Concrete Compressive Strength Analysis

STAT 4355.001 Applied Linear Models

Geodudes (Team 3)

Gabrielle Allin, Ramesh Kanakala, Josh Yoo

Table of Contents

1. Introduction

By observing which variables have the greatest impact in predicting concrete strength, contractors, concrete suppliers, and even scientists among a multitude of other people can efficiently make longer lasting concrete. Concrete is a fundamental aspect of any city used in basic foundations, buildings, roads, pavements, and more. Being used since the Romans, concrete is something that is ever improving. With the help of strength prediction models, models can contribute to many stakeholders involved in concrete production by accelerating production and use it to create high performance material before spending too much capital.

1.1 Data Description

This dataset was taken from kaggle but originally from UCI Machine Learning Repository: https://www.kaggle.com/maajdl/yeh-concret-data. It has 1030 instances available with 9 quantitative data types in the data set. It provides 8 predictor variables that determine the strength of concrete include:

- Cement (measured in kg/m^3): a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.
- Slag (measured in kg/m^3): the glass-like by-product left over after a desired metal has been separated from its raw ore and is considered as a binder along with fly ash.
- Fly Ash (measured in kg/m^3): a byproduct from burning pulverized coal in electric power generating plants and is considered as a binder along with slag.
- Water (measured in kg/m^3): is utilized to mix with cement for preparation.
- Superplasticizer (measured in kg/m^3): ensures better flow properties since this minimizes particle segregation allowing to decrease water-cement ratio which contributes to the increase of compressive strength.
- Coarse Aggregate (measured in kg/m^3): are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter.
- Fine Aggregate (measured in kg/m^3): generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve.
- Age (measured in days): the age of the cement; concrete hardens with time in which increases strength.

With the Concrete Compressive Strength being the Response Variable:

- csMPa (measured in MPa): Concrete Compressive Strength

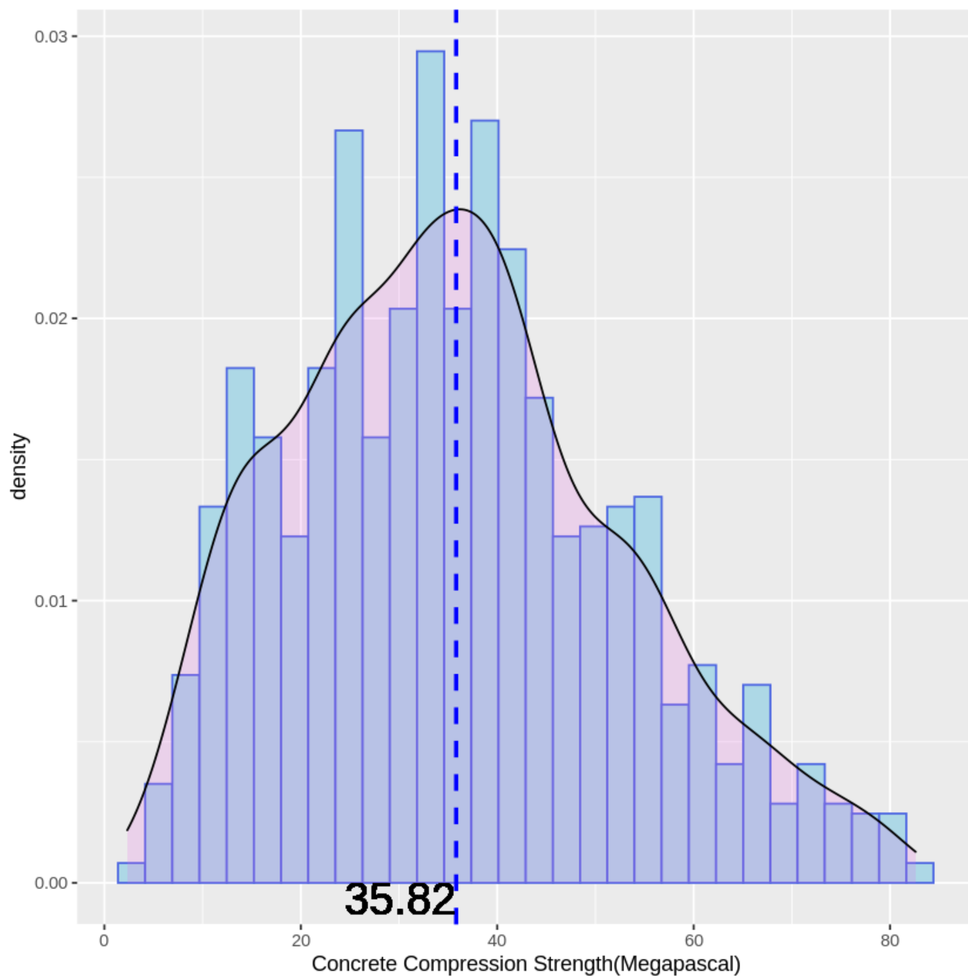
1.2 Analysis Goal

The goal of this analysis is to analyze which parameters influence concrete strength prediction more than others and what transformations are needed to model the data.

1.3 Data Exploration

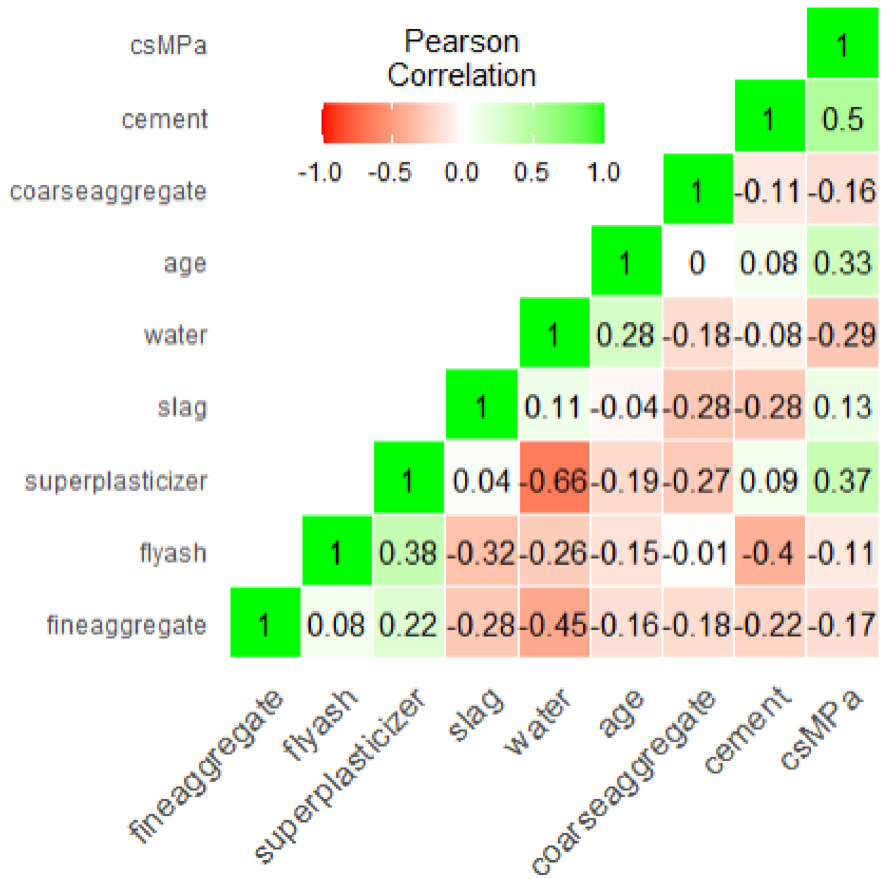
1.3.1 Histogram

With the histogram, there is a mean-response value of 35.82. Likewise, there is a right skew in the histogram but nonetheless the data appears to still be well-distributed.



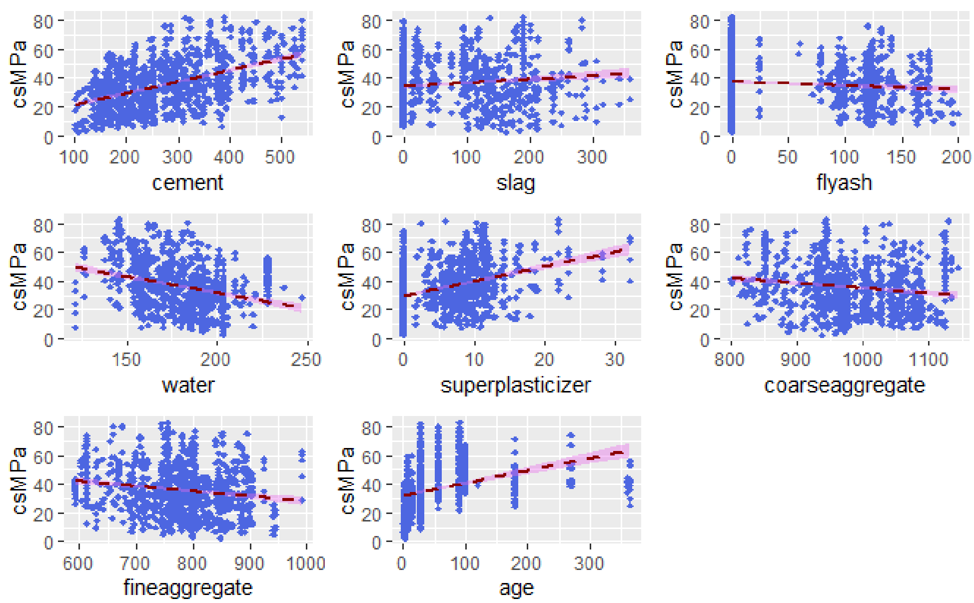
1.3.2 Pearson Correlation Heat Map

With the Pearson Correlation Heat Map, we can observe that there is a positive correlation between Compressive Strength (csMPA) and Cement which is valid because the increasing amount of cement in preparing concrete leads to stronger concrete. Other positive correlations in accordance with the Compressive Strength (csMPA) include: Super Plasticizer, Fly Ash and Age. These correlations aid with understanding how the predictor variables affect the response variable. However, there is a negative correlation presented with water.



1.3.3 Scatterplot

With the scatterplot, we can observe the different linear relations with the 8 predictor variables and the response variable. There are positive linear relations for Cement, Slag Superplasticizer and Age. However, there are negative linear relations for Water, Fly Ash, Fine Aggregate and Coarse Aggregate.



2. Data Analysis

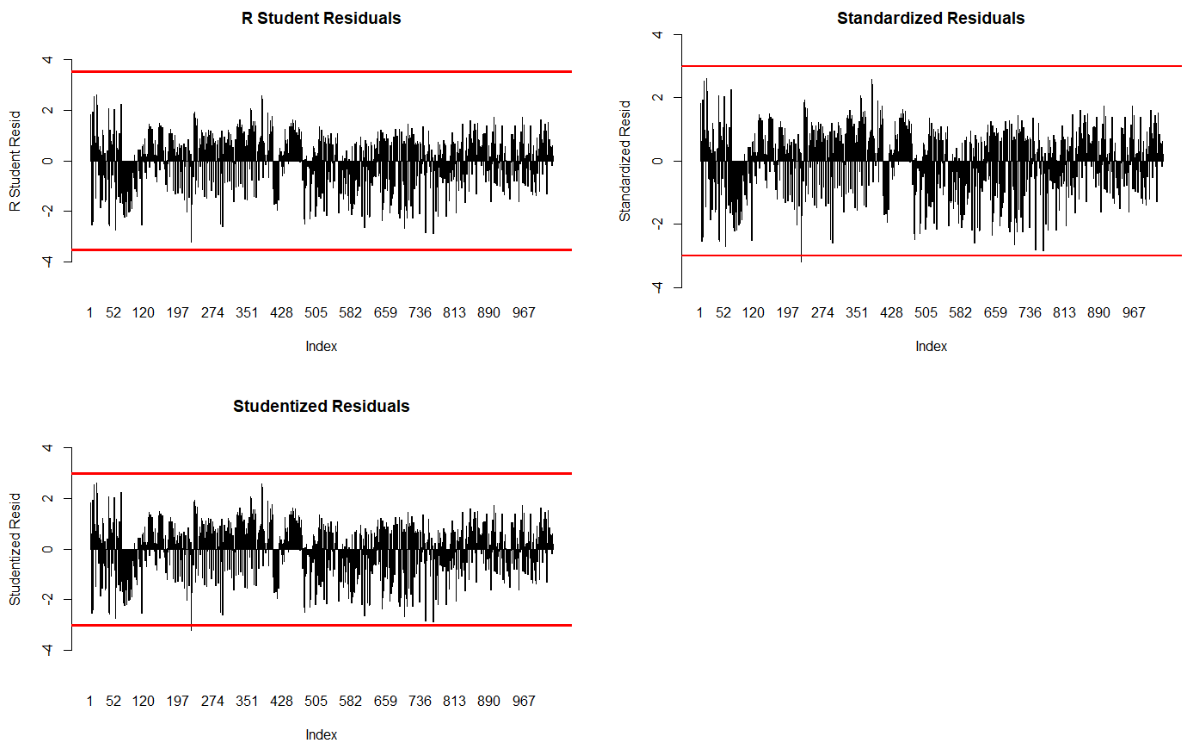
2.1 Full Model Building

Now that the basic understanding of the dataset is known, the next task to tackle was building the full fit linear model. This would allow us to have a greater insight of our variables and see which ones contribute to the response variable using a statistical test.

```
Call:
lm(formula = csMPa ~ ., data = conc)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.8749 -0.6117  0.1697  0.6539  2.3891 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)       0.9744083  2.3441309   0.416 0.677732    
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 ** 
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .  
fineaggregate     0.0014005  0.0009436   1.484 0.138054    
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,    Adjusted R-squared:  0.5994 
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

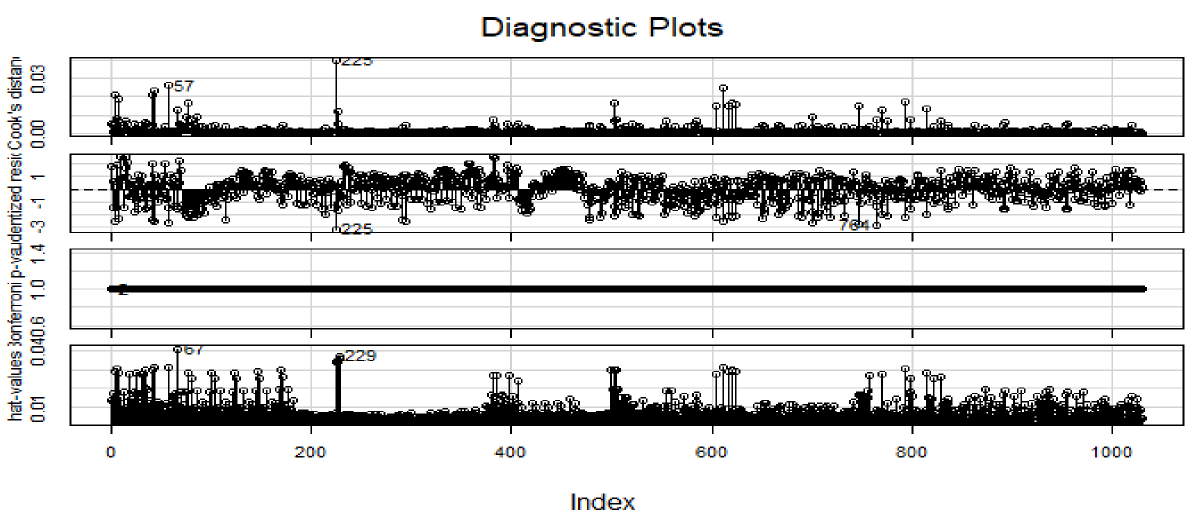
From the table above, it is clear that when considering a significance level of 0.001, superplasticizer, coarseaggregate, and fineaggregate are not seen as significant. This will be important later when the reduced model is explored, but for now, we focus only on the full fit linear model.

Using the model, we take a look at R student, Standardized, and Studentized Residual graphs. Here, we can see that all of the points fall within the boundaries(+-3) except for 225. This point gets close, or sometimes beyond the line on multiple occasions. It is important to note this, as it is clearly an outlier and will likely show up again in future analytical graphs.



2.1.2.1 R student, Standardized, and Studentized Residual graphs

When looking at the Diagnostic Plots, and in cook's Distance in particular, 225 stands out among the rest as the greatest point. This clearly reflects the insight that was given from the previous graphs, and this further provides merit to the idea that 225 is an outlier.



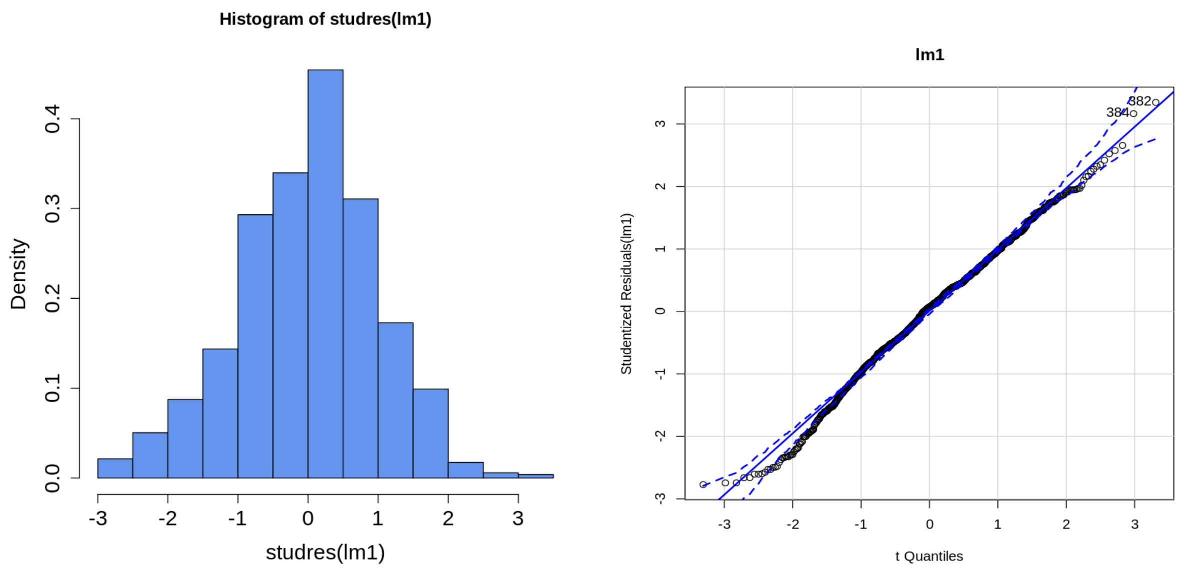
When looking at the variance inflation factors, we can see that the values are lower than 10 for each of the variables. This tells us that none of the x variables are statistically correlated with each other. In other words, our data is good and needs no further changes regarding this test.

```
      cement              slag            flyash
    7.488944          7.276963          6.170634
       water  superplasticizer  coarseaggregate
    7.003957          2.963776          5.074617
fineaggregate               age
    7.005081          1.118367
```

2.1.2.2 Diagnostic Plots

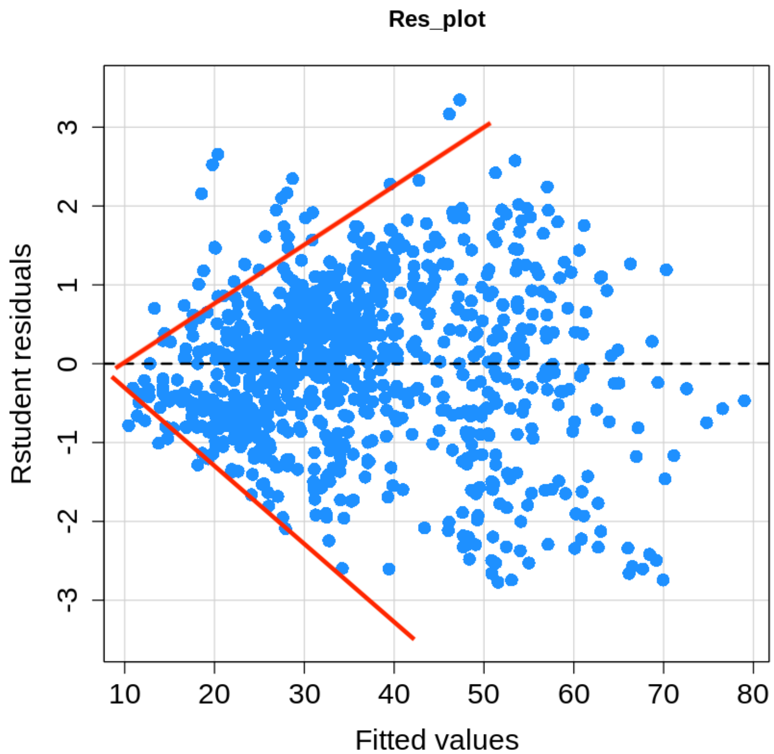
Now we take a look at the residual histogram, qqplot, and residual plot.

From this graph, it is clear that the residuals are nicely spread in a normal distribution, and the qq plot reflects the same idea. There are slight deviations from the linear line along the start and beginning, but overall, it shows a nicely even distribution.



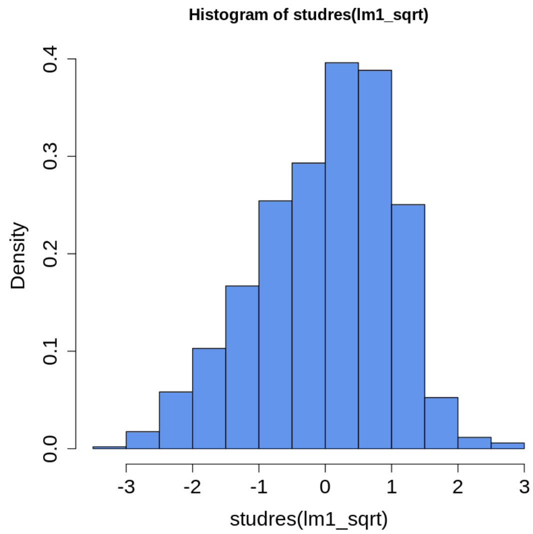
2.1.2.3 Residual Histogram & QQPlot

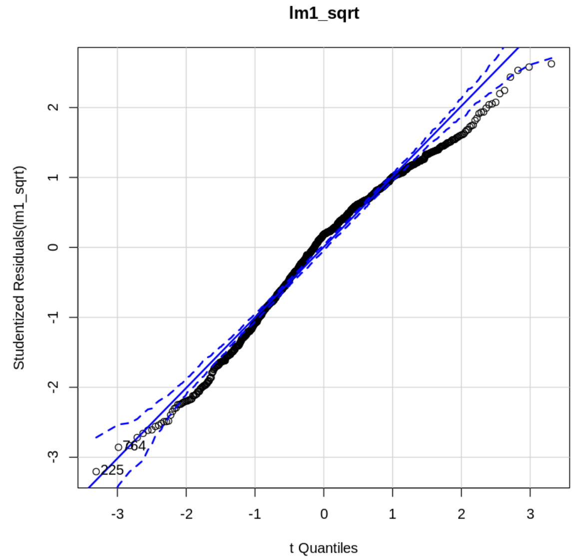
We now come to the residual plot, and it shows something very interesting. There is a gathering of points on the 0 line on the left side, and it starts to gradually spread as the fitted values increase, creating a cone pattern on the plot. We drew a couple lines to make it easier to see. Because this cone shape is so apparent, we can assess that a square root transformation is necessary. So we did the transformation and created the graphs again to see the differences.



2.1.2.3 Residual Plot

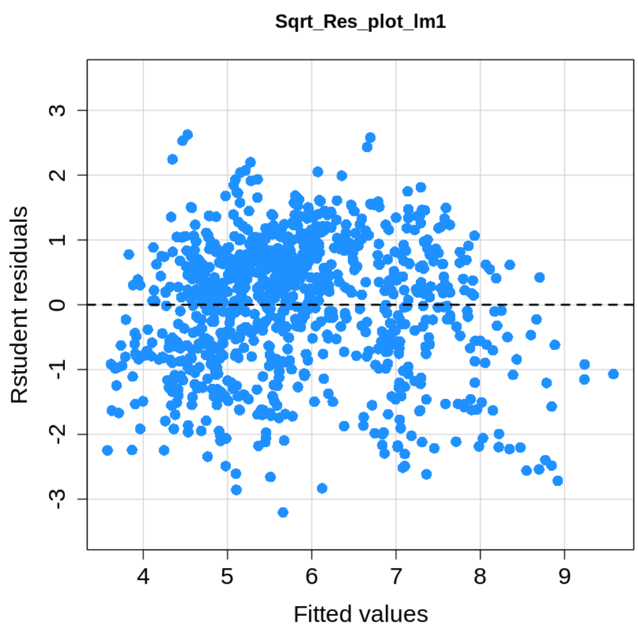
The new residual histogram is showing a strong left skew now, and the qqplot reflects it also as apparent by the bowing in the middle and the two legs of the graph sticking out the opposite direction from it. We can also note that the point 225 sticks out further than any point in this new qqplot, so it confirms the previous graphs that this point is an outlier.





2.1.2.5 Transformed Residual Histogram & QQPlot

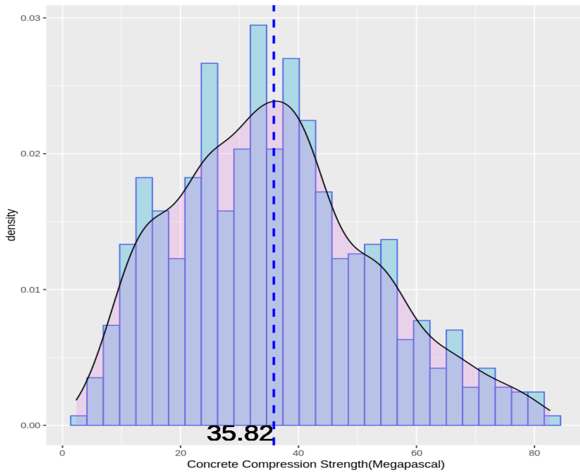
The new residual plot below shows great results from the transformation as there is no longer a cone shape in the plot. There is, however, still a slight clutter of points between 4 and 6, but the points are much better distributed than before. Because of this, we can confidently say that the square root transformation has provided us a much more stable and reliable model.



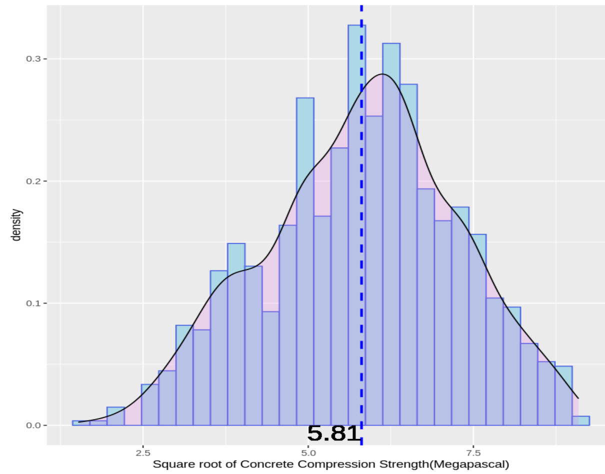
2.1.2.6 Transformed Residual Plot

2.1.3 Density Graph Comparison

Original



Transformed



Here, we take a look at the density graph of the original dataset compared to the square root transformed dataset. Just from observation, the difference is noticeable. The graph changed from a strong right skew to a slightly less pronounced left skew. This alone projects that the new data has a better distribution, but we will hold our conclusion for now.

The original data set has a mean of 35.82, while the transformed has a mean of 5.81. We compare these means to their respected medians to see if the transformed density graph has a better distribution using numbers. We do this comparison by subtracting the quotient of the mean and median from 1 then multiplying by 100. Doing this calculation, we get 3.986% for the original, and 1.056% for the transformed. Clearly, the mean is more than three times closer to the median in the transformed density graph than the original, meaning the data is much better distributed in the former than the latter. This further proves the usefulness of the transformation.

2.2 Reduced Model Building

Selecting variables for the reduced model was somewhat difficult as most of the time, specific variables are removed as they are not very significant and the model is generally expected to improve; in our case, all of the variables were quite useful in that they were all reasonably correlated and had something to offer in predicting concrete compressive strength. Below, you can observe that forward, backward, and stepwise selection actually ended up recommending the original full model:

