log link):
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)         1.824e+00  2.385e-01   7.648 2.04e-14 ***
## FixedAcidity        4.523e-04  9.473e-04   0.477 0.633017
## VolatileAcidity    -1.936e-02  7.560e-03  -2.561 0.010429 *
## CitricAcid          2.116e-03  6.718e-03   0.315 0.752830
## ResidualSugar      -6.323e-05  1.722e-04  -0.367 0.713427
## Chlorides          -3.245e-02  1.851e-02  -1.754 0.079503 .
## FreeSulfurDioxide   4.932e-05  3.854e-05   1.280 0.200613
## TotalSulfurDioxide  4.760e-06  2.460e-05   0.194 0.846535
## Density            -2.990e-01  2.224e-01  -1.344 0.178840
## pH                 -1.910e-03  8.749e-03  -0.218 0.827223
## Sulphates          -4.586e-03  6.391e-03  -0.718 0.473029
## Alcohol             5.950e-03  1.591e-03   3.741 0.000184 ***
## LabelAppeal         2.240e-01  7.112e-03  31.491  < 2e-16 ***
## AcidIndex          -2.682e-01  4.492e-02  -5.971 2.36e-09 ***
## STARS               1.227e-01  6.997e-03  17.531  < 2e-16 ***
## Log(theta)          1.860e+01  2.758e+00   6.742 1.56e-11 ***
##
## Zero-inflation model coefficients (binomial with logit link):
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  2.31678    0.11092   20.89   <2e-16 ***
## STARS       -2.66899    0.09689  -27.55   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Theta = 119421399.3444
## Number of iterations in BFGS optimization: 22
## Log-likelihood: -1.725e+04 on 18 Df
```





MODEL SELECTION

Compare Models by MSE/AIC

	MSE	AIC	
Model1	6.929787		6.926722
Model2	6.849005		6.849920
Model3	6.929788		6.926723
Model4	6.849001		6.849916
Model5	2.002207		2.002977
Model6	NA		1.988813
Model7	18544.983192		18535.285631
Model8	38416.867732		38415.386508
Model9	18547.067808		18537.370350
Model10	38419.044066		38417.562708

	MSE	AIC	
Model11	6.929787		6.926722
Model12	6.849005		6.849920

Compare Models by Loss

Now lets see the output of the Models using test data

We will use the squared loss to validate the model. We will use the squared difference to select a model (MSE) from predictions on the training sets. (Lower numbers are better.)

	Loss: <dbl>
Model1	5.471932
Model2	5.456474
Model3	6.827070
Model4	6.828240
Model5	5.471926
Model6	5.456468
Model7	6.827066
Model8	6.828236
Model9	2.034647
Model10	2.034185

Next

Following deductions can be made as per above values:

- A regular Poisson regression does not perform very well.
- The same can be said for the Negative Binomial.
- The linear model actually performs very well.
- Very surprisinly, Ordinal Logistic Regression does not work as well as the linear model.

Because we are not interested in gaining insight into the underlying causes of wine selection, we will use the squared loss. This will tell us how accurate our model is without caring about confidence intervals etc.

Based on this metric, Zero Poission Inflation is the most accurate.

From the above models, Model12 - Zero Poission Inflations has least loss as it uses less variables and is parsimonious. Also the R2 looks fine. The squared loss is also fine.

- In terms of MSE and AIC, `Model 5` is best followed by `Model 4` and tied `Model 2` and `Model 12`.
- In terms of Loss, `Model 12` is best followed closely by `Model 9` and `Model 10`.

Overall, we choose `Zero Poission Inflation` due to following : - least loss - good MSE score - good AIC score

6.3 Prediction on Evaluation Data

We will use the same method to impute and use log transformation for AcidIndex.

	TARGET	FixedAcidity	VolatileAcidity	CitricAcid	ResidualSugar	Chlorides	FreeSulfurDioxide	TotalSulfurDioxide	Density	pH	Sulphates	Alcohol	LabelAppeal	AcidIndex	STARS
1	3.014741135 81073	5.4	-0.86	0.27	-10.7	0.092	23	398	0.98527	5.02	0.64	12.3	-1	1.791759469 22805	2
2	3.621868615 54457	12.4	0.385	-0.76	-19.7	1.169	-37	68	0.99048	3.37	1.09	16	0	1.791759469 22805	2
3	1.738319397 12905	7.2	1.75	0.17	-33	0.065	9	76	1.04641	4.61	0.68	8.55	0	2.079441541 67984	1
4	1.506971679 78128	6.2	0.1	1.8	1	-0.179	104	89	0.98877	3.2	2.11	12.3	-1	2.079441541 67984	1
5	1.676868088 14121	11.4	0.21	0.28	1.2	0.038	70	53	1.02899	2.54	-0.07	4.8	0	2.302585092 99405	1

	TARGET	FixedAcidity	VolatileAcidity	CitricAcid	ResidualSugar	Chlorides	FreeSulfurDioxide	TotalSulfurDioxide	Density	pH	Sulphates	Alcohol	LabelAppeal	AcidIndex	STARS
6	5.663759271 26166	17.6	0.04	-1.15	1.4	0.535	-250	140	0.95028	3.06	-0.02	11.4	1	2.079441541 67984	4
7	3.384291591 28796	15.5	0.53	-0.53	4.6	1.263	10	17	1.0002	3.07	0.75	8.5	0	2.484906649 788	3
8	5.174466104 97721	15.9	1.19	1.14	31.9	-0.299	115	381	1.03416	2.99	0.31	11.4	1	1.945910149 05531	3
9	1.540804001 34772	11.6	0.32	0.55	-50.9	0.076	35	83	1.0002	3.32	2.18	-0.5	0	2.484906649 788	1
10	4.281610457 53364	3.8	0.22	0.31	-7.7	0.039	40	129	0.9061	4.72	-0.64	10.9	0	1.945910149 05531	3

Showing 1 to 10 of 3,335 entries

- **TARGET:** Number of Cases Purchased as Predicted

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    StdD    Skew    Kurt
##    1.03    1.91    3.30    3.24    4.17    8.27    1.38    0.51   -0.32
```

Make Predictions

Predictions can be found in the following:

https://github.com/Rajwantmishra/DATA621_CR4/blob/master/HW5/Evaluation_Full_Data.csv

Appendix

https://github.com/Rajwantmishra/DATA621_CR4/blob/master/HW5/HomeWork5.Rmd

Thank you