```
[1] "Stepwise:"

Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer +
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8749 -0.6117  0.1697  0.6539  2.3891

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.9744083  2.3441309   0.416 0.677732
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 **
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .
fineaggregate     0.0014005  0.0009436   1.484 0.138054
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,	Adjusted R-squared:  0.5994
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

```
[1] "Forward:"

Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer +
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8749 -0.6117  0.1697  0.6539  2.3891

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.9744083  2.3441309   0.416 0.677732
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 **
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .
fineaggregate     0.0014005  0.0009436   1.484 0.138054
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,    Adjusted R-squared:  0.5994
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

```
[1] "Backward:"

Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer +
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8749 -0.6117  0.1697  0.6539  2.3891

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.9744083  2.3441309   0.416 0.677732
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 **
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .
fineaggregate     0.0014005  0.0009436   1.484 0.138054
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,    Adjusted R-squared:  0.5994
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

The ANOVA table confirms that these models are identical:

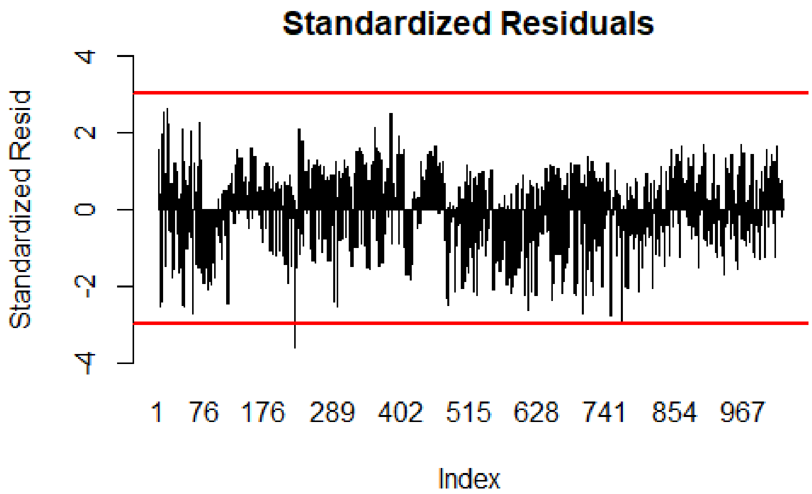
```
Analysis of Variance Table

Model 1: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate +
    fineaggregate + age
Model 2: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate +
    fineaggregate + age
Model 3: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate +
    fineaggregate + age
Model 4: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate +
    fineaggregate + age
  Res.Df    RSS Df Sum of Sq F Pr(>F)
1   1021 858.41
2   1021 858.41  0         0
3   1021 858.41  0         0
4   1021 858.41  0         0
```

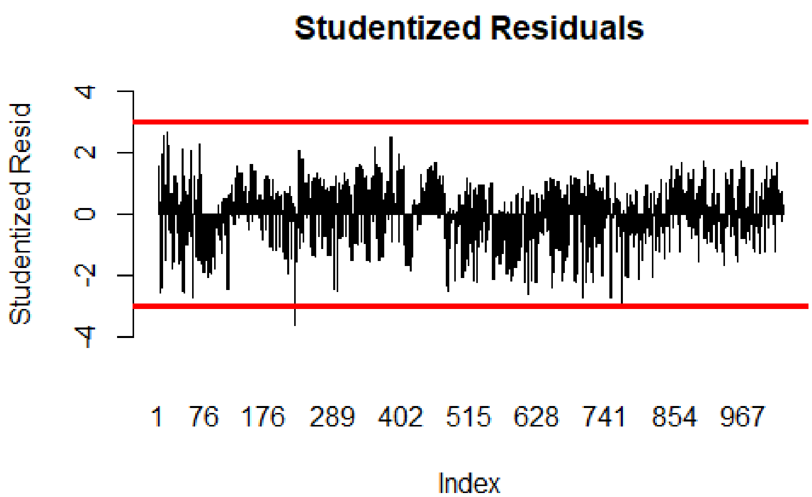
So, in the end, we decided to vary our variables by selecting only those that were significant at the 0.001 level: cement, slag, fly ash, water, and age:

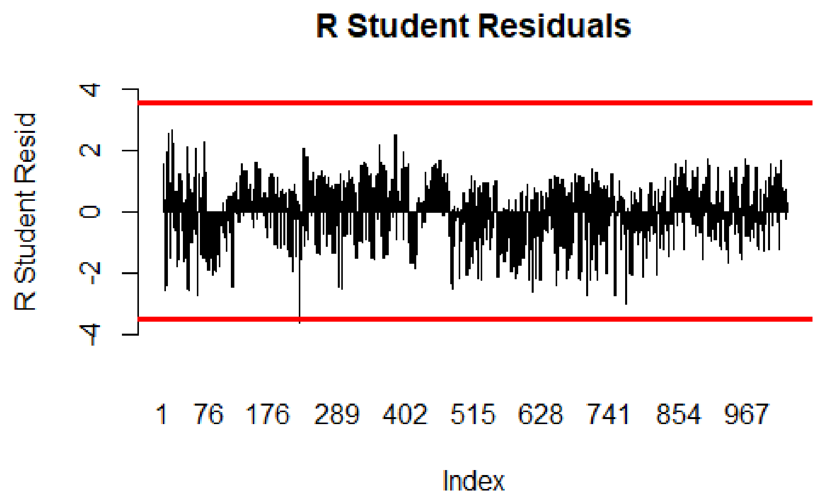
```
Call:
lm(formula = csMPa ~ cement + slag + flyash + water + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.3017 -0.6361  0.1689  0.6652  2.4050 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  5.3368896  0.3253538   16.40   <2e-16 ***
cement       0.0095799  0.0003467   27.63   <2e-16 ***
slag         0.0079010  0.0003998   19.77   <2e-16 ***
flyash       0.0076090  0.0005928   12.84   <2e-16 ***
water       -0.0202804  0.0014741  -13.76   <2e-16 ***
age          0.0101318  0.0004779   21.20   <2e-16 ***
---
Signif. codes:  
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9204 on 1024 degrees of freedom
Multiple R-squared:  0.5982,	Adjusted R-squared:  0.5963 
F-statistic:   305 on 5 and 1024 DF,  p-value: < 2.2e-16

[1] "Variance:  0.847209052557485"
```

We see that the adjusted R^2 value decreased just a little from 0.5994 to 0.5963. This very minimal difference indicates that the variables superplasticizer, coarse aggregate, and fine aggregate did not offer much to the full model and the R^2 was only barely higher than because of the greater number of variables. We also see the variance increase slightly from 0.841 to 0.847 as well as the RSE from 0.9169 to 0.9204.

Moving on to the residual analysis of the reduced model, we can see a few changes:





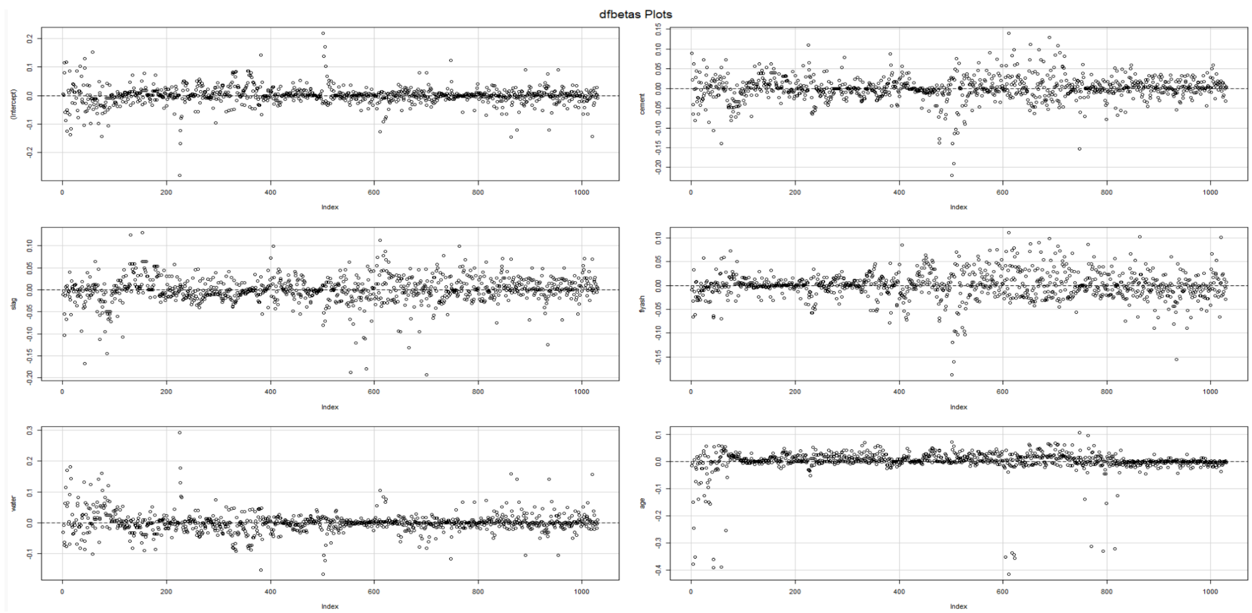


2.2.2.1 RStudent, Standardized and Studentized Residual Graphs

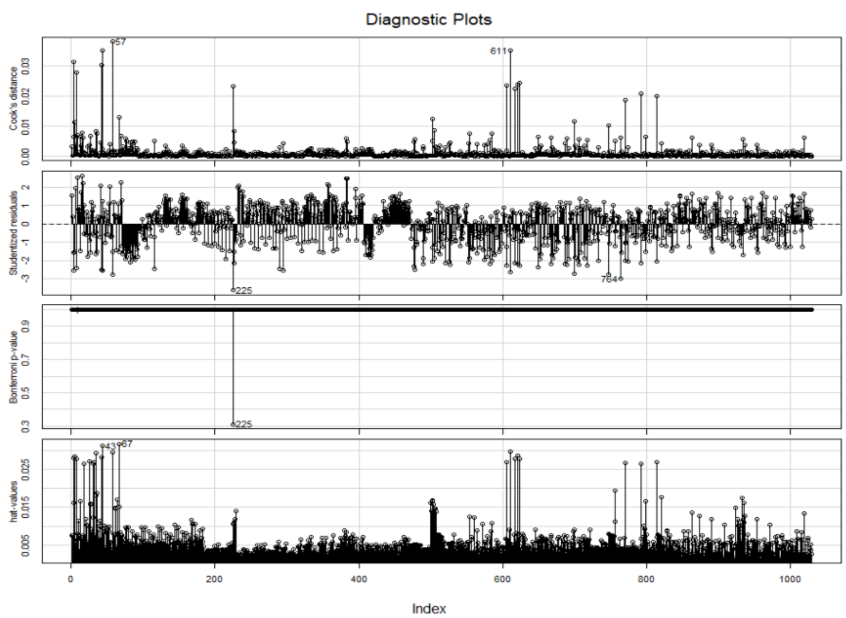
Most variables stay within the cutoff limits but points 225 seems to stick out more than the other variables, passing even the R student residuals plots here. Essentially, the residuals' distribution is the same but they are even larger due to there being less variables. Looking closer at point 225, besides having a somewhat low compressive strength, it is not abnormal in any way so there are no worries. The variance inflation factor values are below 5, actually very close to 1, for all the variables used here which means the variables are not correlated and there is no evidence of multicollinearity:

```
  cement     slag   flyash    water      age
1.594164 1.444858 1.748086 1.203434 1.106834
[1] 225 764
```

We see the point 225 pop up again in the influential analysis as well as point 764. Let's look at how they appear in the dfbetas and diagnostic plots:

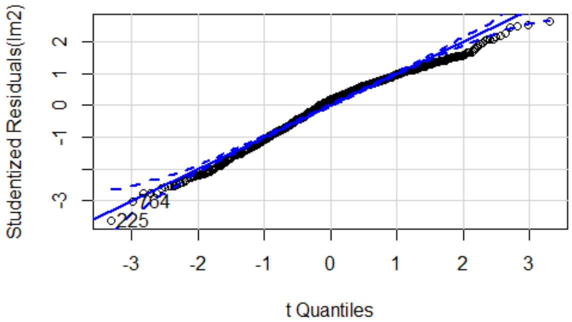


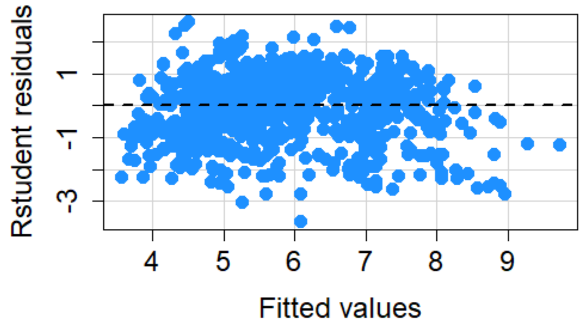
2.2.2.2 DFBETAS Plots



2.2.2.3 Diagnostic Plots

The points in the influential analysis plots mostly hover around the 0 value and all points seem to be in the cutoffs. In the diagnostic plots, Many of the hat-value leverage points at the lower indices have been reduced though point 43 and 67 stick out. Points 229 in the same graph and 225 in Cook's distance have been reduced. Point 611 sticks out for both full and reduced models and point 225 is stuck out greatly in the, again, studentized residuals (as well as 764 here) and the bonferroni p-value plots. Looking directly at these observations, only compressive strength seems low but nothing is really out of the ordinary. Now let's look at the normal probability plot and residuals vs fitted values plot:





2.2.2.4 Normal Probability Plot & Residuals vs. Fitted Values Plot

We can see here with the normal probability plots that, just like with the original, points 382 and 384 stick out above with the untransformed and points 225 and 764 stick out below for the transformed; this means the positively skewed data has been transformed to a more normal plot with perhaps just a little left-skewing. Again, in the residuals vs fitted plot, we see the change from the cone shaped plot of the original residuals, where the variance of errors is not constant to the transformed data, where the residuals are more randomly distributed.

2.3 Model Comparison

Comparing the transformed full and reduced model with the ANOVA table, we see that RSS is higher for model 2:

```
Analysis of Variance Table

Model 1: csMPa ~ cement + slag + flyash + water +
superplasticizer + coarseaggregate +
    fineaggregate + age
Model 2: csMPa ~ cement + slag + flyash + water + age
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   1021 858.41
2   1024 867.54 -3   -9.1322 3.6206 0.0128 *
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This means that the full model outperformed the reduced model. Here is a simple table that allows us to compare all the models:

Model	*RSE*	*Adjusted R^2*	*Variance*
Full	**10.4**	**0.6125**	**108.142**
Reduced	10.45	0.6091	109.1
Full (Transformed)	**0.9169**	**0.5994**	**0.841**
Reduced (Transformed)	0.9204	0.5963	0.847

For all models, we see that the full versions perform better with a lower RSE and Variance and a higher R^2 value; we prefer the variance stabilized full transformed model due to the relatively higher R^2 and lower variance. Moreover, though the other variables don't offer much to the model, the more variables don't hurt by a large margin and are probably useful as they are direct ingredients of concrete mixture. Something interesting we learned is that we can't exactly assess the differences in R^2 between the original and transformed models since R^2 is the proportion of the variance in the dependent variable that is explained by the variation in the independent variables; transforming compressive strength with square root will have also transformed its variance structures too.

3. Conclusion

To summarize our findings: cement, slag, fly ash, water, and age are the most significant predictors in modeling concrete compressive strength and concrete compressive strength is calculated as a nonlinear function of its components. What this means for the future is that concrete mixers/manufacturers should give more weight to or focus on the cement, slag, fly ash, water, and age ingredients in their mixture. When testing various concrete mixtures the compressive strength should be transformed with some function to improve the distribution of the data. This type of research is significant for the foundations (pun intended) of civil engineering, architecture, and infrastructure as a whole. Stronger concrete means structures that endure the test of time as well as natural disasters or any other complication. For future study, perhaps more aspects of concrete mixture such as sub-qualities of air, cement, water, aggregates, and other minerals could be analyzed. Other transformations should also be explored to perhaps create an even more valuable distribution of the data or other types of regression models could be utilized to improve the predictive power.

Reflecting on our project journey, we actually learned much from our experience. First, organizing meetings, assigning roles, and working together as a team has improved all members' communication and efficiency in a group. Outside these logistical aspects, researching the data helped us learn much about concrete such as the many ingredients that it consists of, in what units these are measured, and how extensive the use of concrete is in our modern world. We were successful in many aspects but did have some difficulty with some parts, such as variable selection. Having many useful variables is great but we learned that studying the loss of certain variables allows us to understand the strength of the others in full models; a reduced model should not always be an improvement but is a chance to evaluate specific variables. Also, working with the data over the duration of the project allowed us to catch the skews and shape of the distribution, allowing us to apply our knowledge of transformations and observe how it can make the data more favorable for modeling. However, a non-linear transformation may not have to be our square-root function; we learned about other transformations that we could use in the future with more knowledge.

This project was a great experience with linear modeling but even more with the analysis of models. We hope to use this experience in the future to evaluate and create better, more *concrete* models.

4. Appendix

4.1 Team Responsibility

Gabrielle Allin: Documentation and oversight of deliverables such as proposal, presentation, and the final report while working alongside team members with data exploration, model building, and analysis. Also responsible for making sure the team is consistent with meeting times.

Ramesh Kanakala: Data exploration, primarily model building, primarily analysis, and contributing equally alongside team members for the proposal, presentation, and report.

Hyun Guk Yoo: Primarily data exploration, primarily model building, analysis, and contributing equally alongside team members for the proposal, presentation, and report.

4.2 References

I-Cheng Yeh, "Modeling of strength of high performance concrete using artificial neural networks," Cement and Concrete Research, Vol. 28, No. 12, pp. 1797-1808 (1998)

Maajdl. (2018, June 15). Concrete Strength Regression. Retrieved May 10, 2021, from https://www.kaggle.com/maajdl/yeh-concret-data

4.3 R Notebook attached below:

Code

STAT 4355 Final Project

This is an R script with the purpose of analyzing Concrete Compressive Strength

Gabrielle Allin, Ramesh Kanakala, Hyun Guk Yoo

load the data and look at the first few rows

Hide

```
conc <- read.csv(file = "Concrete_Data_Yeh.csv")
conc <- data.frame((conc1[,1:8]), sqrt(conc1[,9]))
names(conc)[names(conc) == "sqrt.conc1...9.."] <- "csMPa"
head(conc)
```

	cem... <dbl>	slag <dbl>	flyash <dbl>	wa... <dbl>	superplasticizer <dbl>	coarseaggregate <dbl>	fineaggregate <dbl>	... <int>	csMPa <dbl>
1	540.0	0.0	0	162	2.5	1040.0	676.0	28	8.943713
2	540.0	0.0	0	162	2.5	1055.0	676.0	28	7.867020
3	332.5	142.5	0	228	0.0	932.0	594.0	270	6.345865
4	332.5	142.5	0	228	0.0	932.0	594.0	365	6.407027
5	198.6	132.4	0	192	0.0	978.4	825.5	360	6.655825
6	266.0	114.0	0	228	0.0	932.0	670.0	90	6.857842

6 rows

Histogram of csMPa

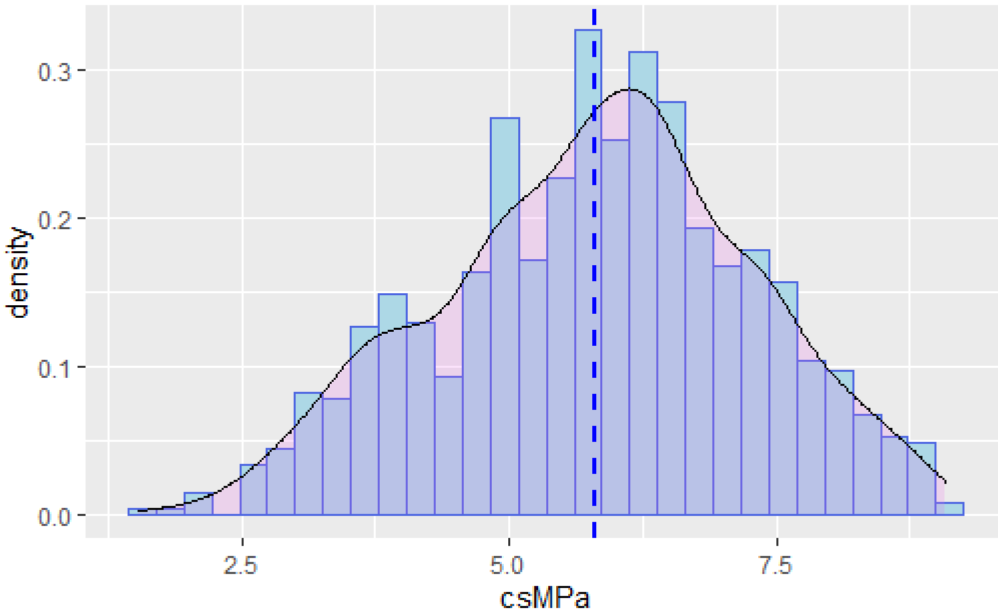
Hide

```
library(ggplot2)
```

```
package 惚牠ggplot2惚牸 was built under R version 4.0.4Keep up to date with changes at
https://www.tidyverse.org/blog/
```

Hide

```
ggplot(conc, aes(x=csMPa)) +
 geom_histogram(aes(y=..density..), colour="#4D66E1", fill="lightblue")+
 geom_density(alpha=.2, fill="#E96CEA") + geom_vline(aes(xintercept=mean(csMPa)),
           color="blue", linetype="dashed", size=1)
```



Scatterplots for csMPa vs each Predictor

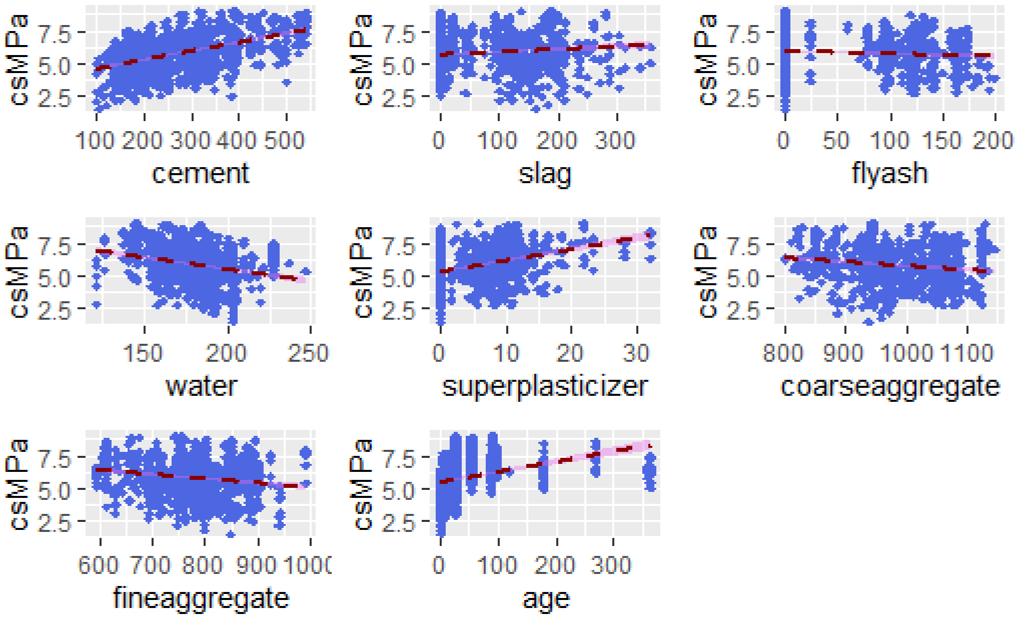
Hide

```
library(gridExtra)
```

```
package 惣犳gridExtra惣乍 was built under R version 4.0.4
```

Hide

```
s1 <- ggplot(conc, aes(x=cement, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s2 <- ggplot(conc, aes(x=slag, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s3 <- ggplot(conc, aes(x=flyash, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s4 <- ggplot(conc, aes(x=water, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s5 <- ggplot(conc, aes(x=superplasticizer, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s6 <- ggplot(conc, aes(x=coarseaggregate, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s7 <- ggplot(conc, aes(x=fineaggregate, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

s8 <- ggplot(conc, aes(x=age, y=csMPa)) +
  geom_point(shape=18, color="#4D66E1")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="#E96CEA")

grid.arrange(s1, s2, s3, s4, s5, s6, s7, s8, nrow = 3)
```



Build Full Model

Hide

```
#full model
lm1 <- lm(csMPa~., data = conc)

#summary with parameter coefficients and other metrics
summary(lm1)
```

```

Call:
lm(formula = csMPa ~ ., data = conc)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.8749 -0.6117  0.1697  0.6539  2.3891 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)       0.9744083  2.3441309   0.416 0.677732    
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 ** 
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .  
fineaggregate     0.0014005  0.0009436   1.484 0.138054    
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:  
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,	Adjusted R-squared:  0.5994 
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

Hide

```
#variance
print(paste("Variance: ", sigma(lm1)^2))
```

```
[1] "Variance:  0.84075407559788"
```

Hide

```
#99% confidence interval
print("99% Confidence Interval: ")
```

```
[1] "99% Confidence Interval: "
```

Hide

```
confint(lm1,level=0.99)
```

```
                        0.5 %      99.5 %
(Intercept)      -5.0749805390  7.023797151
cement            0.0082697829  0.012133043
slag              0.0063287266  0.010941421
flyash            0.0051514318  0.010877964
water            -0.0211512825 -0.002867144
superplasticizer  0.0044273439  0.046943641
coarseaggregate  -0.0007320663  0.003542240
fineaggregate    -0.0010345770  0.003835645
age               0.0088950083  0.011364845
```

Hide

```
#prediction on future observations whose csMPa values are identical to data set
predout <- predict(lm1, conc, interval = "predict", predict.level = .99)
print("Prediction on identical data: ")
```

```
[1] "Prediction on identical data: "
```

Hide

```
predout
```

	fit	lwr	upr
1	7.293582	5.482046	9.105117
2	7.314658	5.503817	9.125499
3	7.735314	5.920799	9.549829
4	8.697657	6.872730	10.522584
5	8.015575	6.189004	9.842145
6	5.093874	3.288362	6.899386
7	8.772058	6.947151	10.596965
8	5.358273	3.549697	7.166849
9	4.465818	2.659344	6.272293
10	5.507075	3.694352	7.319798
11	5.280495	3.477163	7.083826
12	4.652439	2.849446	6.455432
13	7.884116	6.068339	9.699893
14	4.974832	3.168605	6.781060
15	4.525339	2.718313	6.332365
16	5.272437	3.464098	7.080776
17	5.413851	3.602809	7.224894
18	7.998646	6.174649	9.822642
19	5.986328	4.178890	7.793766
20	7.046824	5.234348	8.859299
21	6.972423	5.162029	8.782816
22	4.785796	2.975479	6.596112
23	4.532547	2.721995	6.343100
24	6.325545	4.510123	8.140966
25	8.058166	6.233290	9.883043
26	7.095823	5.280792	8.910855
27	7.809715	5.994973	9.624457
28	6.124609	4.316166	7.933053
29	5.432674	3.622428	7.242919
30	5.294346	3.480706	7.107987
31	7.939125	6.115493	9.762757
32	7.879604	6.055822	9.703386
33	6.192188	4.385025	7.999351
34	7.958517	6.140897	9.776137
35	7.760562	5.934935	9.586189
36	7.586511	5.770025	9.402998
37	5.135069	3.326634	6.943505
38	5.911927	4.105187	7.718667
39	6.135130	4.323866	7.946394
40	6.674818	4.864650	8.484986
41	5.212916	3.406038	7.019793
42	8.846459	7.020767	10.672151
43	8.548855	6.721477	10.376232
44	6.184130	4.374414	7.993846
45	6.060729	4.251783	7.869675
46	5.219945	3.408836	7.031055
47	4.860539	3.055142	6.665936
48	6.898021	5.088901	8.707142
49	4.922341	3.113259	6.731422
50	5.145544	3.336158	6.954930
51	6.823620	5.014962	8.632279
52	5.886526	4.077981	7.695070

53	5.763125	3.955343	7.570907
54	5.153395	3.347460	6.959330
55	4.573067	2.762573	6.383562
56	4.439711	2.636406	6.243015
57	8.920860	7.093581	10.748139
58	4.399191	2.595803	6.202579
59	6.065088	4.257399	7.872778
60	5.283871	3.476154	7.091589
61	6.976782	5.163396	8.790167
62	6.917261	5.103922	8.730599
63	4.417101	2.613099	6.221102
64	6.798219	4.983420	8.613018
65	6.005567	4.198112	7.813022
66	7.036302	5.222353	8.850252
67	8.148931	6.313075	9.984787
68	5.071143	3.262670	6.879616
69	4.346777	2.539846	6.153707
70	7.146511	5.330728	8.962293
71	7.031574	5.227181	8.835967
72	6.906127	5.096607	8.715648
73	7.278391	5.470757	9.086026
74	7.358633	5.551580	9.165686
75	7.308416	5.493056	9.123777
76	7.221840	5.414594	9.029086
77	8.347918	6.523018	10.172818
78	7.278391	5.470757	9.086026
79	6.715821	4.908288	8.523355
80	7.895165	6.072897	9.717433
81	7.278391	5.470757	9.086026
82	7.019734	5.211750	8.827719
83	6.967855	5.163088	8.772622
84	7.039401	5.235247	8.843555
85	7.055049	5.246522	8.863576
86	7.183152	5.366805	8.999498
87	7.039401	5.235247	8.843555
88	6.747353	4.941288	8.553417
89	7.039401	5.235247	8.843555
90	7.297821	5.490936	9.104706
91	7.813204	6.002415	9.623992
92	7.039401	5.235247	8.843555
93	6.613394	4.809668	8.417120
94	7.072093	5.267753	8.876434
95	6.946647	5.137191	8.756103
96	7.318911	5.511315	9.126507
97	7.399152	5.592152	9.206152
98	7.348936	5.533579	9.164294
99	7.262360	5.455187	9.069533
100	8.388438	6.563583	10.213292
101	7.318911	5.511315	9.126507
102	6.756341	4.948842	8.563840
103	7.935685	6.113479	9.757890
104	7.318911	5.511315	9.126507
105	7.060254	5.252286	8.868222
106	7.008375	5.203641	8.813109

107	7.079921	5.275815	8.884026
108	7.095569	5.287106	8.904032
109	7.223672	5.407401	9.039942
110	7.079921	5.275815	8.884026
111	6.787872	4.981824	8.593921
112	7.079921	5.275815	8.884026
113	7.338341	5.531537	9.145144
114	7.853723	6.042974	9.664473
115	7.079921	5.275815	8.884026
116	6.653914	4.850248	8.457580
117	7.284822	5.480626	9.089018
118	7.159376	5.350132	8.968620
119	7.531640	5.724117	9.339163
120	7.611881	5.805031	9.418731
121	7.561665	5.746197	9.377133
122	7.475088	5.668171	9.282005
123	8.601166	6.776422	10.425910
124	7.531640	5.724117	9.339163
125	6.969069	5.161625	8.776513
126	8.148413	6.326409	9.970417
127	7.531640	5.724117	9.339163
128	7.272982	5.464973	9.080992
129	7.221103	5.416413	9.025793
130	7.292649	5.488672	9.096626
131	7.308297	5.500043	9.116551
132	7.436400	5.620399	9.252401
133	7.292649	5.488672	9.096626
134	7.000601	5.194505	8.806697
135	7.292649	5.488672	9.096626
136	7.551069	5.744568	9.357571
137	8.066452	6.255782	9.877121
138	7.292649	5.488672	9.096626
139	6.866642	5.063160	8.670125
140	7.568460	5.764121	9.372798
141	7.443014	5.633718	9.252309
142	7.815278	6.007517	9.623038
143	7.895519	6.088534	9.702503
144	7.845303	6.029354	9.661251
145	7.758726	5.951816	9.565636
146	8.884804	7.059877	10.709731
147	7.815278	6.007517	9.623038
148	7.252707	5.445001	9.060413
149	8.432051	6.609983	10.254119
150	7.815278	6.007517	9.623038
151	7.556620	5.748221	9.365020
152	7.504741	5.699775	9.309707
153	7.576287	5.772146	9.380428
154	7.591935	5.783626	9.400245
155	7.720038	5.904064	9.536012
156	7.576287	5.772146	9.380428
157	7.284239	5.477745	9.090732
158	7.576287	5.772146	9.380428
159	7.834707	6.028273	9.641141
160	8.350090	6.539193	10.160987

161	7.576287	5.772146	9.380428
162	7.150280	5.346708	8.953853
163	7.923007	6.117952	9.728062
164	7.797561	5.987664	9.607458
165	8.169825	6.361231	9.978419
166	8.250066	6.442376	10.057756
167	8.199850	6.382766	10.016934
168	8.113274	6.305834	9.920713
169	9.239351	7.413663	11.065040
170	8.169825	6.361231	9.978419
171	7.607255	5.798684	9.415826
172	8.786598	6.963917	10.609280
173	8.169825	6.361231	9.978419
174	7.911168	6.101744	9.720591
175	7.859289	6.053439	9.665138
176	7.930834	6.125949	9.735720
177	8.074585	6.258110	9.891061
178	7.930834	6.125949	9.735720
179	7.638786	5.831258	9.446314
180	7.930834	6.125949	9.735720
181	8.189255	6.382367	9.996142
182	8.704637	6.892919	10.516356
183	7.930834	6.125949	9.735720
184	7.504828	5.700604	9.309051
185	4.468598	2.663878	6.273319
186	4.580028	2.775485	6.384570
187	4.721846	2.917444	6.526249
188	5.005484	3.201075	6.809894
189	5.451201	3.646008	7.256395
190	4.413761	2.608405	6.219117
191	4.525190	2.720055	6.330326
192	4.667009	2.862068	6.471950
193	4.950647	3.145808	6.755486
194	5.396364	3.590912	7.201816
195	4.683229	2.879525	6.486933
196	4.794658	2.991045	6.598271
197	4.936477	3.132894	6.740059
198	5.220115	3.416306	7.023924
199	5.665832	3.860893	7.470770
200	4.866478	3.062717	6.670239
201	4.977907	3.174251	6.781563
202	5.119726	3.316119	6.923333
203	5.403364	3.599566	7.207162
204	5.849081	4.044209	7.653952
205	4.701707	2.898617	6.504797
206	4.813136	3.010218	6.616054
207	4.954955	3.152170	6.757740
208	5.238593	3.435788	7.041399
209	5.684310	3.880697	7.487923
210	4.578455	2.774155	6.382755
211	4.689884	2.885815	6.493954
212	4.831703	3.027841	6.635565
213	5.115341	3.311608	6.919075
214	5.561058	3.756752	7.365364

215	4.912505	3.108314	6.716697
216	5.023934	3.219857	6.828012
217	5.165753	3.361736	6.969771
218	5.449391	3.645205	7.253578
219	5.895108	4.089883	7.700333
220	4.583993	2.779382	6.388603
221	4.695422	2.890932	6.499912
222	4.837241	3.032819	6.641663
223	5.120879	3.316306	6.925452
224	5.566596	3.761011	7.372180
225	5.658787	3.828749	7.488824
226	5.770216	3.940128	7.600303
227	5.912035	4.081799	7.742270
228	6.195673	4.364858	8.026487
229	6.641389	4.808903	8.473876
230	4.820978	3.016412	6.625543
231	4.932407	3.128043	6.736770
232	5.074226	3.270034	6.878418
233	5.357864	3.553727	7.162001
234	5.803580	3.998756	7.608404
235	4.817282	3.012831	6.621733
236	4.928711	3.124461	6.732961
237	5.070530	3.266450	6.874610
238	5.354168	3.550141	7.158194
239	5.799885	3.995167	7.604602
240	4.613497	2.808829	6.418165
241	4.724926	2.920494	6.529358
242	4.866745	3.062528	6.670962
243	5.150383	3.346309	6.954457
244	5.596100	3.791477	7.400723
245	4.646560	2.843882	6.449239
246	4.757989	2.955515	6.560464
247	4.899808	3.097508	6.702109
248	5.183446	3.381206	6.985686
249	5.629163	3.826243	7.432082
250	4.763569	2.959450	6.567688
251	4.874998	3.071055	6.678941
252	5.016817	3.213013	6.820621
253	5.300455	3.496641	7.104269
254	5.746172	3.941568	7.550775
255	4.969239	3.165855	6.772623
256	5.080668	3.277357	6.883979
257	5.222487	3.419183	7.025791
258	5.506125	3.702548	7.309702
259	5.951842	4.147062	7.756622
260	5.007383	3.203847	6.810920
261	5.118812	3.315356	6.922269
262	5.260631	3.457191	7.064072
263	5.544269	3.740574	7.347965
264	5.989986	4.185116	7.794856
265	5.103422	3.299879	6.906965
266	5.214851	3.411402	7.018300
267	5.356670	3.553255	7.160085
268	5.640308	3.836674	7.443942

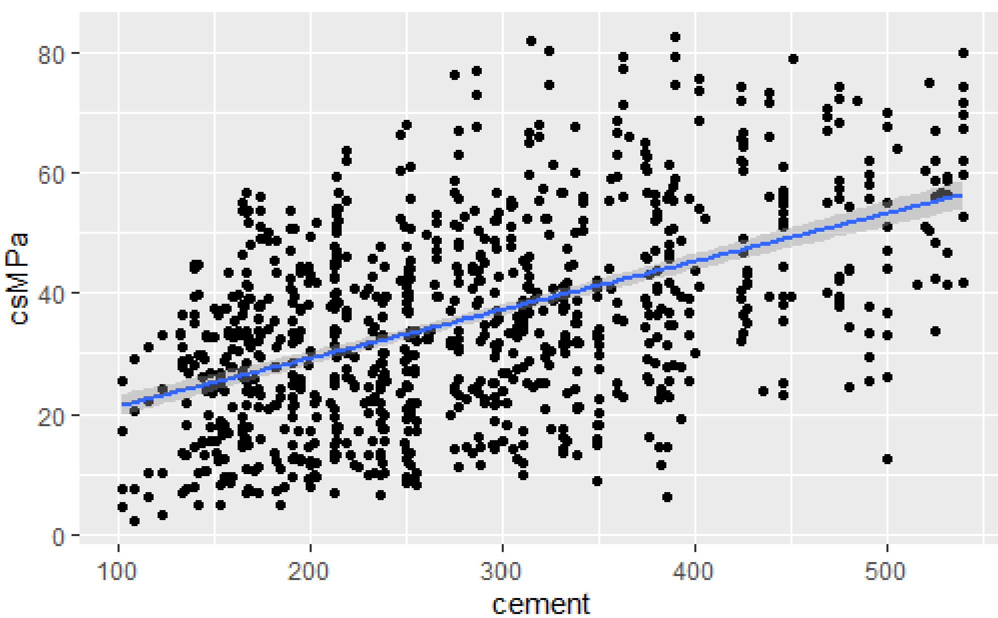
269	6.086025	4.281273	7.890777
270	5.001212	3.198591	6.803833
271	5.112641	3.310172	6.915110
272	5.254460	3.452098	7.056822
273	5.538098	3.735664	7.340532
274	5.983815	4.180492	7.787137
275	4.908987	3.105711	6.712263
276	5.020416	3.217348	6.823484
277	5.162235	3.359347	6.965123
278	5.445873	3.643057	7.248689
279	5.891590	4.088112	7.695068
280	4.924398	3.120942	6.727855
281	5.035827	3.232581	6.839074
282	5.177646	3.374582	6.980711
283	5.461284	3.658297	7.264272
284	5.907001	4.103359	7.710643
285	4.924781	3.120683	6.728879
286	5.036210	3.232216	6.840204
287	5.178029	3.374083	6.981975
288	5.461667	3.657528	7.265806
289	5.907384	4.102169	7.712599
290	4.978152	3.175327	6.780978
291	5.089582	3.286875	6.892288
292	5.231401	3.428760	7.034041
293	5.515038	3.712241	7.317836
294	5.960755	4.156938	7.764573
295	5.098511	3.294390	6.902633
296	5.209941	3.405902	7.013980
297	5.351760	3.547740	7.155779
298	5.635398	3.831130	7.439665
299	6.081114	4.275683	7.886546
300	5.523028	3.720586	7.325471
301	5.634458	3.832132	7.436783
302	5.776277	3.974015	7.578538
303	6.059915	4.257492	7.862337
304	6.505631	4.702182	8.309081
305	5.581372	3.778744	7.384000
306	5.692801	3.890270	7.495332
307	5.834620	4.032127	7.637113
308	6.118258	4.315554	7.920962
309	6.563975	4.760164	8.367785
310	5.501919	3.699384	7.304454
311	5.613348	3.810943	7.415753
312	5.755167	3.952841	7.557493
313	6.038805	4.236350	7.841260
314	6.484522	4.681089	8.287954
315	5.611854	3.808156	7.415552
316	5.723283	3.919623	7.526943
317	5.865102	4.061406	7.668798
318	6.148740	4.344684	7.952796
319	6.594457	4.789062	8.399852
320	5.400959	3.597594	7.204325
321	5.512388	3.709112	7.315665
322	5.654207	3.850958	7.457457

```
323  5.937845 4.134363  7.741328
324  6.383562 4.578939  8.188185
325  5.611272 3.807139  7.415405
326  5.722701 3.918632  7.526770
327  5.864520 4.060447  7.668593
328  6.148158 4.343790  7.952527
329  6.593875 4.788269  8.399481
330  5.761187 3.956204  7.566170
331  5.872616 4.067684  7.677548
332  6.014435 4.209482  7.819388
333  6.298073 4.492791  8.103355
 [ reached getOption("max.print") -- omitted 697 rows ]
```

Confidence/Prediction Interval Curves for Full Model

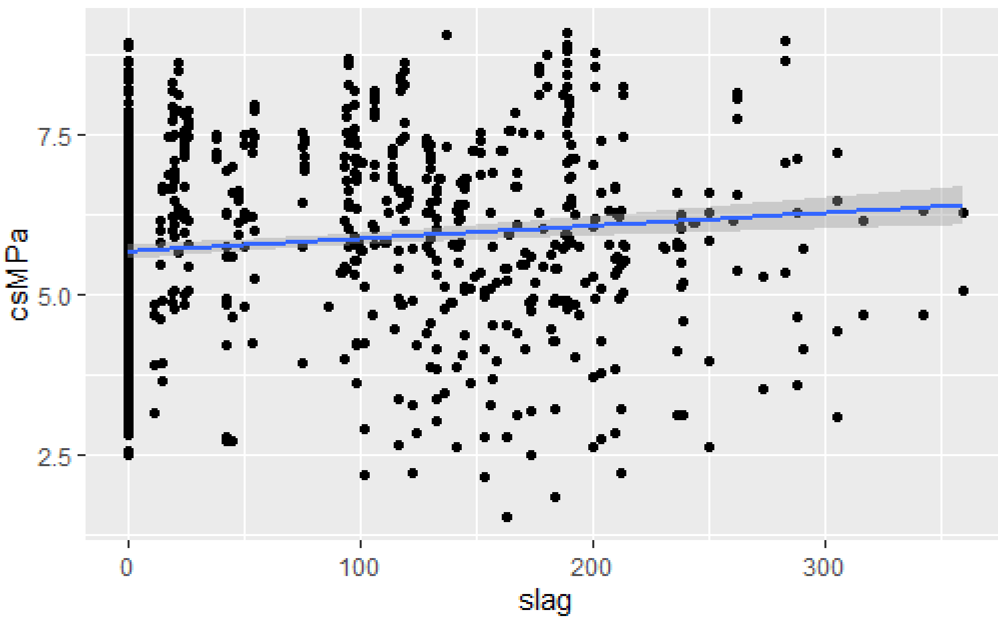
Hide

```
#merge data points and prediction outcome object
merged <- cbind(conc, predout)

#cement
#confidence interval curve
p0 <- ggplot(merged2, aes(cement, csMPa)) + geom_point() + stat_smooth(method = lm)
p0
```



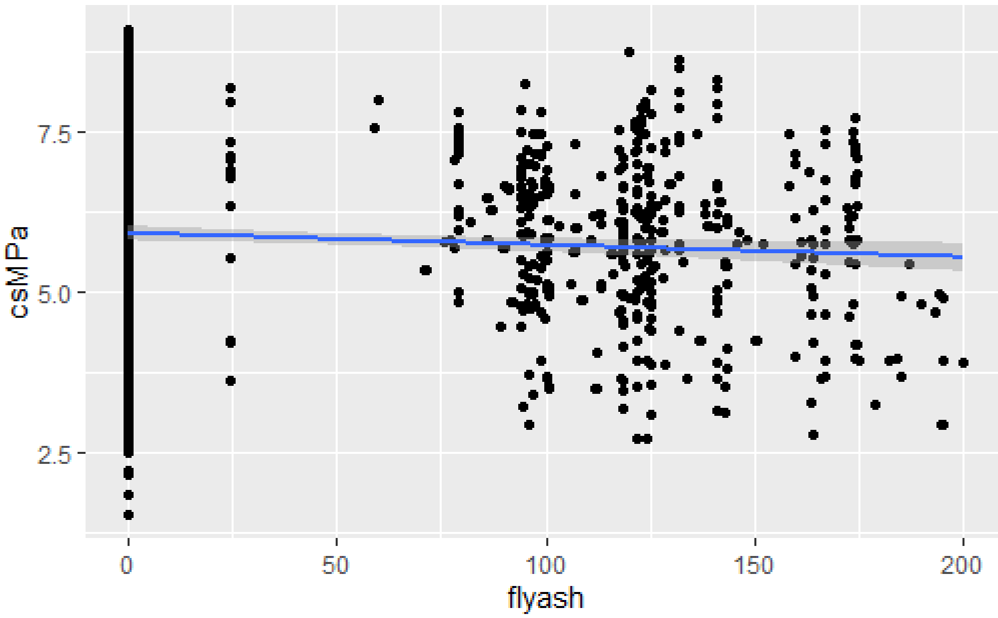
Hide

```
#prediction interval curve
p00 <- p1 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#slag
#confidence interval curve
p1 <- ggplot(merged, aes(slag, csMPa)) + geom_point() + stat_smooth(method = lm)
p1
```



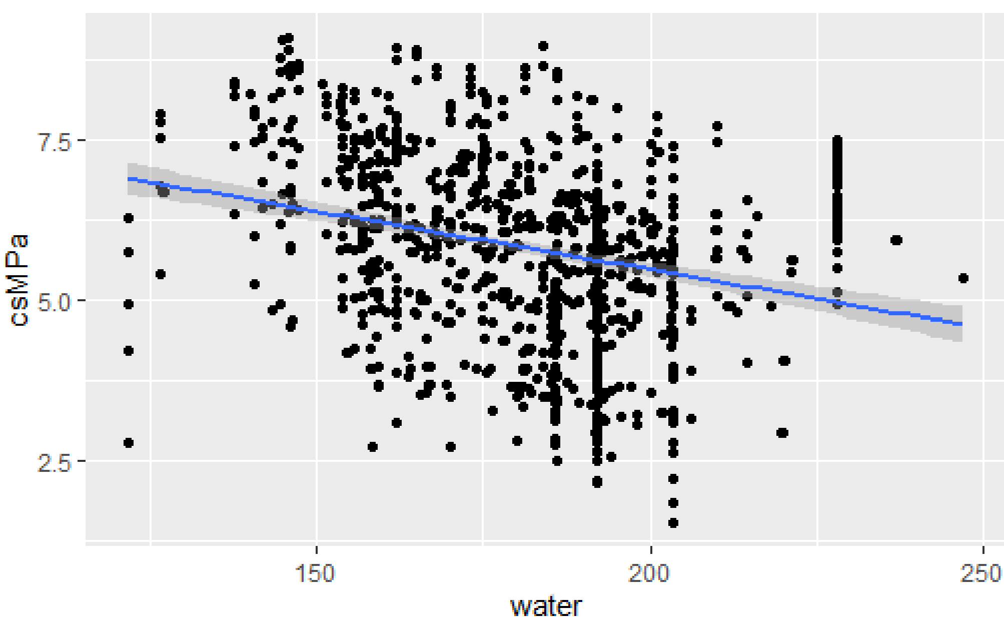
Hide

```
#prediction interval curve
p11 <- p1 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#flyash
#confidence interval curve
p2 <- ggplot(merged, aes(flyash, csMPa)) + geom_point() + stat_smooth(method = lm)
p2
```



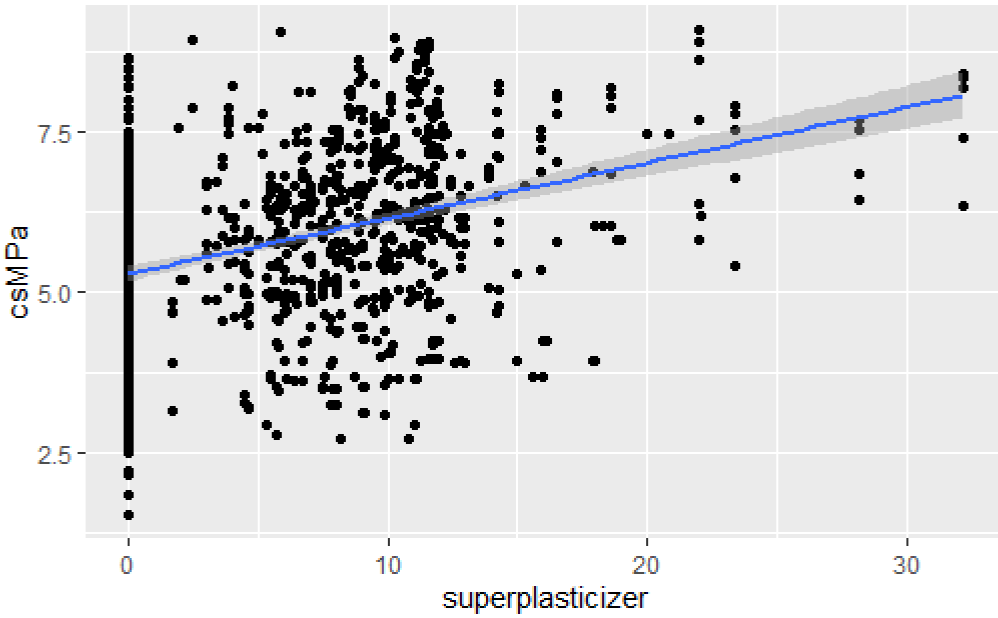
Hide

```
#prediction interval curve
p22 <- p2 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#water
#confidence interval curve
p3 <- ggplot(merged, aes(water, csMPa)) + geom_point() + stat_smooth(method = lm)
p3
```



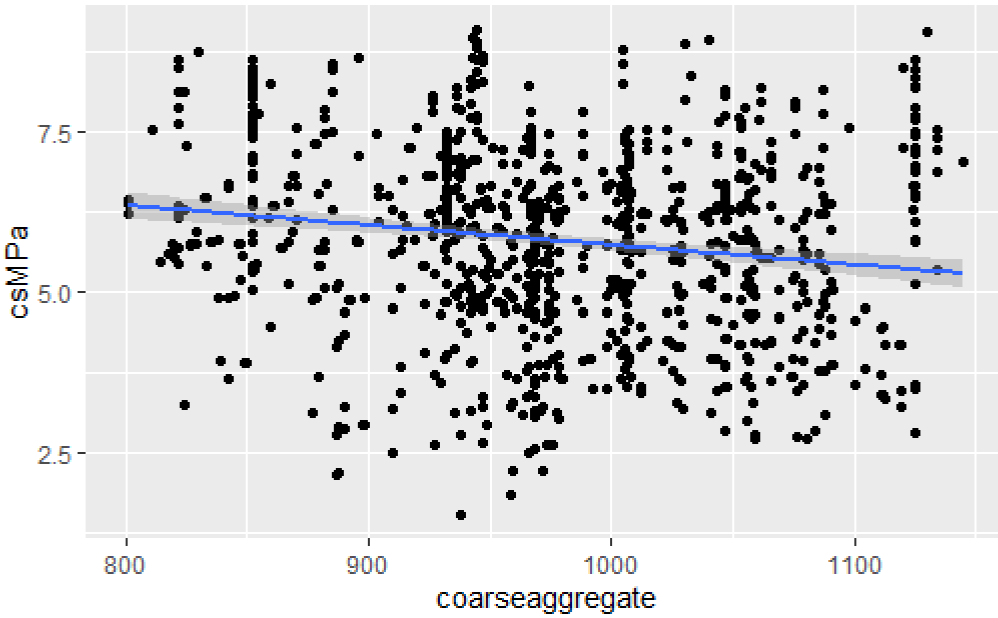
Hide

```
#prediction interval curve
p33 <- p3 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#superplasticizer
#confidence interval curve
p4 <- ggplot(merged, aes(superplasticizer, csMPa)) + geom_point() + stat_smooth(method = lm)
p4
```



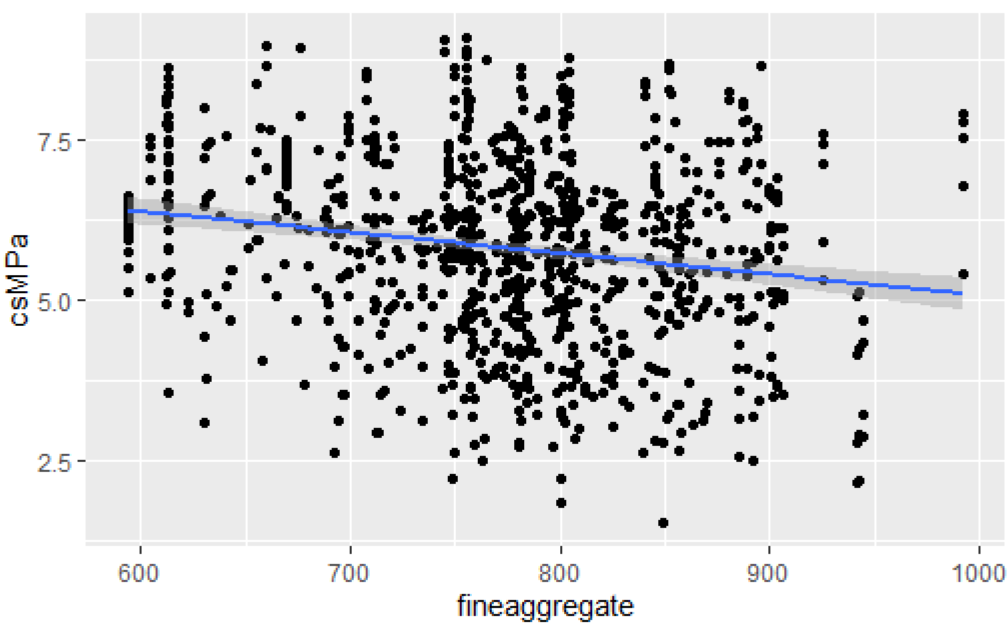
Hide

```
#prediction interval curve
p44 <- p4 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#coarseaggregate
#confidence interval curve
p5 <- ggplot(merged, aes(coarseaggregate, csMPa)) + geom_point() + stat_smooth(method = lm)
p5
```



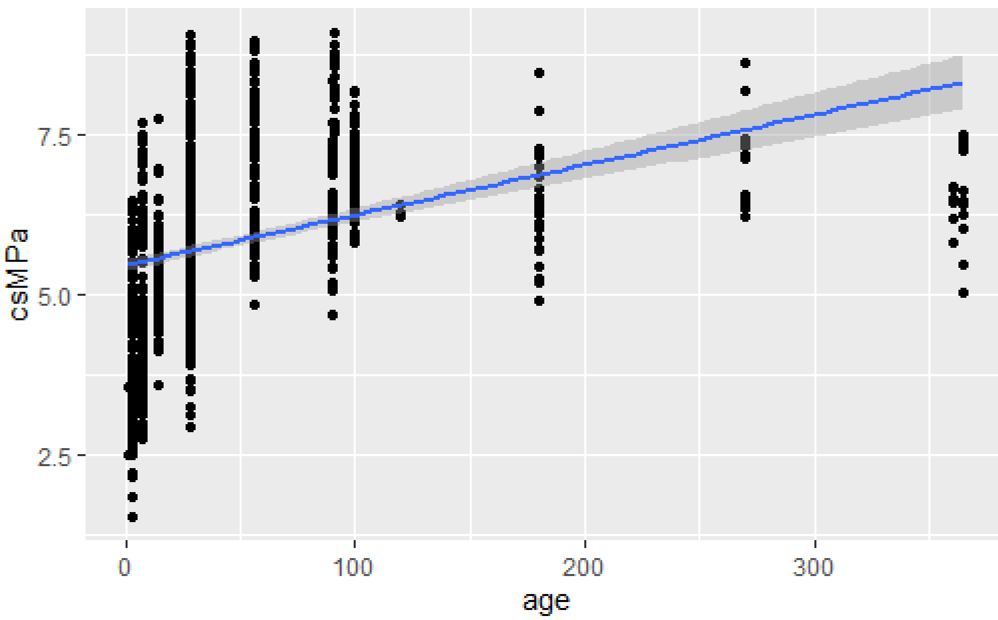
Hide

```
#prediction interval curve
p55 <- p5 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#fineaggregate
#confidence interval curve
p6 <- ggplot(merged, aes(fineaggregate, csMPa)) + geom_point() + stat_smooth(method = lm)
p6
```



Hide

```
#prediction interval curve
p66 <- p6 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#age
#confidence interval curve
p7 <- ggplot(merged, aes(age, csMPa)) + geom_point() + stat_smooth(method = lm)
p7
```



Hide

```
#prediction interval curve
p77 <- p7 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#grid.arrange(p0, p00, p1, p11, p2, p22, p3, p33, p4, p44, p5, p55, p6, p66, p7, p77, nrow = 8)
```

Residual Analysis for Full Model

Hide

```
#View(lm1)
library(MASS)

#standardized residuals
print("standardized residuals:")
```

```
[1] "standardized residuals:"
```

Hide

```
stdres(lm1)
```

```
           1            2            3            4 
 1.8120644693  0.6063283469 -1.5283884468 -2.5348208157 
           5            6            7            8 
-1.5061439132  1.9304985990 -2.3918543451  0.7445067397 
           9           10           11           12 
 2.5244579076  0.8363519596  0.9723884082  0.7004732455 
          13           14           15           16 
-1.4595525970  1.6765591455  2.6169151164  2.1939316187 
          17           18           19           20 
 0.9440253517 -0.5596205055  0.4188946443 -0.5696029848 
          21           22           23           24 
-0.5531428687  0.5797833104 -1.8586909067  0.3560500217 
          25           26           27           28 
-0.8975384106  0.2254133140 -1.5345702686  1.2001452640 
          29           30           31           32 
 0.7520366876  1.0098909193 -0.5588776623 -0.6698009109 
          33           34           35           36 
 0.2923836880 -1.6173924091 -0.4795935103 -1.5295405363 
          37           38           39           40 
 0.3830751376  0.2515961296  0.3989247534 -0.7176458697 
          41           42           43           44 
 2.0706788920 -2.4753132590 -2.5530942774  1.2098235593 
          45           46           47           48 
 0.4215307476  0.7716828329 -1.0736594466 -0.5633027519 
          49           50           51           52 
 0.2216361183  0.6397953158 -0.5662429918  1.0568349304 
          53           54           55           56 
-0.0089054598  2.0362586904 -0.8268255243 -0.6705721923 
          57           58           59           60 
-2.7099300541 -1.5058626694  1.1755609112  0.5067166029 
          61           62           63           64 
 0.4369650386  0.3024022576 -1.3946730926  0.3513571484 
          65           66           67           68 
 1.0659904880  0.4221966227 -1.6295010944  0.4731159838 
          69           70           71           72 
 2.2402912794  1.4730596483 -1.2757388459 -1.6887195711 
          73           74           75           76 
-1.6426047090 -1.4608582478 -2.1165909114 -1.1761775936 
          77           78           79           80 
-2.2215521974 -1.6426047090 -1.5502133180 -1.6227219477 
          81           82           83           84 
-1.6426047090 -2.1916134650 -0.6092494973 -1.2007657423 
          85           86           87           88 
-1.9023224099 -2.0208861668 -1.2007657423 -1.9789909846 
          89           90           91           92 
-1.2007657423 -1.1268496872 -1.5821697830 -1.2007657423 
          93           94           95           96 
-1.8632413608 -0.3008026036 -0.4436462584 -0.3337910955 
          97           98           99          100 
-0.6112992182 -0.6479437482  0.2127114698 -1.0833028659 
         101          102          103          104 
-0.3337910955 -0.9298818623 -1.2013462361 -0.3337910955 
         105          106          107          108 
```

```
-1.4038527317  0.3794789388  0.4338191760 -0.0423772110
          109           110           111           112
-0.3971969819  0.4338191760 -0.6825225697  0.4338191760
          113           114           115           116
 0.1660901338 -0.1830006935 -2.5091633524 -0.7974220067
          117           118           119           120
 0.5809059042  0.6291499754  0.2553115608  0.2731688087
          121           122           123           124
-0.0349156753  0.8644901034 -0.4668533994  0.2553115608
          125           126           127           128
 0.1657898663 -0.7052836590  0.2553115608  0.1938177425
          129           130           131           132
 1.1544703509  1.2588879515  1.4628714956 -0.2327841504
          133           134           135           136
 1.2588879515  1.3437153786  1.2588879515  0.6274101085
          137           138           139           140
 0.6200164302  1.2588879515  0.2157362996  0.4308597257
          141           142           143           144
 0.6723467156  0.2229394026  0.1758359710 -0.0951578424
          145           146           147           148
 0.8151136362 -0.6198555272  0.2229394026  0.1939085389
          149           150           151           152
-0.8439759522  0.2229394026  0.6287400777  1.1817381895
          153           154           155           156
 1.3295072202  1.4945860546 -0.3419264886  1.3295072202
          157           158           159           160
 1.3788148430  1.3295072202  0.6929848955  0.6153669033
          161           162           163           164
 1.3295072202  0.6434483234  0.1455694747  0.3986053008
          165           166           167           168
-0.1043392121 -0.0910121206 -0.3240456413  0.5478933909
          169           170           171           172
-0.9200198826 -0.1043392121 -0.0195012982 -1.2073326903
          173           174           175           176
-0.1043392121  0.3741306685  0.9082943118  1.0658179227
          177           178           179           180
-0.6144164860  1.0658179227  1.2323577162  1.0658179227
          181           182           183           184
 0.4077488914  0.4215262153  1.0658179227  0.7975166463
          185           186           187           188
-1.1657454148  0.3988765386  0.2921793341  0.4607893185
          189           190           191           192
 1.0167818318 -1.3043744628  0.1970893866  0.1226569120
          193           194           195           196
 0.3376395611  0.5279365903 -1.2625105658  0.2233951341
          197           198           199           200
 0.1475982245  0.6641144410  0.4866514663 -1.0805774666
          201           202           203           204
-0.4250510424  0.0200795505  0.5919223289  0.5692999902
          205           206           207           208
-1.2791758180 -0.2615083695  0.0382837774  0.6660118460
          209           210           211           212
 0.6661532855 -1.5436366808 -0.2283415990  0.1268592797
          213           214           215           216
```

```
 0.5474309066  0.4196261305 -2.0104887861 -0.2814565329
          217           218           219           220
 0.1858661040  0.8314351019  0.5035695977 -1.4261094999
          221           222           223           224
 0.3853927343 -0.2145042225  0.2513861432  0.2460076327
          225           226           227           228
-3.1908730567 -1.7191185910 -1.0974037117 -0.5154314815
          229           230           231           232
-0.4201518711 -0.6325993794  0.6346813759  1.8445597331
          233           234           235           236
 1.9328099208  1.6826364857 -1.2981282463 -0.7709758979
          237           238           239           240
 1.3911666591  1.6522288921  1.3882498983 -1.0483430041
          241           242           243           244
-0.0005705387  0.0951891507  0.4906902266  0.8708036128
          245           246           247           248
-0.1991470341  0.3392804144  0.6536866810  1.2110510002
          249           250           251           252
 1.1219538617 -1.1439019403  0.1279280222  0.4250275271
          253           254           255           256
 0.9738246079  0.8329831285 -1.4096256117  0.0531873440
          257           258           259           260
 0.4399069725  1.1117070606  0.6558204262 -1.4827615230
          261           262           263           264
-0.0895815555  0.9345465402  1.2234627594  1.0058649025
          265           266           267           268
-0.7491445738  0.4200461239  0.9271484059  1.1739979673
          269           270           271           272
 0.9070683814 -1.1711249926  0.0670081363  0.6044602755
          273           274           275           276
 1.0886161772  0.8599240241 -0.8299290323  0.4922628841
          277           278           279           280
 0.3092031693  0.6932685283  0.7760610478 -1.4235430780
          281           282           283           284
-0.1018212532  0.5871598507  0.6467693981  0.8112628185
          285           286           287           288
-1.3497032572 -0.4249573023  0.1002643275  0.5493976179
          289           290           291           292
 0.9063914036 -2.4834093460 -0.4947386688  0.3939627548
          293           294           295           296
 1.1806153853  1.1104601324 -2.6007071604 -0.3950054085
          297           298           299           300
 0.2479715212  0.6798066055  0.9388550091 -0.8517466057
          301           302           303           304
 0.2771186335  0.1286737083  0.7147768732  0.5380721945
          305           306           307           308
-0.8423884166  0.8516087799  1.2168473540  1.1210635419
          309           310           311           312
 0.9788304701 -0.7771574603  0.3519373353  0.6168472098
          313           314           315           316
 1.0282561569  0.7972793403 -1.1229185541  0.0574278579
          317           318           319           320
-0.0429635866  0.5413479807  0.1545953573 -1.6197145858
          321           322           323           324
```

```
-0.1716255737 -0.1092251889  0.5960023307  0.8335939459
          325           326           327           328
-1.0327226623  0.8533562577  1.3656438374  1.4478341284
          329           330           331           332
 1.3277744518 -0.9971946983  0.6838641270  1.3470685272
          333           334           335           336
 1.6069522902  1.5397147620 -0.8892273477  0.4619651905
          337           338           339           340
 1.3317850123  1.4321875376  1.0723488969 -1.0213385174
          341           342           343           344
 0.3877168655  1.1097631355  1.1533895098  1.0211783681
          345           346           347           348
-1.4921097817  0.1539349877  0.5771066543  0.8062237665
          349           350           351           352
 0.5896334022 -1.5531419055  0.1161671323  1.0250891650
          353           354           355           356
 1.1455347508  1.2377204316 -0.3289456526  1.0679804073
          357           358           359           360
 2.0485963627  1.9881940574  1.5103607826 -0.7598481400
          361           362           363           364
-0.0499157680  1.3857129508  1.5384304533  1.1579238184
          365           366           367           368
-1.4104097729  0.6192669814  1.5706630864  1.3928219260
          369           370           371           372
 1.1025047184 -1.4560635377 -0.2796425573 -0.0046191440
          373           374           375           376
 0.3496705534  0.6219110154 -0.7744381991  0.2291969938
          377           378           379           380
 0.7232054092  0.8184613073  0.9185693865  0.9764091235
          381           382           383           384
 0.2260053869  2.5713914741  1.2327810606  2.4283946064
          385           386           387           388
-0.6675965602  0.7793777448  0.6980526303  0.2172747440
          389           390           391           392
 0.2376270920  0.1862886637 -0.1319304697 -0.0405848391
          393           394           395           396
-0.0037589780  0.2259194903  1.5294203342  1.9100773233
          397           398           399           400
-0.6703976443  0.4027261657  1.0254667119  1.0400300156
          401           402           403           404
 1.5894633678  0.9382230296  0.9505987298  1.1442273442
          405           406           407           408
 1.7471673719  1.3378019278 -0.8248627484 -1.1080934814
          409           410           411           412
-0.8008770965 -1.6964632436 -0.5306804236 -0.5543986872
          413           414           415           416
-1.6249597632 -1.6721175814 -1.4166820626 -1.9417329868
          417           418           419           420
-1.7106266937 -1.2250338504 -1.5449472120 -0.6028226290
          421           422           423           424
 0.2409902236  0.4973449729  0.1217630018  0.2680912187
          425           426           427           428
 0.3535419238  0.2178077271 -0.1991181482 -0.5934334845
          429           430           431           432
```

```
 0.1812530677 -0.2042866249  0.2247796196 -0.4718459614
          433           434           435           436
 0.3498099840  1.2431277259  0.7865728335  0.8178762910
          437           438           439           440
 0.4962278203  0.6745263068  0.8274295422  0.4253917429
          441           442           443           444
-0.1163002378  0.3010832609  0.9985285362  1.3569529215
          445           446           447           448
 0.7025511763  1.0569383965  1.4999129290  1.2561254946
          449           450           451           452
 1.3528759093  0.3862219370  1.6251657360  1.4762129909
          453           454           455           456
 1.0451237235  0.2811042219  1.1706973689  1.2115873871
          457           458           459           460
 1.5741788913  0.9376912150  0.6941929687  1.1097356286
          461           462           463           464
 0.8782351509  1.0123684402  0.0630776564  1.3074847431
          465           466           467           468
 1.2363455482  0.7090304162 -0.0301935961  0.8143249160
          469           470           471           472
 0.8534295361  1.1610315132  0.5265705854  0.2134704392
          473           474           475           476
-0.7566207418 -0.2338411028 -0.0179393899 -1.2655641606
          477           478           479           480
-2.2986440687 -2.4844002509  0.0742564322 -1.0696245767
          481           482           483           484
-0.9570312119  0.1908032686 -0.1614460546 -0.2266629088
          485           486           487           488
-0.2255663610 -0.0299092270 -0.2984590620 -0.2338076231
          489           490           491           492
-2.2893998914 -1.9705351930 -0.9803660242 -0.9114394612
          493           494           495           496
-0.1284407908 -0.4135670861  0.1170935881 -0.5062749234
          497           498           499           500
 0.5580137376 -0.3929995200  0.5166419142  0.1986506985
          501           502           503           504
 0.3446930626 -2.1703220599 -1.4107024061  0.1794128118
          505           506           507           508
-1.7716497409 -1.0209790359  0.3126900200  0.8334927566
          509           510           511           512
-1.4147905067  1.3662369479 -0.7238090455  0.7728881814
          513           514           515           516
-1.4593738266 -0.7556371057  1.1997512927  0.1404323975
          517           518           519           520
-1.2785229350 -0.5084663403 -0.0227646385  0.9887099764
          521           522           523           524
-1.9717572311 -0.6432357017  0.7428671999  0.9225576481
          525           526           527           528
 0.6812535043 -1.9974546335 -2.1614849040 -0.9833853937
          529           530           531           532
-0.7266911228  1.0042442462  0.8732664941 -0.4285051590
          533           534           535           536
 0.6540309165 -0.8443178750 -0.8186927149  1.0694006046
          537           538           539           540
```

```
 0.9947639979  0.5114859085 -0.0761697779  0.6356251052 
          541           542           543           544 
-1.0619848755 -0.6919179336 -0.0876741381 -0.7870327484 
          545           546           547           548 
-0.4421274555  0.2222463892  0.8928952703  0.2321904954 
          549           550           551           552 
 0.6777960689  1.0828514940  0.1053419531 -1.1081318849 
          553           554           555           556 
-2.0596752000 -1.7333945050 -1.2526045983 -0.4123329354 
          557           558           559           560 
-0.2022870937 -1.3085734372 -1.2525414194 -0.6042919523 
          561           562           563           564 
-0.0019982608  0.2001456071 -0.3485734149 -1.4943641271 
          565           566           567           568 
-0.6625391003 -0.6469246750  0.1087084119 -1.2905721369 
          569           570           571           572 
-0.3399864644 -0.9067003312  0.3996680023 -0.3237908305 
          573           574           575           576 
-1.3615332034 -0.2071619987 -1.9623161430  0.0640421180 
          577           578           579           580 
-0.2537722700 -0.5244155519 -1.6850952492 -0.1029699149 
          581           582           583           584 
-1.2690011398 -2.1175177550  0.5562174235 -0.1054908824 
          585           586           587           588 
-1.8700078718 -0.3283342679 -1.6926904756 -0.1445083061 
          589           590           591           592 
-1.6957994073  0.6569730549 -0.7730306946  0.1993985239 
          593           594           595           596 
 0.7446167473 -0.7258890392 -1.3726978463 -0.4335657621 
          597           598           599           600 
-1.1797912268 -0.2216491909 -1.0011720061 -0.0135862770 
          601           602           603           604 
 0.5876878844  0.9359042617  0.5443176126 -0.3359218048 
          605           606           607           608 
-2.1924553074 -1.2463783382 -0.2301573743  0.3901048712 
          609           610           611           612 
 0.1331077555 -0.6336221679 -2.6077232914  0.4415208291 
          613           614           615           616 
 0.8170389288 -0.7936000290  0.6704720088 -0.2222530792 
          617           618           619           620 
-2.1110433654 -0.8050959589  0.5711345418 -0.3544272586 
          621           622           623           624 
-2.2100059489 -0.2589390351 -2.1814782375 -0.8480121945 
          625           626           627           628 
 0.7409724541  0.5906306427 -0.6283292519 -0.9729511750 
          629           630           631           632 
-0.4390394944 -0.6079666256  0.0590294804 -0.6047905484 
          633           634           635           636 
 0.6284139800 -0.5961917968  0.4632334711 -0.6262808033 
          637           638           639           640 
 0.4908473112 -0.0571933066  0.8868462960  1.1303239542 
          641           642           643           644 
 0.1380009328 -0.5866168787  0.2752527652 -0.4727814223 
          645           646           647           648 
```

```
 0.7728213770 -1.2383288243  1.2309629933  1.0488566497 
          649           650           651           652 
 1.0578573168 -2.3392469892  1.1085553589 -1.9136561782 
          653           654           655           656 
-1.6331998932  0.5904892823  0.8847280179  0.8859567833 
          657           658           659           660 
-1.0881130702  0.7761438955 -0.6841517904  1.0398314394 
          661           662           663           664 
 0.8596160325 -1.1639933024  0.8771908537  0.8369807832 
          665           666           667           668 
-0.5913551540 -0.7235241265 -2.0578240045  0.6172993016 
          669           670           671           672 
-1.6696416625 -1.7459301006  0.7223626015 -0.4367739093 
          673           674           675           676 
-1.4892699186 -0.5743401338 -1.3051963432  0.9382055997 
          677           678           679           680 
-0.9147455136 -0.9825514531  0.4001618451  1.2340094820 
          681           682           683           684 
 0.3042052453  0.7418688177  0.7509393202  0.9923666941 
          685           686           687           688 
 0.8629206691 -0.6631526726 -2.0931507459  1.2599438703 
          689           690           691           692 
-2.2436017450 -0.7417920467 -0.8757100001 -1.9151201241 
          693           694           695           696 
 1.1554607178  0.3019818889  0.6587042395  0.6250257803 
          697           698           699           700 
-0.7866572331 -0.9169160002  0.7603704444 -2.6507610851 
          701           702           703           704 
-1.7933936830  0.6752449541 -0.2953336770  0.9732663346 
          705           706           707           708 
-1.9457889203 -2.2372192760  0.5918503653  1.4446128214 
          709           710           711           712 
-1.5313889477  0.8624536927  1.0128105491  0.9135417583 
          713           714           715           716 
-0.9423081130 -1.7886270689 -0.9391285940  1.2793101431 
          717           718           719           720 
-0.8411616962 -2.2418540937 -0.7549181528  1.0458613870 
          721           722           723           724 
 0.8891289709 -1.0970839532 -0.3654296404  0.6298720257 
          725           726           727           728 
 0.7134512801  0.6449045409 -0.9655150318 -0.5797230921 
          729           730           731           732 
 0.7814872851  0.6669375555  0.4641409466 -0.9771249319 
          733           734           735           736 
-2.0966467415  0.7312455414  0.6776832188  0.3623109519 
          737           738           739           740 
-0.4878262926  0.0640305683 -0.0997679222  0.3996253336 
          741           742           743           744 
 1.3538592158  0.4939930685  0.6192689070  0.5621829856 
          745           746           747           748 
-0.5530852662  0.2175736660 -2.8231356286 -1.1413734233 
          749           750           751           752 
-0.4624681265 -0.1940502624  0.2680455510  0.3710121175 
          753           754           755           756 
```

```
  0.8175013051  1.1822086084  0.6480726877 -0.2260991027
           757           758           759           760
 -1.0699273908 -0.4088991525  0.0478382211  0.4198606834
           761           762           763           764
  0.3793188160  0.1381357850 -0.7269295041 -2.8477170028
           765           766           767           768
 -1.4132349339 -0.3792732667  0.0525114729  0.2422738679
           769           770           771           772
 -0.1678364179 -1.9908602692 -1.0807055720 -1.0149014095
           773           774           775           776
 -0.3451730450  0.7540276259 -2.1737746380  0.2307041037
           777           778           779           780
 -0.2623555256  0.6450038036 -0.6181563025  0.4300305507
           781           782           783           784
  0.0524242760 -0.6418290682  0.0930888162  0.2464019907
           785           786           787           788
 -0.8671298217 -0.6706094095  0.8190723398  0.6720962015
           789           790           791           792
 -0.7023442669  0.6647082948  0.5946011624 -0.2688011479
           793           794           795           796
 -2.1986540133 -0.0153535406 -0.8566078129 -0.4996499407
           797           798           799           800
 -0.1676128496 -0.8712670810 -1.5693705726 -0.4642189642
           801           802           803           804
 -0.3839161567  0.1873165769  0.6404445235 -0.7876413592
           805           806           807           808
  1.0373933402  1.1090586942 -0.3583292752  0.7409541272
           809           810           811           812
 -0.7166002456  0.1873165769 -0.6382087061  0.6731946540
           813           814           815           816
  0.6480045724 -0.1073449862 -2.0558946345 -0.7871298555
           817           818           819           820
 -0.0631887911  0.3466862886  0.7645908965  0.2805946446
           821           822           823           824
 -1.1517662863  0.1150381953  0.4634315655 -0.7597026763
           825           826           827           828
  0.2732098153  0.7397334421 -1.0759234382 -0.0264231854
           829           830           831           832
  1.4544528729  0.6105509089 -0.5273570379 -0.8137882115
           833           834           835           836
 -0.1835353845 -0.1921681714 -1.6304944119 -1.3985630963
           837           838           839           840
  0.3937790309  0.9103358697 -0.5105525851  0.1992271511
           841           842           843           844
  0.4651604680  0.0867852180 -1.2089986220  1.0451221707
           845           846           847           848
  1.1882212805  1.5974083702  1.5403982184  0.8600516392
           849           850           851           852
  0.3333700893 -0.5241969854  0.6911189842  0.0470634255
           853           854           855           856
  1.1779029957  1.0327105705  0.2989885277  1.4432139885
           857           858           859           860
  0.2030574008 -0.1533581802  1.2123472847 -1.3015711719
           861           862           863           864
```

```
 0.2438343054  0.1463540917  1.4947441506  0.8289983215
          865           866           867           868
 0.4939220673  0.8165482806  0.5532622016  0.5032042425
          869           870           871           872
 0.5355430713 -0.0873108442 -0.1822957489  0.6175480560
          873           874           875           876
 0.2029885629  1.0483288277  0.2941017900 -0.5537702293
          877           878           879           880
 1.0764988777  0.6607024101  1.0633166506  0.5675600532
          881           882           883           884
-0.8190798589 -0.3956228605  1.3737394368  0.2896157541
          885           886           887           888
-0.3964684310 -0.3228466899 -0.7821474102  0.6147872260
          889           890           891           892
-0.3667243627  0.1721030451 -1.5522493624 -1.6252897082
          893           894           895           896
 0.7067495195 -0.1072524701 -0.0456208616  1.1578161210
          897           898           899           900
 1.0155734267  0.6217848080  1.7389188802 -0.8754179626
          901           902           903           904
 0.6785088575  0.0366846549  1.4167086587 -0.8949633416
          905           906           907           908
 0.1059225122 -0.9773946023  0.2198333120 -0.0689841155
          909           910           911           912
-0.2944564519  0.2296630311 -0.0946562793 -1.0042563833
          913           914           915           916
 0.6876519275  0.0341397424  0.2877092405 -0.3358674744
          917           918           919           920
 1.3778806333  0.3797671270 -1.1847025263 -0.0714137974
          921           922           923           924
-0.2413817567 -1.3421093968  0.2813848051  0.5757920914
          925           926           927           928
 0.0206903392 -0.2560675978 -0.5182827655 -0.1567908632
          929           930           931           932
-0.8583946510 -0.5095000130 -0.3429611435 -1.0644200073
          933           934           935           936
-0.4036858654 -1.4971059103 -0.4142312600 -0.0525492649
          937           938           939           940
 1.0460835181  0.2979168969 -0.5531054792  1.0360405408
          941           942           943           944
 0.6816806226  0.8437213116  0.2809210888 -0.8055093081
          945           946           947           948
-0.3895351859  1.3682042851  0.2933817288 -0.3958897822
          949           950           951           952
-0.3176855807 -0.7798411163  0.4363646536 -0.3590758193
          953           954           955           956
 0.1826096898 -1.5590982553 -1.6177380130  0.7220713643
          957           958           959           960
-0.1060439546 -0.0623445976  1.1434137331  1.0279639632
          961           962           963           964
 0.6219739411  1.7222006703 -0.8751836776  0.6804198885
          965           966           967           968
 0.0217123632  1.4222012669 -0.8900473583  0.1056662027
          969           970           971           972
```

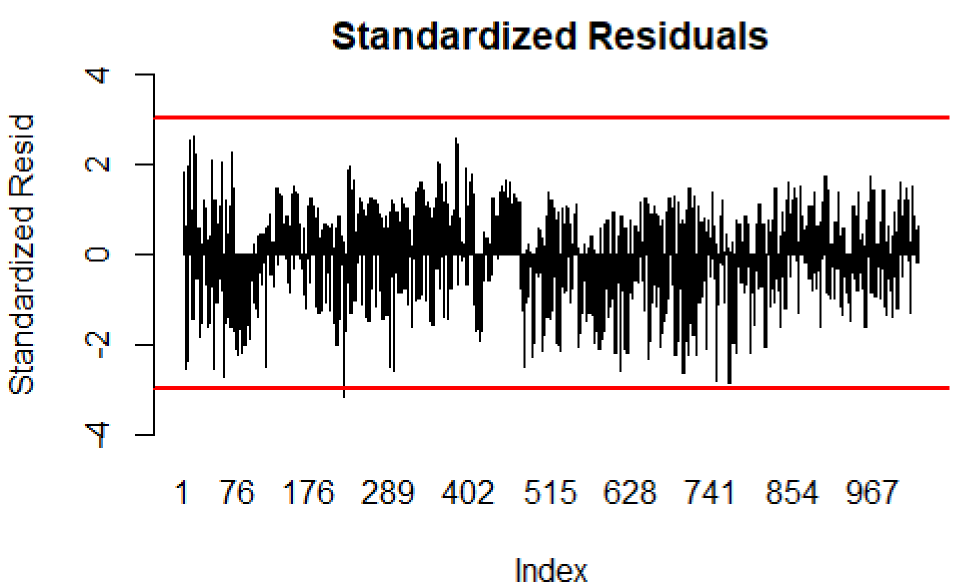
```
-0.9686405692  0.1990921244 -0.0753524520 -0.2840843573
          973           974           975           976
 0.2248523515 -0.1098799109 -0.9999018177  0.6849829040
          977           978           979           980
 0.0296118939  0.2915276938 -0.3457859171  1.3938277402
          981           982           983           984
 0.3772569412 -1.1861041489 -0.0665967889 -0.2568054825
          985           986           987           988
-1.3368788986  0.2601961749  0.6100905342 -0.5268990155
          989           990           991           992
-0.8155739446 -0.1732524725 -0.2027055771 -1.2197462924
          993           994           995           996
-1.3853184498  0.3854641292  0.9178825001 -0.5038357601
          997           998           999          1000
 0.1985790770  0.4652780312  0.0972177771 -1.2016722295
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = stdres(lm1), names.arg = 1:1030,
        main = "Standardized Residuals", xlab = "Index",
        ylab = "Standardized Resid", ylim=c(-4,4))
#Add cutoff values. Either 2 or 3 can be chosen.
abline(h=3, col = "Red", lwd=2)
```

Hide

```
abline(h=-3, col = "Red", lwd=2)
```



Hide

```
#studentized residuals
print("studentized residuals:")
```

```
[1] "studentized residuals:"
```

Hide

```
studres(lm1)
```

```
            1             2             3             4 
 1.8140963080  0.6061404825 -1.5293903541 -2.5415891049 
            5             6             7             8 
-1.5070813060  1.9330842411 -2.3974088623  0.7443441293 
            9            10            11            12 
 2.5311331284  0.8362287826  0.9723624499  0.7002984203 
           13            14            15            16 
-1.4603619575  1.6780493644  2.6244496691  2.1980442314 
           17            18            19            20 
 0.9439750003 -0.5594321882  0.4187254380 -0.5694144526 
           21            22            23            24 
-0.5529547787  0.5795947309 -1.8609315144  0.3558977112 
           25            26            27            28 
-0.8974528818  0.2253085049 -1.5355905000  1.2004044079 
           29            30            31            32 
 0.7518765841  1.0099007608 -0.5586893676 -0.6696199520 
           33            34            35            36 
 0.2922527034 -1.6186751288 -0.4794125920 -1.5305458455 
           37            38            39            40 
 0.3829150125  0.2514806846  0.3987604239 -0.7174753192 
           41            42            43            44 
 2.0740241350 -2.4815580696 -2.5600286600  1.2100986348 
           45            46            47            48 
 0.4213609337  0.7715298636 -1.0737398457 -0.5631143361 
           49            50            51            52 
 0.2215328822  0.6396101498 -0.5660545134  1.0568954964 
           53            54            55            56 
-0.0089010980  2.0394065539 -0.8266973315 -0.6703913646 
           57            58            59            60 
-2.7183965469 -1.5067992607  1.1757810700  0.5065320904 
           61            62            63            64 
 0.4367918418  0.3022676669 -1.3953196810  0.3512062743 
           65            66            67            68 
 1.0660617366  0.4220266567 -1.6308248972  0.4729360795 
           69            70            71            72 
 2.2447178537  1.4739051499 -1.2761314478 -1.6902545666 
           73            74            75            76 
-1.6439737665 -1.4616710675 -2.1202107871 -1.1763987046 
           77            78            79            80 
-2.2258501583 -1.6439737665 -1.5512806935 -1.6240226632 
           81            82            83            84 
-1.6439737665 -2.1957107488 -0.6090617874 -1.2010258976 
           85            86            87            88 
-1.9047692107 -2.0239481976 -1.2010258976 -1.9818262522 
           89            90            91            92 
-1.2010258976 -1.1269987427 -1.5833369628 -1.2010258976 
           93            94            95            96 
-1.8655029792 -0.3006685828 -0.4434716914 -0.3336457977 
           97            98            99           100 
-0.6111116258 -0.6477595538  0.2126119872 -1.0833950355 
          101           102           103           104 
-0.3336457977 -0.9298201864 -1.2016073388 -0.3336457977 
          105           106           107           108 
```

```
-1.4045212794  0.3793198074  0.4336466443 -0.0423564904
          109           110           111           112
-0.3970330967  0.4336466443 -0.6823439250  0.4336466443
          113           114           115           116
 0.1660110196 -0.1829140530 -2.5157026907 -0.7972797135
          117           118           119           120
 0.5807173302  0.6289637279  0.2551946463  0.2730449789
          121           122           123           124
-0.0348985932  0.8643830549 -0.4666745308  0.2551946463
          125           126           127           128
 0.1657108870 -0.7051099693  0.2551946463  0.1937263675
          129           130           131           132
 1.1546587351  1.2592489873  1.4636896635 -0.2326762990
          133           134           135           136
 1.2592489873  1.3442463099  1.2592489873  0.6272237043
          137           138           139           140
 0.6198294219  1.2592489873  0.2156355391  0.4306878312
          141           142           143           144
 0.6721661940  0.2228356228  0.1757525014 -0.0951116524
          145           146           147           148
 0.8149795792 -0.6196685070  0.2228356228  0.1938171244
          149           150           151           152
-0.8438569500  0.2228356228  0.6285537927  1.1819679453
          153           154           155           156
 1.3300077555  1.4954907978 -0.3417785696  1.3300077555
          157           158           159           160
 1.3794243115  1.3300077555  0.6928083972  0.6151795663
          161           162           163           164
 1.3300077555  0.6432635775  0.1454996794  0.3984410531
          165           166           167           168
-0.1042886590 -0.0909679086 -0.3239035686  0.5477055352
          169           170           171           172
-0.9199506348 -0.1042886590 -0.0194917494 -1.2076036337
          173           174           175           176
-0.1042886590  0.3739730416  0.9082164038  1.0658889675
          177           178           179           180
-0.6142290867  1.0658889675  1.2326711841  1.0658889675
          181           182           183           184
 0.4075823479  0.4213564025  1.0658889675  0.7973743952
          185           186           187           188
-1.1659505958  0.3987122214  0.2920484239  0.4606115041
          189           190           191           192
 1.0167987014 -1.3048231642  0.1969965925  0.1225977335
          193           194           195           196
 0.3374930151  0.5277500266 -1.2628782982  0.2232911643
          197           198           199           200
 0.1475274995  0.6639325510  0.4864695105 -1.0806662797
          201           202           203           204
-0.4248804306  0.0200697188  0.5917339242  0.5691114621
          205           206           207           208
-1.2795749890 -0.2613890274  0.0382650521  0.6658302596
          209           210           211           212
 0.6659717220 -1.5446841002 -0.2282355769  0.1267981388
          213           214           215           216
```

```
 0.5472430737  0.4194567548 -2.0134935667 -0.2813295795
          217           218           219           220
 0.1857782031  0.8313093084  0.5033854472 -1.4268327435
          221           222           223           224
 0.3852319765 -0.2144039818  0.2512707816  0.2458944172
          225           226           227           228
-3.2053322901 -1.7207687633 -1.0975136272 -0.5152460439
          229           230           231           232
-0.4199823740 -0.6324134592  0.6344956640  1.8467358187
          233           234           235           236
 1.9354071528  1.6841489903 -1.2985644443 -0.7708226569
          237           238           239           240
 1.3918049513  1.6536317184  1.3888813277 -1.0483938952
          241           242           243           244
-0.0005702593  0.0951429458  0.4905077092  0.8707004575
          245           246           247           248
-0.1990533508  0.3391333407  0.6535032473  1.2113281200
          249           250           251           252
 1.1220962121 -1.1440749732  0.1278663833  0.4248569205
          253           254           255           256
 0.9737999454  0.8328581523 -1.4103081478  0.0531613645
          257           258           259           260
 0.4397331653  1.1118356336  0.6556372913 -1.4836334734
          261           262           263           264
-0.0895380271  0.9344885383  1.2237608541  1.0058707031
          265           266           267           268
-0.7489834927  0.4198766512  0.9270846048  1.1742157189
          269           270           271           272
 0.9069895892 -1.1713383413  0.0669754605  0.6042723204
          273           274           275           276
 1.0887149586  0.8598142233 -0.8298024492  0.4920801543
          277           278           279           280
 0.3090661813  0.6930920913  0.7759097870 -1.4242599089
          281           282           283           284
-0.1017718942  0.5869713471  0.6465850560  0.8111269054
          285           286           287           288
-1.3502472377 -0.4247867115  0.1002157078  0.5492096905
          289           290           291           292
 0.9063121249 -2.4897238264 -0.4945556119  0.3937997104
          293           294           295           296
 1.1808433869  1.1105870524 -2.6080863097 -0.3948420917
          297           298           299           300
 0.2478575196  0.6796274397  0.9388004538 -0.8516320072
          301           302           303           304
 0.2769933081  0.1286117221  0.7146055656  0.5378848960
          305           306           307           308
-0.8422685333  0.8514941020  1.2171342004  1.1212046815
          309           310           311           312
 0.9788103706 -0.7770066342  0.3517862824  0.6166599732
          313           314           315           316
 1.0282850455  0.7971369837 -1.1230622195  0.0573998204
          317           318           319           320
-0.0429425804  0.5411604792  0.1545214395 -1.6210051299
          321           322           323           324
```

```
-0.1715439798 -0.1091723243  0.5958140420  0.8334692939
          325           326           327           328
-1.0327563368  0.8532425903  1.3662232544  1.4486127708
          329           330           331           332
 1.3282713345 -0.9971919596  0.6836857452  1.3476067483
          333           334           335           336
 1.6082001509  1.5407503746 -0.8891361398  0.4617871678
          337           338           339           340
 1.3322903670  1.4329260790  1.0724277192 -1.0213601125
          341           342           343           344
 0.3875554793  1.1098891337  1.1535763067  1.0211997961
          345           346           347           348
-1.4930076065  0.1538613703  0.5769180702  0.8060854781
          349           350           351           352
 0.5894449450 -1.5542182313  0.1161109968  1.0251146966
          353           354           355           356
 1.1457101308  1.2380433068 -0.3288019468  1.0680540125
          357           358           359           360
 2.0518141461  1.9910782474  1.5113102353 -0.7596907697
          361           362           363           364
-0.0498913783  1.3863384395  1.5394622148  1.1581173012
          365           366           367           368
-1.4110942198  0.6190799175  1.5717937843  1.3934641283
          369           370           371           372
 1.1026212114 -1.4568636906 -0.2795162829 -0.0046168814
          373           374           375           376
 0.3495202012  0.6217241524 -0.7742863000  0.2290906184
          377           378           379           380
 0.7230363753  0.8183288927  0.9184990473  0.9763868079
          381           382           383           384
 0.2259003320  2.5784947149  1.2330952674  2.4342451384
          385           386           387           388
-0.6674152328  0.7792278074  0.6978772516  0.2171733358
          389           390           391           392
 0.2375172618  0.1862005773 -0.1318669694 -0.0405649919
          393           394           395           396
-0.0037571367  0.2258144711  1.5304252882  1.9125618881
          397           398           399           400
-0.6702167867  0.4025608711  1.0254926421  1.0400716511
          401           402           403           404
 1.5906539920  0.9381679656  0.9505538302  1.1444008441
          405           406           407           408
 1.7489279830  1.3383201115 -0.8247335497 -1.1082172779
          409           410           411           412
-0.8007363536 -1.6980271372 -0.5304936451 -0.5542105477
          413           414           415           416
-1.6262680754 -1.6735916288 -1.4173818857 -1.9443752504
          417           418           419           420
-1.7122442223 -1.2253346397 -1.5459985923 -0.6026345995
          421           422           423           424
 0.2408790288  0.4971615814  0.1217042416  0.2679693299
          425           426           427           428
 0.3533903781  0.2177060949 -0.1990244774 -0.5932451193
          429           430           431           432
```

```
   0.1811671981 -0.2041907312  0.2246750738 -0.4716662627
            433           434           435           436
   0.3496595885  1.2434601927  0.7864258537  0.8177435874
            437           438           439           440
   0.4960445710  0.6743461700  0.8273016608  0.4252210547
            441           442           443           444
  -0.1162440398  0.3009491399  0.9985270967  1.3575128921
            445           446           447           448
   0.7023768356  1.0569990817  1.5008326465  1.2564814565
            449           450           451           452
   1.3534268617  0.3860609543  1.6264747486  1.4770670440
            453           454           455           456
   1.0451710050  0.2809774002  1.1709100647  1.2118654019
            457           458           459           460
   1.5753206706  0.9376357237  0.6940167326  1.1098615905
            461           462           463           464
   0.8781367091  1.0123807923  0.0630468815  1.3079397265
            465           466           467           468
   1.2366660016  0.7088576443 -0.0301788197  0.8141904760
            469           470           471           472
   0.8533159113  1.1612296189  0.5263841331  0.2133706354
            473           474           475           476
  -0.7564622257 -0.2337328181 -0.0179306054 -1.2659375758
            477           478           479           480
  -2.3034862132 -2.4907232916  0.0742202592 -1.0697001383
            481           482           483           484
  -0.9569917644  0.1907132065 -0.1613690323 -0.2265575813
            485           486           487           488
  -0.2254614884 -0.0298945895 -0.2983258802 -0.2336993521
            489           490           491           492
  -2.2941746651 -1.9733259490 -0.9803473389 -0.9113638398
            493           494           495           496
  -0.1283789130 -0.4133991338  0.1170370173 -0.5060904608
            497           498           499           500
   0.5578254703 -0.3928367284  0.5164563572  0.1985572294
            501           502           503           504
   0.3445442674 -2.1742801857 -1.4113875668  0.1793277558
            505           506           507           508
  -1.7735100705 -1.0210002560  0.3125518192  0.8333680508
            509           510           511           512
  -1.4154856754  1.3668177031 -0.7236401802  0.7727356782
            513           514           515           516
  -1.4601827141 -0.7554782451  1.2000097951  0.1403649643
            517           518           519           520
  -1.2789208547 -0.5082816329 -0.0227534934  0.9886990947
            521           522           523           524
  -1.9745543941 -0.6430509306  0.7427040602  0.9224903235
            525           526           527           528
   0.6810746142 -2.0003885555 -2.1653861314 -0.9833695089
            529           530           531           532
  -0.7265230732  1.0042484337  0.8731648852 -0.4283337793
            533           534           535           536
   0.6538475304 -0.8441990635 -0.8185604148  1.0694758992
            537           538           539           540
```

```
  0.9947589048  0.5113008756 -0.0761326836  0.6354394903 
           541           542           543           544 
 -1.0620514182 -0.6917412062 -0.0876315221 -0.7868859618 
           545           546           547           548 
 -0.4419531949  0.2221428983  0.8928065463  0.2320828876 
           549           550           551           552 
  0.6776165268  1.0829431060  0.1052909250 -1.1082557319 
           553           554           555           556 
 -2.0629565575 -1.7351003830 -1.2529541342 -0.4121652786 
           557           558           559           560 
 -0.2021920581 -1.3090306283 -1.2528908404 -0.6041039893 
           561           562           563           564 
 -0.0019972820  0.2000514931 -0.3484234036 -1.4952682492 
           565           566           567           568 
 -0.6623569636 -0.6467403522  0.1086557915 -1.2909934090 
           569           570           571           572 
 -0.3398391646 -0.9066212744  0.3995034827 -0.3236488433 
           573           574           575           576 
 -1.3621033848 -0.2070648751 -1.9650640338  0.0640108764 
           577           578           579           580 
 -0.2536559631 -0.5242292810 -1.6866168224 -0.1029200110 
           581           582           583           584 
 -1.2693809929 -2.1211433103  0.5560292170 -0.1054397838 
           585           586           587           588 
 -1.8723009443 -0.3281907646 -1.6942402524 -0.1444389979 
           589           590           591           592 
 -1.6973608118  0.6567900850 -0.7728782467  0.1993047321 
           593           594           595           596 
  0.7444541726 -0.7257207608 -1.3732932706 -0.4333932845 
           597           598           599           600 
 -1.1800179435 -0.2215459494 -1.0011731572 -0.0135796232 
           601           602           603           604 
  0.5874993899  0.9358473404  0.5441299419 -0.3357758142 
           605           606           607           608 
 -2.1965581538 -1.2467166225 -0.2300506028  0.3899428457 
           609           610           611           612 
  0.1330437089 -0.6334363490 -2.6151694608  0.4413466918 
           613           614           615           616 
  0.8169058131 -0.7934560536  0.6702911639 -0.2221495856 
           617           618           619           620 
 -2.1146293594 -0.8049571471  0.5709459914 -0.3542754422 
           621           622           623           624 
 -2.2142258194 -0.2588206960 -2.1855089123 -0.8478954609 
           625           626           627           628 
  0.7408087100  0.5904422073 -0.6281429297 -0.9729257238 
           629           630           631           632 
 -0.4388658660 -0.6077788460  0.0590006663 -0.6046026089 
           633           634           635           636 
  0.6282276655 -0.5960035141  0.4630552258 -0.6260943003 
           637           638           639           640 
  0.4906647725 -0.0571653828  0.8867534944  1.1304778162 
           641           642           643           644 
  0.1379346214 -0.5864283663  0.2751281447 -0.4726015719 
           645           646           647           648 
```

```
 0.7726688478 -1.2386527733  1.2312740318  1.0489081196
          649           650           651           652
 1.0579190627 -2.3443919977  1.1086797636 -1.9161582856
          653           654           655           656
-1.6345363862  0.5903008437  0.8846338110  0.8858633901
          657           658           659           660
-1.0882112217  0.7759926675 -0.6839734654  1.0398728564
          661           662           663           664
 0.8595060479 -1.1641958447  0.8770917409  0.8368579451
          665           666           667           668
-0.5911667354 -0.7233551815 -2.0610946871  0.6171120965
          669           670           671           672
-1.6711067376 -1.7476857548  0.7221933334 -0.4366007526
          673           674           675           676
-1.4901598426 -0.5741515578 -1.3056467010  0.9381505217
          677           678           679           680
-0.9146723245 -0.9825347923  0.3999971996  1.2343258363
          681           682           683           684
 0.3040700151  0.7417053586  0.7507788436  0.9923592960
          685           686           687           688
 0.8628126686 -0.6629706314 -2.0966287724  1.2603068530
          689           690           691           692
-2.2480512829 -0.7416285631 -0.8756099408 -1.9176294283
          693           694           695           696
 1.1556505600  0.3018474477  0.6585215223  0.6248391703
          697           698           699           700
-0.7865102888 -0.9168444240  0.7602132617 -2.6586267921
          701           702           703           704
-1.7953452110  0.6750649462 -0.2952016215  0.9732411678
          705           706           707           708
-1.9484518041 -2.2416246063  0.5916619587  1.4453831227
          709           710           711           712
-1.5323997275  0.8623454103  1.0128233511  0.9134676803
          713           714           715           716
-0.9422563571 -1.7905583910 -0.9390742593  1.2797095717
          717           718           719           720
-0.8410411362 -2.2462914996 -0.7547590418  1.0459094928
          721           722           723           724
 0.8890376969 -1.0971934593 -0.3652745282  0.6296858449
          725           726           727           728
 0.7132796286  0.6447199694 -0.9654829533 -0.5795345123
          729           730           731           732
 0.7813382025  0.6667561198  0.4639625433 -0.9771032697
          733           734           735           736
-2.1001457065  0.7310788171  0.6775036559  0.3621567609
          737           738           739           740
-0.4876441711  0.0639993323 -0.0997195383  0.3994608250
          741           742           743           744
 1.3544123371  0.4938101093  0.6190818432  0.5619945974
          745           746           747           748
-0.5528971785  0.2174721322 -2.8328311920 -1.1415428393
          749           750           751           752
-0.4622900153 -0.1939587863  0.2679236798  0.3708553824
          753           754           755           756
```

```
 0.8173684168  1.1824391005  0.6478885097 -0.2259940090
          757           758           759           760
-1.0700033137 -0.4087323273  0.0478148418  0.4196912535
          761           762           763           764
 0.3791597292  0.1380694114 -0.7267615228 -2.8576936089
          765           766           767           768
-1.4139262863 -0.3791141925  0.0524858218  0.2421621545
          769           770           771           772
-0.1677565198 -1.9937587256 -1.0807945423 -1.0149163473
          773           774           775           776
-0.3450240985  0.7538682062 -2.1777551301  0.2305971070
          777           778           779           780
-0.2622358538  0.6448192442 -0.6179691581  0.4298588367
          781           782           783           784
 0.0523986673 -0.6416441330  0.0930436128  0.2462886170
          785           786           787           788
-0.8670243886 -0.6704285880  0.8189402279  0.6719156363
          789           790           791           792
-0.7021698776  0.6645264991  0.5944128305 -0.2686789865
          793           794           795           796
-2.2027979614 -0.0153460217 -0.8564960462 -0.4994662615
          797           798           799           800
-0.1675330517 -0.8711642155 -1.5704972111 -0.4640405475
          801           802           803           804
-0.3837558013  0.1872280397  0.6402594303 -0.7874948289
          805           806           807           808
 1.0374320844  1.1091837623 -0.3581762753  0.7407903772
          809           810           811           812
-0.7164294171  0.1872280397 -0.6380233655  0.6730142810
          813           814           815           816
 0.6478203858 -0.1072930102 -2.0591542137 -0.7869831097
          817           818           819           820
-0.0631579625  0.3465368668  0.7644352521  0.2804680135
          821           822           823           824
-1.1519507066  0.1149825906  0.4632532856 -0.7595452539
          825           826           827           828
 0.2730859700  0.7395693069 -1.0760065741 -0.0264102514
          829           830           831           832
 1.4552487929  0.6103632727 -0.5271705211 -0.8136535117
          833           834           835           836
-0.1834485085 -0.1920775142 -1.6318216162 -1.3992189478
          837           838           839           840
 0.3936160347  0.9102594429 -0.5103676513  0.1991334331
          841           842           843           844
 0.4649818887  0.0867430275 -1.2092723265  1.0451694505
          845           846           847           848
 1.1884612514  1.5986248172  1.5414358835  0.8599419146
          849           850           851           852
 0.3332249289 -0.5240107333  0.6909420869  0.0470404232
          853           854           855           856
 1.1781267775  1.0327442320  0.2988551559  1.4439806815
          857           858           859           860
 0.2029620343 -0.1532848253  1.2126265693 -1.3020142433
          861           862           863           864
```

```
 0.2437219630  0.1462839366  1.4956493364  0.8288712531 
          865           866           867           868 
 0.4937391174  0.8164149241  0.5530741068  0.5030201350 
          869           870           871           872 
 0.5353559410 -0.0872684020 -0.1822094192  0.6173608684 
          873           874           875           876 
 0.2028932260  1.0483797028  0.2939701808 -0.5535821143 
          877           878           879           880 
 1.0765827118  0.6605199918  1.0633847523  0.5673715515 
          881           882           883           884 
-0.8189477508 -0.3954593830  1.3743372419  0.2894857811 
          885           886           887           888 
-0.3963047341 -0.3227050202 -0.7819985972  0.6145998508 
          889           890           891           892 
-0.3665688711  0.1720212381 -1.5533229563 -1.6265991426 
          893           894           895           896 
 0.7065761853 -0.1072005379 -0.0455985613  1.1580094442 
          897           898           899           900 
 1.0155890536  0.6215979351  1.7406465946 -0.8753177172 
          901           902           903           904 
 0.6783294479  0.0366667096  1.4174085473 -0.8948760338 
          905           906           907           908 
 0.1058712093 -0.9773731867  0.2197308301 -0.0689504853 
          909           910           911           912 
-0.2943247141  0.2295564634 -0.0946103284 -1.0042605829 
          913           914           915           916 
 0.6874743075  0.0341230390  0.2875799681 -0.3357215013 
          917           918           919           920 
 1.3784879471  0.3796079154 -1.1849369347 -0.0713789946 
          921           922           923           924 
-0.2412704036 -1.3426368524  0.2812578786  0.5756035096 
          925           926           927           928 
 0.0206802087 -0.2559503857 -0.5180970501 -0.1567159480 
          929           930           931           932 
-0.8582839401 -0.5093151927 -0.3428128959 -1.0644894049 
          933           934           935           936 
-0.4035203299 -1.4980177213 -0.4140631494 -0.0525235954 
          937           938           939           940 
 1.0461318724  0.2977839098 -0.5529173907  1.0360778098 
          941           942           943           944 
 0.6815018148  0.8436021676  0.2807943355 -0.8053706878 
          945           946           947           948 
-0.3893733123  1.3687894891  0.2932503810 -0.3957262353 
          949           950           951           952 
-0.3175456617 -0.7796913657  0.4361915827 -0.3589225948 
          953           954           955           956 
 0.1825232217 -1.5601929061 -1.6190218956  0.7219020157 
          957           958           959           960 
-0.1059925942 -0.0623141776  1.1435860660  1.0279925407 
          961           962           963           964 
 0.6217870830  1.7238627811 -0.8750832832  0.6802408391 
          965           966           967           968 
 0.0217017328  1.4229147560 -0.8899567026  0.1056150211 
          969           970           971           972 
```

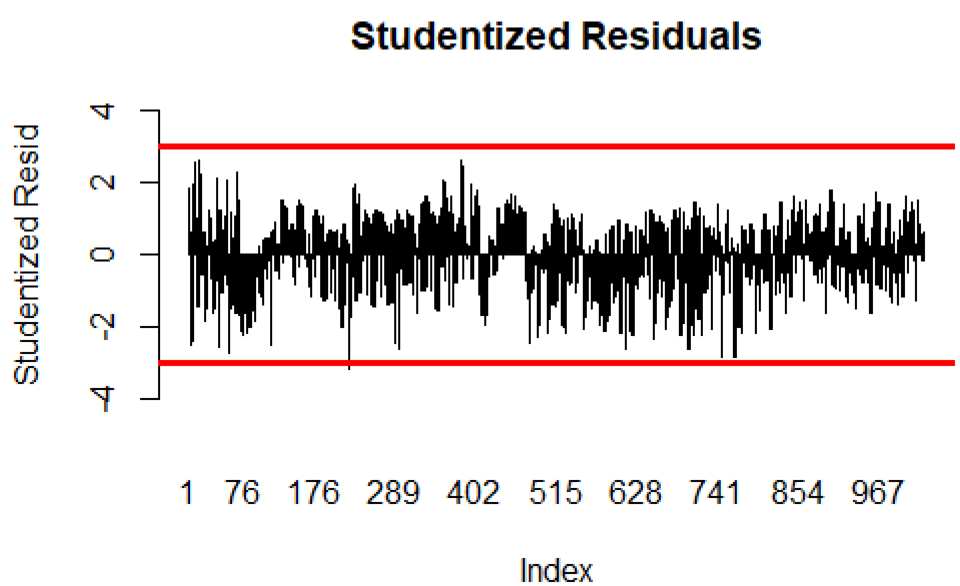
```
-0.9686112571  0.1989984648 -0.0753157510 -0.2839564253 
          973           974           975           976 
 0.2247477754 -0.1098267371 -0.9999017214  0.6848047442 
          977           978           979           980 
 0.0295974017  0.2913970213 -0.3456367779  1.3944723238 
          981           982           983           984 
 0.3770984310 -1.1863407679 -0.0665643119 -0.2566879801 
          985           986           987           988 
-1.3373951050  0.2600773444  0.6099028716 -0.5267125362 
          989           990           991           992 
-0.8154401118 -0.1731701527 -0.2026103616 -1.2200380486 
          993           994           995           996 
-1.3859430171  0.3853033520  0.9178116461 -0.5036515784 
          997           998           999          1000 
 0.1984856389  0.4650994316  0.0971706061 -1.2019338648 
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = studres(lm1), names.arg = 1:1030,
        main = "Studentized Residuals", xlab = "Index",
        ylab = "Studentized Resid", ylim=c(-5,5))
#Add cutoff values. Either 2 or 3 can be chosen.
abline(h=3, col = "Red", lwd=3)
```

Hide

```
abline(h=-3, col = "Red", lwd=3)
```



Hide

```
#R-student residuals
print("R-student residuals:")
```

```
[1] "R-student residuals:"
```

Hide

```
RStudent <- rstudent(lm1)
RStudent
```

```
           1            2            3            4 
 1.8140963080  0.6061404825 -1.5293903541 -2.5415891049 
           5            6            7            8 
-1.5070813060  1.9330842411 -2.3974088623  0.7443441293 
           9           10           11           12 
 2.5311331284  0.8362287826  0.9723624499  0.7002984203 
          13           14           15           16 
-1.4603619575  1.6780493644  2.6244496691  2.1980442314 
          17           18           19           20 
 0.9439750003 -0.5594321882  0.4187254380 -0.5694144526 
          21           22           23           24 
-0.5529547787  0.5795947309 -1.8609315144  0.3558977112 
          25           26           27           28 
-0.8974528818  0.2253085049 -1.5355905000  1.2004044079 
          29           30           31           32 
 0.7518765841  1.0099007608 -0.5586893676 -0.6696199520 
          33           34           35           36 
 0.2922527034 -1.6186751288 -0.4794125920 -1.5305458455 
          37           38           39           40 
 0.3829150125  0.2514806846  0.3987604239 -0.7174753192 
          41           42           43           44 
 2.0740241350 -2.4815580696 -2.5600286600  1.2100986348 
          45           46           47           48 
 0.4213609337  0.7715298636 -1.0737398457 -0.5631143361 
          49           50           51           52 
 0.2215328822  0.6396101498 -0.5660545134  1.0568954964 
          53           54           55           56 
-0.0089010980  2.0394065539 -0.8266973315 -0.6703913646 
          57           58           59           60 
-2.7183965469 -1.5067992607  1.1757810700  0.5065320904 
          61           62           63           64 
 0.4367918418  0.3022676669 -1.3953196810  0.3512062743 
          65           66           67           68 
 1.0660617366  0.4220266567 -1.6308248972  0.4729360795 
          69           70           71           72 
 2.2447178537  1.4739051499 -1.2761314478 -1.6902545666 
          73           74           75           76 
-1.6439737665 -1.4616710675 -2.1202107871 -1.1763987046 
          77           78           79           80 
-2.2258501583 -1.6439737665 -1.5512806935 -1.6240226632 
          81           82           83           84 
-1.6439737665 -2.1957107488 -0.6090617874 -1.2010258976 
          85           86           87           88 
-1.9047692107 -2.0239481976 -1.2010258976 -1.9818262522 
          89           90           91           92 
-1.2010258976 -1.1269987427 -1.5833369628 -1.2010258976 
          93           94           95           96 
-1.8655029792 -0.3006685828 -0.4434716914 -0.3336457977 
          97           98           99          100 
-0.6111116258 -0.6477595538  0.2126119872 -1.0833950355 
         101          102          103          104 
-0.3336457977 -0.9298201864 -1.2016073388 -0.3336457977 
         105          106          107          108 
```

```
-1.4045212794  0.3793198074  0.4336466443 -0.0423564904
          109           110           111           112
-0.3970330967  0.4336466443 -0.6823439250  0.4336466443
          113           114           115           116
 0.1660110196 -0.1829140530 -2.5157026907 -0.7972797135
          117           118           119           120
 0.5807173302  0.6289637279  0.2551946463  0.2730449789
          121           122           123           124
-0.0348985932  0.8643830549 -0.4666745308  0.2551946463
          125           126           127           128
 0.1657108870 -0.7051099693  0.2551946463  0.1937263675
          129           130           131           132
 1.1546587351  1.2592489873  1.4636896635 -0.2326762990
          133           134           135           136
 1.2592489873  1.3442463099  1.2592489873  0.6272237043
          137           138           139           140
 0.6198294219  1.2592489873  0.2156355391  0.4306878312
          141           142           143           144
 0.6721661940  0.2228356228  0.1757525014 -0.0951116524
          145           146           147           148
 0.8149795792 -0.6196685070  0.2228356228  0.1938171244
          149           150           151           152
-0.8438569500  0.2228356228  0.6285537927  1.1819679453
          153           154           155           156
 1.3300077555  1.4954907978 -0.3417785696  1.3300077555
          157           158           159           160
 1.3794243115  1.3300077555  0.6928083972  0.6151795663
          161           162           163           164
 1.3300077555  0.6432635775  0.1454996794  0.3984410531
          165           166           167           168
-0.1042886590 -0.0909679086 -0.3239035686  0.5477055352
          169           170           171           172
-0.9199506348 -0.1042886590 -0.0194917494 -1.2076036337
          173           174           175           176
-0.1042886590  0.3739730416  0.9082164038  1.0658889675
          177           178           179           180
-0.6142290867  1.0658889675  1.2326711841  1.0658889675
          181           182           183           184
 0.4075823479  0.4213564025  1.0658889675  0.7973743952
          185           186           187           188
-1.1659505958  0.3987122214  0.2920484239  0.4606115041
          189           190           191           192
 1.0167987014 -1.3048231642  0.1969965925  0.1225977335
          193           194           195           196
 0.3374930151  0.5277500266 -1.2628782982  0.2232911643
          197           198           199           200
 0.1475274995  0.6639325510  0.4864695105 -1.0806662797
          201           202           203           204
-0.4248804306  0.0200697188  0.5917339242  0.5691114621
          205           206           207           208
-1.2795749890 -0.2613890274  0.0382650521  0.6658302596
          209           210           211           212
 0.6659717220 -1.5446841002 -0.2282355769  0.1267981388
          213           214           215           216
```

```
  0.5472430737  0.4194567548 -2.0134935667 -0.2813295795 
           217           218           219           220 
  0.1857782031  0.8313093084  0.5033854472 -1.4268327435 
           221           222           223           224 
  0.3852319765 -0.2144039818  0.2512707816  0.2458944172 
           225           226           227           228 
 -3.2053322901 -1.7207687633 -1.0975136272 -0.5152460439 
           229           230           231           232 
 -0.4199823740 -0.6324134592  0.6344956640  1.8467358187 
           233           234           235           236 
  1.9354071528  1.6841489903 -1.2985644443 -0.7708226569 
           237           238           239           240 
  1.3918049513  1.6536317184  1.3888813277 -1.0483938952 
           241           242           243           244 
 -0.0005702593  0.0951429458  0.4905077092  0.8707004575 
           245           246           247           248 
 -0.1990533508  0.3391333407  0.6535032473  1.2113281200 
           249           250           251           252 
  1.1220962121 -1.1440749732  0.1278663833  0.4248569205 
           253           254           255           256 
  0.9737999454  0.8328581523 -1.4103081478  0.0531613645 
           257           258           259           260 
  0.4397331653  1.1118356336  0.6556372913 -1.4836334734 
           261           262           263           264 
 -0.0895380271  0.9344885383  1.2237608541  1.0058707031 
           265           266           267           268 
 -0.7489834927  0.4198766512  0.9270846048  1.1742157189 
           269           270           271           272 
  0.9069895892 -1.1713383413  0.0669754605  0.6042723204 
           273           274           275           276 
  1.0887149586  0.8598142233 -0.8298024492  0.4920801543 
           277           278           279           280 
  0.3090661813  0.6930920913  0.7759097870 -1.4242599089 
           281           282           283           284 
 -0.1017718942  0.5869713471  0.6465850560  0.8111269054 
           285           286           287           288 
 -1.3502472377 -0.4247867115  0.1002157078  0.5492096905 
           289           290           291           292 
  0.9063121249 -2.4897238264 -0.4945556119  0.3937997104 
           293           294           295           296 
  1.1808433869  1.1105870524 -2.6080863097 -0.3948420917 
           297           298           299           300 
  0.2478575196  0.6796274397  0.9388004538 -0.8516320072 
           301           302           303           304 
  0.2769933081  0.1286117221  0.7146055656  0.5378848960 
           305           306           307           308 
 -0.8422685333  0.8514941020  1.2171342004  1.1212046815 
           309           310           311           312 
  0.9788103706 -0.7770066342  0.3517862824  0.6166599732 
           313           314           315           316 
  1.0282850455  0.7971369837 -1.1230622195  0.0573998204 
           317           318           319           320 
 -0.0429425804  0.5411604792  0.1545214395 -1.6210051299 
           321           322           323           324 
```

```
-0.1715439798 -0.1091723243  0.5958140420  0.8334692939 
          325           326           327           328 
-1.0327563368  0.8532425903  1.3662232544  1.4486127708 
          329           330           331           332 
 1.3282713345 -0.9971919596  0.6836857452  1.3476067483 
          333           334           335           336 
 1.6082001509  1.5407503746 -0.8891361398  0.4617871678 
          337           338           339           340 
 1.3322903670  1.4329260790  1.0724277192 -1.0213601125 
          341           342           343           344 
 0.3875554793  1.1098891337  1.1535763067  1.0211997961 
          345           346           347           348 
-1.4930076065  0.1538613703  0.5769180702  0.8060854781 
          349           350           351           352 
 0.5894449450 -1.5542182313  0.1161109968  1.0251146966 
          353           354           355           356 
 1.1457101308  1.2380433068 -0.3288019468  1.0680540125 
          357           358           359           360 
 2.0518141461  1.9910782474  1.5113102353 -0.7596907697 
          361           362           363           364 
-0.0498913783  1.3863384395  1.5394622148  1.1581173012 
          365           366           367           368 
-1.4110942198  0.6190799175  1.5717937843  1.3934641283 
          369           370           371           372 
 1.1026212114 -1.4568636906 -0.2795162829 -0.0046168814 
          373           374           375           376 
 0.3495202012  0.6217241524 -0.7742863000  0.2290906184 
          377           378           379           380 
 0.7230363753  0.8183288927  0.9184990473  0.9763868079 
          381           382           383           384 
 0.2259003320  2.5784947149  1.2330952674  2.4342451384 
          385           386           387           388 
-0.6674152328  0.7792278074  0.6978772516  0.2171733358 
          389           390           391           392 
 0.2375172618  0.1862005773 -0.1318669694 -0.0405649919 
          393           394           395           396 
-0.0037571367  0.2258144711  1.5304252882  1.9125618881 
          397           398           399           400 
-0.6702167867  0.4025608711  1.0254926421  1.0400716511 
          401           402           403           404 
 1.5906539920  0.9381679656  0.9505538302  1.1444008441 
          405           406           407           408 
 1.7489279830  1.3383201115 -0.8247335497 -1.1082172779 
          409           410           411           412 
-0.8007363536 -1.6980271372 -0.5304936451 -0.5542105477 
          413           414           415           416 
-1.6262680754 -1.6735916288 -1.4173818857 -1.9443752504 
          417           418           419           420 
-1.7122442223 -1.2253346397 -1.5459985923 -0.6026345995 
          421           422           423           424 
 0.2408790288  0.4971615814  0.1217042416  0.2679693299 
          425           426           427           428 
 0.3533903781  0.2177060949 -0.1990244774 -0.5932451193 
          429           430           431           432 
```

```
 0.1811671981 -0.2041907312  0.2246750738 -0.4716662627 
          433           434           435           436 
 0.3496595885  1.2434601927  0.7864258537  0.8177435874 
          437           438           439           440 
 0.4960445710  0.6743461700  0.8273016608  0.4252210547 
          441           442           443           444 
-0.1162440398  0.3009491399  0.9985270967  1.3575128921 
          445           446           447           448 
 0.7023768356  1.0569990817  1.5008326465  1.2564814565 
          449           450           451           452 
 1.3534268617  0.3860609543  1.6264747486  1.4770670440 
          453           454           455           456 
 1.0451710050  0.2809774002  1.1709100647  1.2118654019 
          457           458           459           460 
 1.5753206706  0.9376357237  0.6940167326  1.1098615905 
          461           462           463           464 
 0.8781367091  1.0123807923  0.0630468815  1.3079397265 
          465           466           467           468 
 1.2366660016  0.7088576443 -0.0301788197  0.8141904760 
          469           470           471           472 
 0.8533159113  1.1612296189  0.5263841331  0.2133706354 
          473           474           475           476 
-0.7564622257 -0.2337328181 -0.0179306054 -1.2659375758 
          477           478           479           480 
-2.3034862132 -2.4907232916  0.0742202592 -1.0697001383 
          481           482           483           484 
-0.9569917644  0.1907132065 -0.1613690323 -0.2265575813 
          485           486           487           488 
-0.2254614884 -0.0298945895 -0.2983258802 -0.2336993521 
          489           490           491           492 
-2.2941746651 -1.9733259490 -0.9803473389 -0.9113638398 
          493           494           495           496 
-0.1283789130 -0.4133991338  0.1170370173 -0.5060904608 
          497           498           499           500 
 0.5578254703 -0.3928367284  0.5164563572  0.1985572294 
          501           502           503           504 
 0.3445442674 -2.1742801857 -1.4113875668  0.1793277558 
          505           506           507           508 
-1.7735100705 -1.0210002560  0.3125518192  0.8333680508 
          509           510           511           512 
-1.4154856754  1.3668177031 -0.7236401802  0.7727356782 
          513           514           515           516 
-1.4601827141 -0.7554782451  1.2000097951  0.1403649643 
          517           518           519           520 
-1.2789208547 -0.5082816329 -0.0227534934  0.9886990947 
          521           522           523           524 
-1.9745543941 -0.6430509306  0.7427040602  0.9224903235 
          525           526           527           528 
 0.6810746142 -2.0003885555 -2.1653861314 -0.9833695089 
          529           530           531           532 
-0.7265230732  1.0042484337  0.8731648852 -0.4283337793 
          533           534           535           536 
 0.6538475304 -0.8441990635 -0.8185604148  1.0694758992 
          537           538           539           540 
```

```
 0.9947589048  0.5113008756 -0.0761326836  0.6354394903
          541           542           543           544
-1.0620514182 -0.6917412062 -0.0876315221 -0.7868859618
          545           546           547           548
-0.4419531949  0.2221428983  0.8928065463  0.2320828876
          549           550           551           552
 0.6776165268  1.0829431060  0.1052909250 -1.1082557319
          553           554           555           556
-2.0629565575 -1.7351003830 -1.2529541342 -0.4121652786
          557           558           559           560
-0.2021920581 -1.3090306283 -1.2528908404 -0.6041039893
          561           562           563           564
-0.0019972820  0.2000514931 -0.3484234036 -1.4952682492
          565           566           567           568
-0.6623569636 -0.6467403522  0.1086557915 -1.2909934090
          569           570           571           572
-0.3398391646 -0.9066212744  0.3995034827 -0.3236488433
          573           574           575           576
-1.3621033848 -0.2070648751 -1.9650640338  0.0640108764
          577           578           579           580
-0.2536559631 -0.5242292810 -1.6866168224 -0.1029200110
          581           582           583           584
-1.2693809929 -2.1211433103  0.5560292170 -0.1054397838
          585           586           587           588
-1.8723009443 -0.3281907646 -1.6942402524 -0.1444389979
          589           590           591           592
-1.6973608118  0.6567900850 -0.7728782467  0.1993047321
          593           594           595           596
 0.7444541726 -0.7257207608 -1.3732932706 -0.4333932845
          597           598           599           600
-1.1800179435 -0.2215459494 -1.0011731572 -0.0135796232
          601           602           603           604
 0.5874993899  0.9358473404  0.5441299419 -0.3357758142
          605           606           607           608
-2.1965581538 -1.2467166225 -0.2300506028  0.3899428457
          609           610           611           612
 0.1330437089 -0.6334363490 -2.6151694608  0.4413466918
          613           614           615           616
 0.8169058131 -0.7934560536  0.6702911639 -0.2221495856
          617           618           619           620
-2.1146293594 -0.8049571471  0.5709459914 -0.3542754422
          621           622           623           624
-2.2142258194 -0.2588206960 -2.1855089123 -0.8478954609
          625           626           627           628
 0.7408087100  0.5904422073 -0.6281429297 -0.9729257238
          629           630           631           632
-0.4388658660 -0.6077788460  0.0590006663 -0.6046026089
          633           634           635           636
 0.6282276655 -0.5960035141  0.4630552258 -0.6260943003
          637           638           639           640
 0.4906647725 -0.0571653828  0.8867534944  1.1304778162
          641           642           643           644
 0.1379346214 -0.5864283663  0.2751281447 -0.4726015719
          645           646           647           648
```

```
 0.7726688478 -1.2386527733  1.2312740318  1.0489081196 
          649           650           651           652 
 1.0579190627 -2.3443919977  1.1086797636 -1.9161582856 
          653           654           655           656 
-1.6345363862  0.5903008437  0.8846338110  0.8858633901 
          657           658           659           660 
-1.0882112217  0.7759926675 -0.6839734654  1.0398728564 
          661           662           663           664 
 0.8595060479 -1.1641958447  0.8770917409  0.8368579451 
          665           666           667           668 
-0.5911667354 -0.7233551815 -2.0610946871  0.6171120965 
          669           670           671           672 
-1.6711067376 -1.7476857548  0.7221933334 -0.4366007526 
          673           674           675           676 
-1.4901598426 -0.5741515578 -1.3056467010  0.9381505217 
          677           678           679           680 
-0.9146723245 -0.9825347923  0.3999971996  1.2343258363 
          681           682           683           684 
 0.3040700151  0.7417053586  0.7507788436  0.9923592960 
          685           686           687           688 
 0.8628126686 -0.6629706314 -2.0966287724  1.2603068530 
          689           690           691           692 
-2.2480512829 -0.7416285631 -0.8756099408 -1.9176294283 
          693           694           695           696 
 1.1556505600  0.3018474477  0.6585215223  0.6248391703 
          697           698           699           700 
-0.7865102888 -0.9168444240  0.7602132617 -2.6586267921 
          701           702           703           704 
-1.7953452110  0.6750649462 -0.2952016215  0.9732411678 
          705           706           707           708 
-1.9484518041 -2.2416246063  0.5916619587  1.4453831227 
          709           710           711           712 
-1.5323997275  0.8623454103  1.0128233511  0.9134676803 
          713           714           715           716 
-0.9422563571 -1.7905583910 -0.9390742593  1.2797095717 
          717           718           719           720 
-0.8410411362 -2.2462914996 -0.7547590418  1.0459094928 
          721           722           723           724 
 0.8890376969 -1.0971934593 -0.3652745282  0.6296858449 
          725           726           727           728 
 0.7132796286  0.6447199694 -0.9654829533 -0.5795345123 
          729           730           731           732 
 0.7813382025  0.6667561198  0.4639625433 -0.9771032697 
          733           734           735           736 
-2.1001457065  0.7310788171  0.6775036559  0.3621567609 
          737           738           739           740 
-0.4876441711  0.0639993323 -0.0997195383  0.3994608250 
          741           742           743           744 
 1.3544123371  0.4938101093  0.6190818432  0.5619945974 
          745           746           747           748 
-0.5528971785  0.2174721322 -2.8328311920 -1.1415428393 
          749           750           751           752 
-0.4622900153 -0.1939587863  0.2679236798  0.3708553824 
          753           754           755           756 
```

```
 0.8173684168  1.1824391005  0.6478885097 -0.2259940090
          757           758           759           760
-1.0700033137 -0.4087323273  0.0478148418  0.4196912535
          761           762           763           764
 0.3791597292  0.1380694114 -0.7267615228 -2.8576936089
          765           766           767           768
-1.4139262863 -0.3791141925  0.0524858218  0.2421621545
          769           770           771           772
-0.1677565198 -1.9937587256 -1.0807945423 -1.0149163473
          773           774           775           776
-0.3450240985  0.7538682062 -2.1777551301  0.2305971070
          777           778           779           780
-0.2622358538  0.6448192442 -0.6179691581  0.4298588367
          781           782           783           784
 0.0523986673 -0.6416441330  0.0930436128  0.2462886170
          785           786           787           788
-0.8670243886 -0.6704285880  0.8189402279  0.6719156363
          789           790           791           792
-0.7021698776  0.6645264991  0.5944128305 -0.2686789865
          793           794           795           796
-2.2027979614 -0.0153460217 -0.8564960462 -0.4994662615
          797           798           799           800
-0.1675330517 -0.8711642155 -1.5704972111 -0.4640405475
          801           802           803           804
-0.3837558013  0.1872280397  0.6402594303 -0.7874948289
          805           806           807           808
 1.0374320844  1.1091837623 -0.3581762753  0.7407903772
          809           810           811           812
-0.7164294171  0.1872280397 -0.6380233655  0.6730142810
          813           814           815           816
 0.6478203858 -0.1072930102 -2.0591542137 -0.7869831097
          817           818           819           820
-0.0631579625  0.3465368668  0.7644352521  0.2804680135
          821           822           823           824
-1.1519507066  0.1149825906  0.4632532856 -0.7595452539
          825           826           827           828
 0.2730859700  0.7395693069 -1.0760065741 -0.0264102514
          829           830           831           832
 1.4552487929  0.6103632727 -0.5271705211 -0.8136535117
          833           834           835           836
-0.1834485085 -0.1920775142 -1.6318216162 -1.3992189478
          837           838           839           840
 0.3936160347  0.9102594429 -0.5103676513  0.1991334331
          841           842           843           844
 0.4649818887  0.0867430275 -1.2092723265  1.0451694505
          845           846           847           848
 1.1884612514  1.5986248172  1.5414358835  0.8599419146
          849           850           851           852
 0.3332249289 -0.5240107333  0.6909420869  0.0470404232
          853           854           855           856
 1.1781267775  1.0327442320  0.2988551559  1.4439806815
          857           858           859           860
 0.2029620343 -0.1532848253  1.2126265693 -1.3020142433
          861           862           863           864
```

```
  0.2437219630  0.1462839366  1.4956493364  0.8288712531
           865           866           867           868
  0.4937391174  0.8164149241  0.5530741068  0.5030201350
           869           870           871           872
  0.5353559410 -0.0872684020 -0.1822094192  0.6173608684
           873           874           875           876
  0.2028932260  1.0483797028  0.2939701808 -0.5535821143
           877           878           879           880
  1.0765827118  0.6605199918  1.0633847523  0.5673715515
           881           882           883           884
 -0.8189477508 -0.3954593830  1.3743372419  0.2894857811
           885           886           887           888
 -0.3963047341 -0.3227050202 -0.7819985972  0.6145998508
           889           890           891           892
 -0.3665688711  0.1720212381 -1.5533229563 -1.6265991426
           893           894           895           896
  0.7065761853 -0.1072005379 -0.0455985613  1.1580094442
           897           898           899           900
  1.0155890536  0.6215979351  1.7406465946 -0.8753177172
           901           902           903           904
  0.6783294479  0.0366667096  1.4174085473 -0.8948760338
           905           906           907           908
  0.1058712093 -0.9773731867  0.2197308301 -0.0689504853
           909           910           911           912
 -0.2943247141  0.2295564634 -0.0946103284 -1.0042605829
           913           914           915           916
  0.6874743075  0.0341230390  0.2875799681 -0.3357215013
           917           918           919           920
  1.3784879471  0.3796079154 -1.1849369347 -0.0713789946
           921           922           923           924
 -0.2412704036 -1.3426368524  0.2812578786  0.5756035096
           925           926           927           928
  0.0206802087 -0.2559503857 -0.5180970501 -0.1567159480
           929           930           931           932
 -0.8582839401 -0.5093151927 -0.3428128959 -1.0644894049
           933           934           935           936
 -0.4035203299 -1.4980177213 -0.4140631494 -0.0525235954
           937           938           939           940
  1.0461318724  0.2977839098 -0.5529173907  1.0360778098
           941           942           943           944
  0.6815018148  0.8436021676  0.2807943355 -0.8053706878
           945           946           947           948
 -0.3893733123  1.3687894891  0.2932503810 -0.3957262353
           949           950           951           952
 -0.3175456617 -0.7796913657  0.4361915827 -0.3589225948
           953           954           955           956
  0.1825232217 -1.5601929061 -1.6190218956  0.7219020157
           957           958           959           960
 -0.1059925942 -0.0623141776  1.1435860660  1.0279925407
           961           962           963           964
  0.6217870830  1.7238627811 -0.8750832832  0.6802408391
           965           966           967           968
  0.0217017328  1.4229147560 -0.8899567026  0.1056150211
           969           970           971           972
```

```
-0.9686112571  0.1989984648 -0.0753157510 -0.2839564253 
          973           974           975           976 
 0.2247477754 -0.1098267371 -0.9999017214  0.6848047442 
          977           978           979           980 
 0.0295974017  0.2913970213 -0.3456367779  1.3944723238 
          981           982           983           984 
 0.3770984310 -1.1863407679 -0.0665643119 -0.2566879801 
          985           986           987           988 
-1.3373951050  0.2600773444  0.6099028716 -0.5267125362 
          989           990           991           992 
-0.8154401118 -0.1731701527 -0.2026103616 -1.2200380486 
          993           994           995           996 
-1.3859430171  0.3853033520  0.9178116461 -0.5036515784 
          997           998           999          1000 
 0.1984856389  0.4650994316  0.0971706061 -1.2019338648 
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = RStudent, names.arg = 1:1030,
        main = "R Student Residuals", xlab = "Index",
        ylab = "R Student Resid", ylim=c(-5,5))
cor.level <- 0.05/(2*25)
cor.qt <- qt(cor.level, 21, lower.tail=F)
RStudent> cor.qt
```

```
  1     2     3     4     5     6     7     8     9    10 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   11    12    13    14    15    16    17    18    19    20 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   21    22    23    24    25    26    27    28    29    30 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   31    32    33    34    35    36    37    38    39    40 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   41    42    43    44    45    46    47    48    49    50 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   51    52    53    54    55    56    57    58    59    60 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   61    62    63    64    65    66    67    68    69    70 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   71    72    73    74    75    76    77    78    79    80 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   81    82    83    84    85    86    87    88    89    90 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   91    92    93    94    95    96    97    98    99   100 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  101   102   103   104   105   106   107   108   109   110 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  111   112   113   114   115   116   117   118   119   120 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  121   122   123   124   125   126   127   128   129   130 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  131   132   133   134   135   136   137   138   139   140 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  141   142   143   144   145   146   147   148   149   150 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  151   152   153   154   155   156   157   158   159   160 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  161   162   163   164   165   166   167   168   169   170 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  171   172   173   174   175   176   177   178   179   180 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  181   182   183   184   185   186   187   188   189   190 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  191   192   193   194   195   196   197   198   199   200 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  201   202   203   204   205   206   207   208   209   210 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  211   212   213   214   215   216   217   218   219   220 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  221   222   223   224   225   226   227   228   229   230 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  231   232   233   234   235   236   237   238   239   240 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  241   242   243   244   245   246   247   248   249   250 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  251   252   253   254   255   256   257   258   259   260 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  261   262   263   264   265   266   267   268   269   270 
```

```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  271   272   273   274   275   276   277   278   279   280
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  281   282   283   284   285   286   287   288   289   290
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  291   292   293   294   295   296   297   298   299   300
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  301   302   303   304   305   306   307   308   309   310
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  311   312   313   314   315   316   317   318   319   320
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  321   322   323   324   325   326   327   328   329   330
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  331   332   333   334   335   336   337   338   339   340
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  341   342   343   344   345   346   347   348   349   350
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  351   352   353   354   355   356   357   358   359   360
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  361   362   363   364   365   366   367   368   369   370
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  371   372   373   374   375   376   377   378   379   380
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  381   382   383   384   385   386   387   388   389   390
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  391   392   393   394   395   396   397   398   399   400
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  401   402   403   404   405   406   407   408   409   410
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  411   412   413   414   415   416   417   418   419   420
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  421   422   423   424   425   426   427   428   429   430
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  431   432   433   434   435   436   437   438   439   440
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  441   442   443   444   445   446   447   448   449   450
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  451   452   453   454   455   456   457   458   459   460
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  461   462   463   464   465   466   467   468   469   470
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  471   472   473   474   475   476   477   478   479   480
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  481   482   483   484   485   486   487   488   489   490
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  491   492   493   494   495   496   497   498   499   500
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  501   502   503   504   505   506   507   508   509   510
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  511   512   513   514   515   516   517   518   519   520
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  521   522   523   524   525   526   527   528   529   530
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  531   532   533   534   535   536   537   538   539   540
```

```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  541   542   543   544   545   546   547   548   549   550
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  551   552   553   554   555   556   557   558   559   560
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  561   562   563   564   565   566   567   568   569   570
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  571   572   573   574   575   576   577   578   579   580
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  581   582   583   584   585   586   587   588   589   590
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  591   592   593   594   595   596   597   598   599   600
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  601   602   603   604   605   606   607   608   609   610
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  611   612   613   614   615   616   617   618   619   620
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  621   622   623   624   625   626   627   628   629   630
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  631   632   633   634   635   636   637   638   639   640
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  641   642   643   644   645   646   647   648   649   650
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  651   652   653   654   655   656   657   658   659   660
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  661   662   663   664   665   666   667   668   669   670
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  671   672   673   674   675   676   677   678   679   680
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  681   682   683   684   685   686   687   688   689   690
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  691   692   693   694   695   696   697   698   699   700
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  701   702   703   704   705   706   707   708   709   710
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  711   712   713   714   715   716   717   718   719   720
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  721   722   723   724   725   726   727   728   729   730
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  731   732   733   734   735   736   737   738   739   740
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  741   742   743   744   745   746   747   748   749   750
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  751   752   753   754   755   756   757   758   759   760
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  761   762   763   764   765   766   767   768   769   770
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  771   772   773   774   775   776   777   778   779   780
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  781   782   783   784   785   786   787   788   789   790
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  791   792   793   794   795   796   797   798   799   800
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  801   802   803   804   805   806   807   808   809   810
```

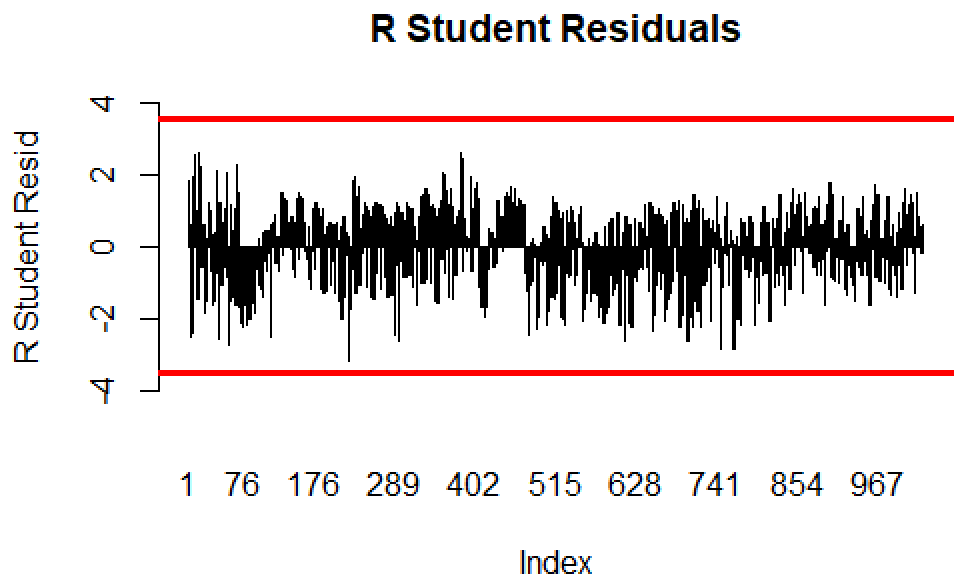
```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  811   812   813   814   815   816   817   818   819   820
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  821   822   823   824   825   826   827   828   829   830
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  831   832   833   834   835   836   837   838   839   840
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  841   842   843   844   845   846   847   848   849   850
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  851   852   853   854   855   856   857   858   859   860
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  861   862   863   864   865   866   867   868   869   870
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  871   872   873   874   875   876   877   878   879   880
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  881   882   883   884   885   886   887   888   889   890
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  891   892   893   894   895   896   897   898   899   900
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  901   902   903   904   905   906   907   908   909   910
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  911   912   913   914   915   916   917   918   919   920
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  921   922   923   924   925   926   927   928   929   930
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  931   932   933   934   935   936   937   938   939   940
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  941   942   943   944   945   946   947   948   949   950
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  951   952   953   954   955   956   957   958   959   960
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  961   962   963   964   965   966   967   968   969   970
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  971   972   973   974   975   976   977   978   979   980
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  981   982   983   984   985   986   987   988   989   990
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  991   992   993   994   995   996   997   998   999  1000
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
abline(h=cor.qt , col = "Red", lwd=3)
```

Hide

```
abline(h=-cor.qt , col = "Red", lwd=3)
```



Diagnostics for Leverage and Influence for Full Model

Hide

```
#influential analysis
myInf <- influence.measures(lm1)
myInf
```

```
Influence measures of
	 lm(formula = csMPa ~ ., data = conc) :
```

	dfb.1_ <dbl>	dfb.cmnt <dbl>	dfb.slag <dbl>	dfb.flys <dbl>	dfb.watr <dbl>	dfb.s <(
1	8.898494e-02	-6.548752e-03	-5.750190e-02	-4.131575e-02	-1.175152e-01	-1.063330e
2	2.190639e-02	4.240779e-03	-1.263369e-02	-8.058517e-03	-3.246416e-02	-3.259633e
3	-2.444197e-02	1.645640e-02	1.046786e-02	1.588697e-02	2.788118e-03	-2.619123e
4	-3.480012e-02	1.966548e-02	3.223385e-03	1.146868e-02	1.207175e-02	-4.135650e
5	3.082927e-02	-2.030218e-02	-5.383306e-02	-3.207318e-02	1.304539e-03	3.345837e
6	3.368617e-02	-5.492674e-02	-5.075131e-02	-6.157406e-02	1.869804e-02	3.202261e
7	-4.778769e-02	2.440131e-02	3.176216e-02	2.536324e-02	2.123697e-02	2.183037e
8	2.093851e-02	-1.558149e-02	-2.446391e-02	-2.333391e-02	1.094822e-03	4.396942e
9	4.803057e-02	-7.700499e-02	-7.567039e-02	-9.037289e-02	2.926193e-02	4.474176e
10	3.394348e-02	-2.159979e-02	-4.744526e-02	-3.635216e-02	-5.590791e-03	4.773081e

1-10 of 1,030 rows | 1-7 of 14 columns Previous 1 2 3 4 5 6 ... 100 Next

Hide

```
summary(myInf)
```

```
Potentially influential observations of
	 lm(formula = csMPa ~ ., data = conc) :

    dfb.1_ dfb.cmnt dfb.slag dfb.flys dfb.watr dfb.sprp
4   -0.03   0.02     0.00     0.01     0.01     0.00
5    0.03  -0.02    -0.05    -0.03     0.00     0.03
7   -0.05   0.02     0.03     0.03     0.02     0.00
9    0.05  -0.08    -0.08    -0.09     0.03     0.04
15   0.06  -0.08    -0.10    -0.11     0.02     0.05
18  -0.01   0.01     0.02     0.01     0.00    -0.01
25  -0.02   0.02     0.04     0.03     0.01    -0.01
26   0.01  -0.01    -0.01    -0.01     0.00     0.00
31  -0.01   0.01     0.01     0.01     0.00    -0.01
32  -0.01   0.01     0.01     0.01     0.00    -0.01
35   0.00   0.01     0.00     0.00     0.00    -0.01
42  -0.06   0.03     0.06     0.04     0.03     0.00
43   0.00   0.01    -0.06    -0.02    -0.01     0.00
57  -0.09   0.04     0.10     0.06     0.05     0.00
67   0.14  -0.11    -0.17    -0.12    -0.09     0.00
69   0.02  -0.06    -0.02    -0.06     0.04     0.04
75  -0.01   0.01     0.02     0.07     0.02    -0.11
77   0.00   0.02     0.05     0.12    -0.04    -0.29
86  -0.03   0.04     0.03     0.09     0.03    -0.13
100  0.00   0.01     0.02     0.06    -0.02    -0.14
109 -0.01   0.01     0.01     0.02     0.01    -0.03
115  0.04  -0.07    -0.08    -0.02    -0.02    -0.03
121  0.00   0.00     0.00     0.00     0.00     0.00
123  0.00   0.00     0.01     0.02    -0.01    -0.06
126  0.00   0.00     0.02     0.03    -0.01    -0.08
132  0.00   0.00     0.00     0.01     0.00    -0.02
144  0.00   0.00     0.00     0.00     0.00     0.00
146  0.00   0.01     0.01     0.03    -0.01    -0.08
149  0.00   0.00     0.02     0.04    -0.01    -0.09
155  0.00   0.01     0.00     0.01     0.00    -0.02
167  0.00   0.00     0.00     0.01     0.00    -0.02
169  0.00   0.01     0.01     0.04    -0.01    -0.12
225 -0.45   0.33     0.29     0.20     0.55     0.37
226 -0.24   0.18     0.16     0.11     0.29     0.20
227 -0.15   0.11     0.10     0.07     0.19     0.13
228 -0.07   0.05     0.05     0.03     0.09     0.06
229 -0.06   0.04     0.04     0.02     0.07     0.05
290  0.04   0.00    -0.02    -0.04    -0.03    -0.03
295  0.01   0.03     0.01     0.00     0.00    -0.06
381  0.02  -0.01    -0.01    -0.01    -0.03    -0.02
382  0.00   0.03     0.05     0.00    -0.07    -0.06
384  0.04  -0.03    -0.08    -0.10    -0.03     0.08
385 -0.09   0.05     0.07     0.06     0.08     0.04
397 -0.09   0.05     0.07     0.06     0.08     0.04
477 -0.05  -0.01     0.03     0.01     0.06     0.01
478 -0.05  -0.01     0.04     0.01     0.06     0.01
489  0.10  -0.12    -0.09    -0.10    -0.08    -0.04
500 -0.02   0.03     0.02     0.03     0.02     0.00
501 -0.01   0.03     0.02     0.03     0.01    -0.02
```

```
502  0.25  -0.33    -0.26    -0.32    -0.25     0.03
503  0.17  -0.21    -0.17    -0.21    -0.16     0.02
504 -0.02   0.03     0.02     0.03     0.02     0.00
507 -0.01   0.03     0.02     0.03     0.01    -0.02
605 -0.06   0.04     0.06     0.05     0.07     0.05
611 -0.03   0.06     0.05     0.05     0.06     0.04
617 -0.04   0.04     0.04     0.04     0.06     0.05
621 -0.01   0.03     0.03     0.03     0.02     0.02
623 -0.07   0.07     0.07     0.06     0.09     0.06
650 -0.01   0.02    -0.04     0.01     0.00     0.03
689  0.00   0.05     0.00     0.04    -0.03     0.00
700 -0.01  -0.01    -0.09    -0.02     0.01     0.07
706  0.00   0.05    -0.01     0.04    -0.02     0.01
718 -0.01   0.04    -0.02     0.03    -0.01     0.01
747  0.17  -0.20    -0.12    -0.12    -0.17    -0.04
756  0.00  -0.01     0.00     0.00     0.01     0.01
757  0.00  -0.04    -0.02    -0.03     0.03     0.05
764 -0.17   0.12     0.17     0.15     0.16     0.12
770  0.00  -0.01     0.00    -0.01     0.03     0.05
793  0.12  -0.12    -0.11    -0.10    -0.07     0.01
815  0.01  -0.01    -0.01    -0.01     0.02     0.04
828  0.00   0.00     0.00     0.00     0.00     0.00
829  0.05   0.05     0.01     0.02    -0.11    -0.18
909 -0.03   0.02     0.01     0.02     0.03     0.02
972 -0.02   0.02     0.01     0.02     0.03     0.02
    dfb.crsg dfb.fngg dfb.age dffit   cov.r   cook.d hat
4    0.04     0.06    -0.37   -0.44_*  0.98    0.02   0.03_*
5   -0.03    -0.05    -0.25   -0.27    1.02    0.01   0.03_*
7    0.05     0.07    -0.34   -0.41_*  0.99    0.02   0.03_*
9   -0.06    -0.08    -0.08    0.23    0.96_*  0.01   0.01
15  -0.07    -0.10    -0.09    0.24    0.96_*  0.01   0.01
18   0.01     0.01    -0.08   -0.09    1.03_*  0.00   0.03_*
25   0.03     0.03    -0.12   -0.15    1.03_*  0.00   0.03_*
26  -0.01    -0.01     0.02    0.03    1.03_*  0.00   0.02
31   0.01     0.01    -0.08   -0.09    1.03_*  0.00   0.03_*
32   0.01     0.01    -0.10   -0.11    1.03_*  0.00   0.03_*
35   0.00     0.00    -0.07   -0.08    1.04_*  0.00   0.03_*
42   0.07     0.09    -0.35   -0.43_*  0.98    0.02   0.03_*
43   0.00     0.03    -0.39   -0.46_*  0.98    0.02   0.03_*
57   0.10     0.12    -0.37   -0.49_*  0.98    0.03   0.03_*
67  -0.14    -0.15    -0.28   -0.34_*  1.03_*  0.01   0.04_*
69  -0.03    -0.05    -0.06    0.21    0.97_*  0.00   0.01
75   0.03    -0.04     0.00   -0.29_*  0.99    0.01   0.02
77   0.00     0.01     0.03   -0.38_*  0.99    0.02   0.03_*
86  -0.04     0.09     0.04   -0.28_*  0.99    0.01   0.02
100  0.00     0.01     0.01   -0.19    1.03_*  0.00   0.03_*
109 -0.01     0.02     0.01   -0.06    1.03_*  0.00   0.02
115 -0.05    -0.04     0.03   -0.18    0.96_*  0.00   0.01
121  0.00     0.00     0.00    0.00    1.03_*  0.00   0.02
123  0.00     0.00     0.00   -0.08    1.04_*  0.00   0.03_*
126  0.01     0.00     0.00   -0.11    1.03_*  0.00   0.03
132  0.00     0.01     0.00   -0.03    1.03_*  0.00   0.02
144  0.00     0.00     0.00   -0.01    1.03_*  0.00   0.02
146  0.00     0.00    -0.01   -0.11    1.04_*  0.00   0.03_*
```

```
149  0.01     0.00    -0.01   -0.14    1.03_*  0.00   0.03
155 -0.01     0.01     0.00   -0.05    1.03_*  0.00   0.02
167  0.00    -0.01    -0.01   -0.05    1.03_*  0.00   0.02
169  0.00     0.00    -0.03   -0.16    1.03_*  0.00   0.03_*
225  0.37     0.39    -0.01   -0.61_*  0.95_*  0.04   0.03_*
226  0.20     0.21    -0.01   -0.33_*  1.02    0.01   0.03_*
227  0.13     0.13    -0.02   -0.21    1.03_*  0.00   0.03_*
228  0.06     0.06    -0.02   -0.10    1.04_*  0.00   0.04_*
229  0.05     0.05    -0.02   -0.08    1.05_*  0.00   0.04_*
290 -0.06    -0.02     0.04   -0.16    0.96_*  0.00   0.00
295 -0.05     0.01     0.03   -0.19    0.96_*  0.00   0.01
381 -0.02    -0.02     0.00    0.04    1.04_*  0.00   0.03_*
382  0.06     0.00     0.01    0.26    0.96_*  0.01   0.01
384 -0.01    -0.06    -0.04    0.21    0.96_*  0.00   0.01
385  0.10     0.07     0.01   -0.11    1.03_*  0.00   0.03_*
397  0.10     0.07     0.01   -0.11    1.03_*  0.00   0.03_*
477  0.04     0.06     0.04   -0.18    0.97_*  0.00   0.01
478  0.04     0.06     0.05   -0.19    0.96_*  0.00   0.01
489 -0.08    -0.11     0.02   -0.19    0.97_*  0.00   0.01
500  0.02     0.02     0.00    0.03    1.04_*  0.00   0.03_*
501  0.00     0.01     0.00    0.05    1.03_*  0.00   0.02
502 -0.20    -0.24     0.05   -0.38_*  1.00    0.02   0.03_*
503 -0.13    -0.16     0.03   -0.25    1.02    0.01   0.03_*
504  0.02     0.02     0.00    0.03    1.04_*  0.00   0.03_*
507  0.00     0.01     0.00    0.04    1.03_*  0.00   0.02
605  0.06     0.03    -0.34   -0.37_*  0.99    0.02   0.03_*
611  0.04    -0.02    -0.42   -0.47_*  0.98    0.02   0.03_*
617  0.05     0.00    -0.33   -0.37_*  1.00    0.01   0.03_*
621  0.02    -0.03    -0.35   -0.39_*  1.00    0.02   0.03_*
623  0.07     0.04    -0.34   -0.38_*  1.00    0.02   0.03_*
650  0.00     0.02     0.06   -0.20    0.97_*  0.00   0.01
689  0.01    -0.02     0.06   -0.20    0.97_*  0.00   0.01
700 -0.01     0.03     0.07   -0.28    0.96_*  0.01   0.01
706  0.01    -0.01     0.06   -0.18    0.97_*  0.00   0.01
718  0.00     0.01     0.06   -0.18    0.97_*  0.00   0.01
747 -0.21    -0.10     0.11   -0.37_*  0.96_*  0.01   0.02
756  0.00     0.00    -0.01   -0.03    1.03_*  0.00   0.02
757 -0.02     0.01    -0.12   -0.18    1.03    0.00   0.03_*
764  0.17     0.15     0.10   -0.26    0.95_*  0.01   0.01
770  0.00    -0.03    -0.31   -0.34_*  1.00    0.01   0.03_*
793 -0.13    -0.14    -0.35   -0.39_*  1.00    0.02   0.03_*
815  0.00    -0.04    -0.33   -0.35_*  1.00    0.01   0.03_*
828  0.00     0.00     0.00    0.00    1.04_*  0.00   0.03_*
829 -0.07     0.00     0.01    0.24    1.02    0.01   0.03_*
909  0.02     0.02     0.00   -0.04    1.03_*  0.00   0.02
972  0.02     0.02     0.00   -0.04    1.03_*  0.00   0.02
```

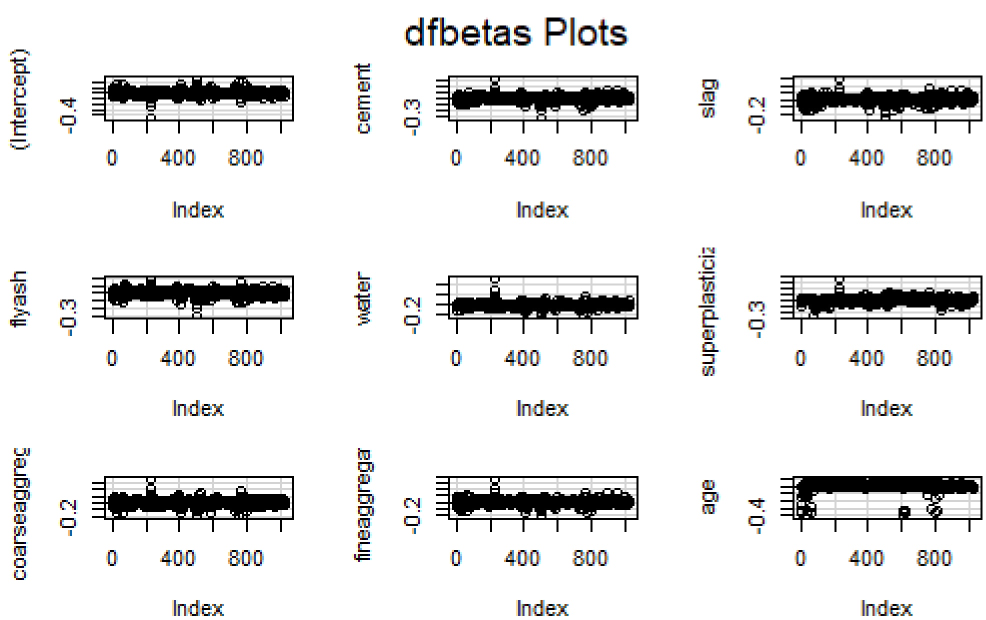
Hide

```
library(car)
```

```
package 惚徸car惚忭 was built under R version 4.0.5Loading required package: carData
Registered S3 method overwritten by 'data.table':
  method           from
  print.data.table
```

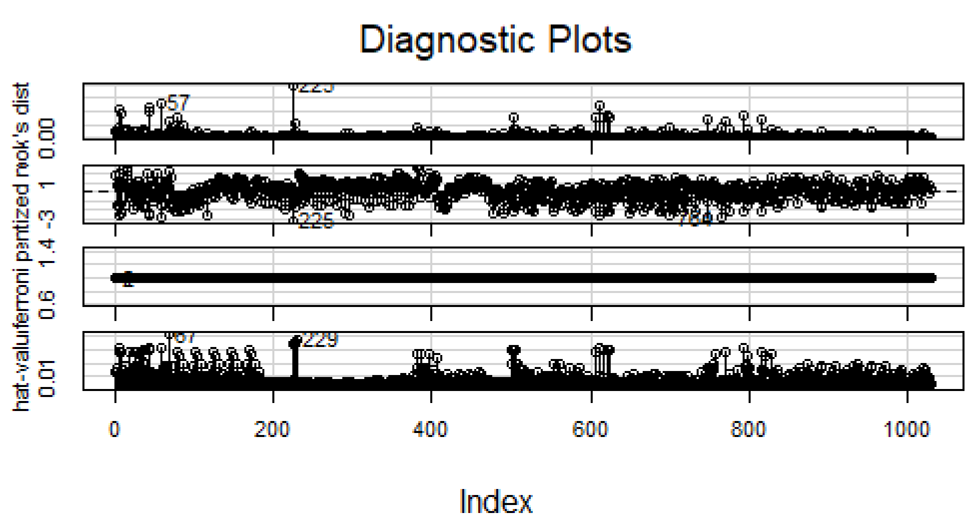
Hide

```
dfbetasPlots(lm1,intercept=T)
```



Hide

```
influenceIndexPlot(lm1)
```



Hide

```
#variance inflation factors
vif(lm1)
```

```
          cement             slag           flyash 
        7.488944         7.276963         6.170634 
           water superplasticizer  coarseaggregate 
        7.003957         2.963776         5.074617 
   fineaggregate              age 
        7.005081         1.118367 
```

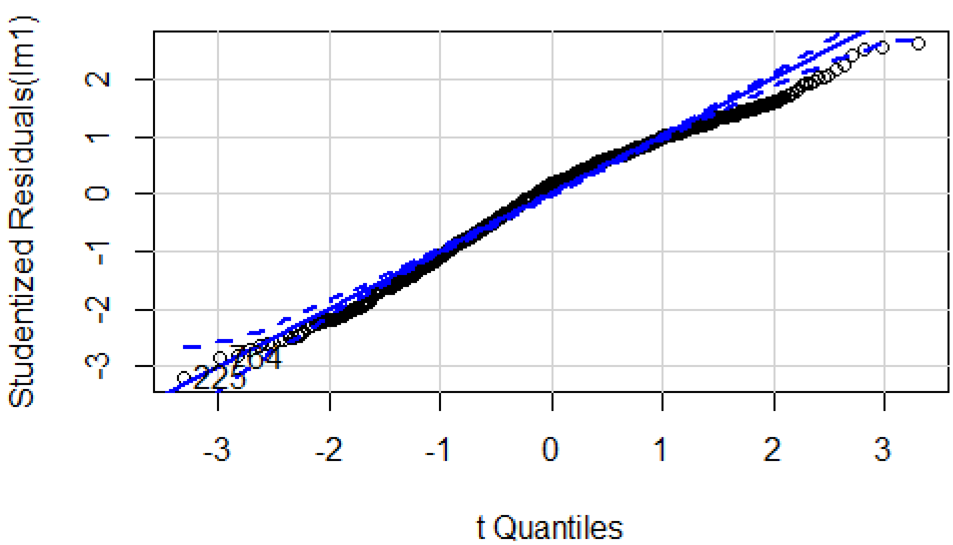
Hide

```
#normal probability plot of residuals
qqPlot(lm1)
```

```
[1] 225 764
```

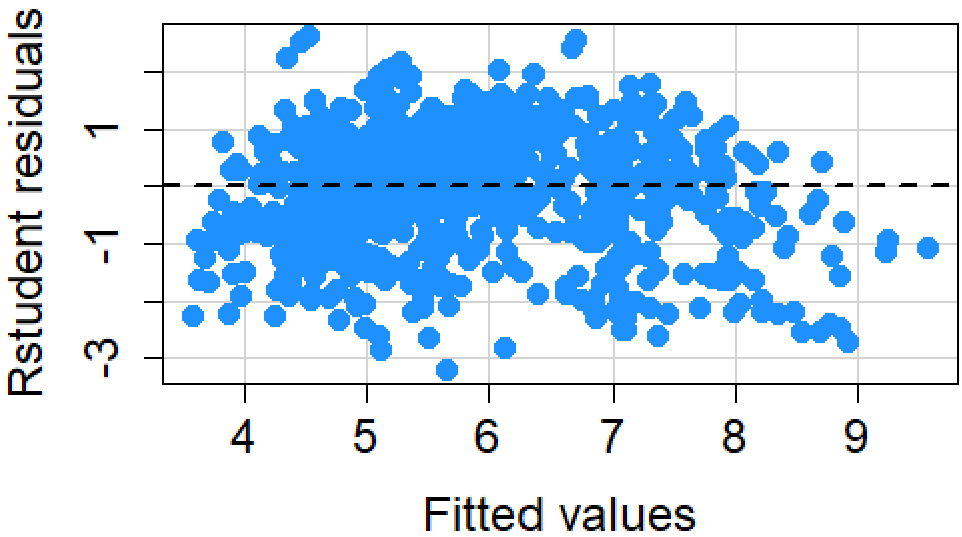
Hide

```
#plot of the residuals versus the fitted values
par(mfrow=c(1,1))
```



Hide

```
residualPlot(lm1, type="rstudent", quadratic=F, col = "dodgerblue",
             pch=16, cex=1.5, cex.axis=1.5, cex.lab=1.5)
```



Forward/Backward/Stepwise Selection

Hide

```
#library(tidyverse)
library(caret)
```

```
Loading required package: lattice
```

Hide

```
library(MASS)

# Stepwise regression model
step.model <- stepAIC(lm1, direction = "both",
                      trace = FALSE)
summary(step.model)
```

```
Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer +
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8749 -0.6117  0.1697  0.6539  2.3891

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.9744083  2.3441309   0.416 0.677732
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 **
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .
fineaggregate     0.0014005  0.0009436   1.484 0.138054
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,    Adjusted R-squared:  0.5994
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

Hide

```
# Forward regression model
forw.model <- stepAIC(lm1, direction = "forward",
                      trace = FALSE)
summary(forw.model)
```

```
Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer +
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8749 -0.6117  0.1697  0.6539  2.3891

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.9744083  2.3441309   0.416 0.677732
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 **
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .
fineaggregate     0.0014005  0.0009436   1.484 0.138054
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,    Adjusted R-squared:  0.5994
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

Hide

```
# Backward regression model
back.model <- stepAIC(lm1, direction = "backward",
                      trace = FALSE)
summary(back.model)
```

```

Call:
lm(formula = csMPa ~ cement + slag + flyash + water + superplasticizer + 
    coarseaggregate + fineaggregate + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.8749 -0.6117  0.1697  0.6539  2.3891 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)       0.9744083  2.3441309   0.416 0.677732    
cement            0.0102014  0.0007485  13.629  < 2e-16 ***
slag              0.0086351  0.0008937   9.662  < 2e-16 ***
flyash            0.0080147  0.0011095   7.224 9.89e-13 ***
water            -0.0120092  0.0035425  -3.390 0.000726 ***
superplasticizer  0.0256855  0.0082375   3.118 0.001871 ** 
coarseaggregate   0.0014051  0.0008281   1.697 0.090064 .  
fineaggregate     0.0014005  0.0009436   1.484 0.138054    
age               0.0101299  0.0004785  21.169  < 2e-16 ***
---
Signif. codes:  
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9169 on 1021 degrees of freedom
Multiple R-squared:  0.6025,	Adjusted R-squared:  0.5994 
F-statistic: 193.4 on 8 and 1021 DF,  p-value: < 2.2e-16
```

Hide

```
anova(step.model, forw.model, back.model)
```

```
Analysis of Variance Table

Model 1: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate + 
    fineaggregate + age
Model 2: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate + 
    fineaggregate + age
Model 3: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate + 
    fineaggregate + age
  Res.Df    RSS Df Sum of Sq F Pr(>F)
1   1021 858.41                      
2   1021 858.41  0         0         
3   1021 858.41  0         0         
```

Build Reduced Model

Hide

```
#reduced model
lm2 <- lm(csMPa~cement+slag+flyash+water+age, data = conc)

#summary with parameter coefficients and other metrics
summary(lm2)
```

```


Call:
lm(formula = csMPa ~ cement + slag + flyash + water + age, data = conc)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.3017 -0.6361  0.1689  0.6652  2.4050 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  5.3368896  0.3253538   16.40   <2e-16 ***
cement       0.0095799  0.0003467   27.63   <2e-16 ***
slag         0.0079010  0.0003998   19.77   <2e-16 ***
flyash       0.0076090  0.0005928   12.84   <2e-16 ***
water       -0.0202804  0.0014741  -13.76   <2e-16 ***
age          0.0101318  0.0004779   21.20   <2e-16 ***
---
Signif. codes:  
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9204 on 1024 degrees of freedom
Multiple R-squared:  0.5982,    Adjusted R-squared:  0.5963 
F-statistic:   305 on 5 and 1024 DF,  p-value: < 2.2e-16
```

Hide

```
#variance
print(paste("Variance: ", sigma(lm2)^2))
```

```
[1] "Variance:  0.847209052557485"
```

Hide

```
#99% confidence interval
print("99% Confidence Interval: ")
```

```
[1] "99% Confidence Interval: "
```

Hide

```
confint(lm2,level=0.99)
```

```
                  0.5 %       99.5 %
(Intercept)  4.497268937  6.176510343
cement       0.008685310  0.010474550
slag         0.006869379  0.008932623
flyash       0.006079236  0.009138850
water       -0.024084379 -0.016476346
age          0.008898609  0.011365078
```

Hide

```
#prediction on future observations whose csMPa values are identical to data set
predout2 <- predict(lm2, conc, interval = "predict", predict.level = .99)
print("Prediction on identical data: ")
```

```
[1] "Prediction on identical data: "
```

Hide

```
predout2
```

```
        fit      lwr       upr
1  7.508325 5.695343  9.321306
2  7.508325 5.695343  9.321306
3  7.759784 5.939131  9.580437
4  8.722309 6.890964 10.553655
5  8.039190 6.207476  9.870905
6  5.073808 3.262519  6.885097
7  8.802058 6.971015 10.633101
8  5.387627 3.574203  7.201051
9  4.445634 2.633583  6.257686
10 5.547125 3.730715  7.363536
11 5.303593 3.494254  7.112931
12 4.675418 2.866248  6.484589
13 7.919282 6.098116  9.740449
14 4.946210 3.133702  6.758718
15 4.509433 2.697191  6.321675
16 5.265206 3.452272  7.078140
17 5.346754 3.535357  7.158150
18 7.987664 6.157660  9.817668
19 6.015801 4.203254  7.828349
20 7.087165 5.270234  8.904097
21 7.007416 5.192015  8.822817
22 4.718579 2.907553  6.529606
23 4.465283 2.653878  6.276689
24 6.258620 4.443371  8.073869
25 8.051463 6.220920  9.882006
26 7.088938 5.268585  8.909292
27 7.839533 6.018983  9.660083
28 6.113273 4.299444  7.927101
29 5.467376 3.652819  7.281933
30 5.334356 3.517139  7.151574
31 7.923865 6.093941  9.753788
32 7.860065 6.029763  9.690367
33 6.215458 4.402555  8.028362
34 7.999031 6.176529  9.821534
35 7.732467 5.900034  9.564900
36 7.600286 5.777267  9.423305
37 5.148380 3.334015  6.962744
38 5.936052 4.123783  7.748321
39 6.175300 4.360027  7.990572
40 6.688420 4.871923  8.504917
41 5.201407 3.389484  7.013329
42 8.881807 7.050351 10.713264
43 8.562811 6.728715 10.396907
44 6.177072 4.362386  7.991758
45 6.095550 4.282002  7.909099
46 5.254607 3.439287  7.069928
47 4.816851 3.006853  6.626849
48 6.927667 5.113076  8.742259
49 4.935611 3.120661  6.750561
50 5.174858 3.360715  6.989002
51 6.847918 5.033414  8.662422
52 5.858076 4.043052  7.673100
```

53	5.776554	3.962671	7.590436
54	5.137608	3.326233	6.948982
55	4.505811	2.694486	6.317135
56	4.462650	2.653112	6.272187
57	8.961557	7.128971	10.794142
58	4.422122	2.612491	6.231753
59	6.049474	4.236040	7.862907
60	5.307878	3.494863	7.120892
61	6.961339	5.141930	8.780749
62	6.897540	5.077911	8.717169
63	4.443234	2.632920	6.253548
64	6.769942	4.948490	8.591393
65	5.985674	4.172173	7.799175
66	7.025139	5.205488	8.844790
67	8.082352	6.247737	9.916966
68	5.095109	3.281420	6.908799
69	4.318035	2.504976	6.131095
70	7.305914	5.492962	9.118867
71	6.995359	5.184648	8.806070
72	6.881116	5.068624	8.693608
73	7.165596	5.354632	8.976560
74	7.208185	5.396990	9.019380
75	7.133379	5.318398	8.948360
76	7.183617	5.371752	8.995482
77	7.991636	6.177195	9.806076
78	7.165596	5.354632	8.976560
79	6.654964	4.845146	8.464782
80	7.581346	5.766404	9.396289
81	7.165596	5.354632	8.976560
82	6.942677	5.130995	8.754359
83	6.975400	5.164204	8.786596
84	6.990025	5.179320	8.800730
85	6.975181	5.161244	8.789117
86	7.076352	5.265471	8.887233
87	6.990025	5.179320	8.800730
88	6.762762	4.949980	8.575543
89	6.990025	5.179320	8.800730
90	7.199204	5.386655	9.011753
91	7.636884	5.823665	9.450103
92	6.990025	5.179320	8.800730
93	6.550597	4.740747	8.360447
94	7.035886	5.225235	8.846537
95	6.921643	5.109207	8.734080
96	7.206123	5.395208	9.017039
97	7.248712	5.437563	9.059862
98	7.173906	5.358932	8.988880
99	7.224144	5.412371	9.035918
100	8.032163	6.217748	9.846578
101	7.206123	5.395208	9.017039
102	6.695491	4.885728	8.505254
103	7.621874	5.806981	9.436767
104	7.206123	5.395208	9.017039
105	6.983204	5.171556	8.794853
106	7.015928	5.204772	8.827083

107	7.030552	5.219900	8.841205
108	7.015708	5.201838	8.829578
109	7.116879	5.306040	8.927719
110	7.030552	5.219900	8.841205
111	6.803289	4.990524	8.616054
112	7.030552	5.219900	8.841205
113	7.239731	5.427271	9.052192
114	7.677411	5.864217	9.490606
115	7.030552	5.219900	8.841205
116	6.591125	4.781341	8.400908
117	7.248655	5.438194	9.059115
118	7.134412	5.322143	8.946681
119	7.418892	5.608105	9.229679
120	7.461481	5.650443	9.272519
121	7.386675	5.571613	9.201737
122	7.436913	5.625490	9.248336
123	8.244932	6.430522	10.059342
124	7.418892	5.608105	9.229679
125	6.908260	5.098659	8.717861
126	7.834642	6.019884	9.649401
127	7.418892	5.608105	9.229679
128	7.195973	5.384371	9.007575
129	7.228696	5.417624	9.039769
130	7.243321	5.432814	9.053828
131	7.228477	5.414827	9.042127
132	7.329648	5.518898	9.140399
133	7.243321	5.432814	9.053828
134	7.016058	5.203252	8.828863
135	7.243321	5.432814	9.053828
136	7.452500	5.640380	9.264621
137	7.890180	6.076987	9.703374
138	7.243321	5.432814	9.053828
139	6.803893	4.994330	8.613456
140	7.532346	5.721806	9.342887
141	7.418104	5.605724	9.230483
142	7.702584	5.891635	9.513533
143	7.745173	5.933950	9.556395
144	7.670367	5.854855	9.485878
145	7.720605	5.909316	9.531894
146	8.528623	6.713888	10.343359
147	7.702584	5.891635	9.513533
148	7.191952	5.382233	9.001670
149	8.118334	6.303423	9.933245
150	7.702584	5.891635	9.513533
151	7.479665	5.667791	9.291539
152	7.512388	5.701093	9.323683
153	7.527013	5.716368	9.337658
154	7.512169	5.698480	9.325857
155	7.613340	5.802375	9.424304
156	7.527013	5.716368	9.337658
157	7.299749	5.486557	9.112942
158	7.527013	5.716368	9.337658
159	7.736192	5.924191	9.548192
160	8.173872	6.360346	9.987397

161	7.527013	5.716368	9.337658
162	7.087585	5.277983	8.897187
163	7.886961	6.075785	9.698136
164	7.772718	5.959666	9.585770
165	8.057198	6.245512	9.868885
166	8.099787	6.287800	9.911775
167	8.024981	6.208374	9.841588
168	8.075219	6.263563	9.886875
169	8.883238	7.067561	10.698914
170	8.057198	6.245512	9.868885
171	7.546566	5.736166	9.356966
172	8.472949	6.657313	10.288585
173	8.057198	6.245512	9.868885
174	7.834279	6.021531	9.647027
175	7.867003	6.054894	9.679111
176	7.881627	6.070274	9.692981
177	7.967954	6.156187	9.779722
178	7.881627	6.070274	9.692981
179	7.654364	5.840154	9.468574
180	7.881627	6.070274	9.692981
181	8.090806	6.278421	9.903192
182	8.528486	6.714012	10.342961
183	7.881627	6.070274	9.692981
184	7.442199	5.632012	9.252386
185	4.394583	2.585573	6.203594
186	4.506034	2.697252	6.314816
187	4.647879	2.839304	6.456455
188	4.931571	3.123122	6.740020
189	5.377372	3.568352	7.186393
190	4.313404	2.503868	6.122941
191	4.424855	2.615585	6.234124
192	4.566701	2.757686	6.375715
193	4.850392	3.041602	6.659182
194	5.296193	3.486986	7.105401
195	4.638778	2.829235	6.448322
196	4.750229	2.940809	6.559648
197	4.892074	3.082728	6.701420
198	5.175766	3.366281	6.985251
199	5.621567	3.811094	7.432041
200	4.860905	3.051245	6.670565
201	4.972355	3.162791	6.781919
202	5.114201	3.304674	6.923728
203	5.397893	3.588153	7.207632
204	5.843694	4.032852	7.654536
205	4.667899	2.858956	6.476842
206	4.779349	2.970582	6.588115
207	4.921195	3.112568	6.729822
208	5.204886	3.396252	7.013520
209	5.650687	3.841273	7.460102
210	4.506008	2.696338	6.315678
211	4.617458	2.808032	6.426885
212	4.759304	2.950103	6.568505
213	5.042996	3.233959	6.852032
214	5.488797	3.679249	7.298344

215	4.859607	3.049927	6.669288
216	4.971058	3.161472	6.780643
217	5.112903	3.303354	6.922453
218	5.396595	3.586831	7.206359
219	5.842396	4.031527	7.653266
220	4.621584	2.811261	6.431907
221	4.733035	2.922844	6.543225
222	4.874880	3.064773	6.684987
223	5.158572	3.348346	6.968798
224	5.604373	3.793192	7.415554
225	6.085559	4.269824	7.901293
226	6.197009	4.381163	8.012855
227	6.338855	4.522782	8.154928
228	6.622546	4.805735	8.439358
229	7.068347	5.249611	8.887084
230	4.691084	2.882507	6.499661
231	4.802534	2.994156	6.610913
232	4.944380	3.136169	6.752591
233	5.228072	3.419910	7.036234
234	5.673873	3.865018	7.482728
235	4.692042	2.883467	6.500617
236	4.803492	2.995116	6.611869
237	4.945338	3.137129	6.753547
238	5.229030	3.420870	7.037190
239	5.674831	3.865978	7.483683
240	4.508457	2.698817	6.318098
241	4.619907	2.810510	6.429305
242	4.761753	2.952579	6.570927
243	5.045445	3.236432	6.854457
244	5.491246	3.681718	7.300774
245	4.577934	2.769231	6.386637
246	4.689384	2.880902	6.497866
247	4.831230	3.022945	6.639515
248	5.114921	3.306743	6.923100
249	5.560723	3.751943	7.369502
250	4.689913	2.881264	6.498562
251	4.801363	2.992939	6.609788
252	4.943209	3.134986	6.751433
253	5.226901	3.418793	7.035008
254	5.672702	3.864006	7.481398
255	4.936306	3.126715	6.745898
256	5.047757	3.238265	6.857248
257	5.189602	3.380154	6.999051
258	5.473294	3.663645	7.282944
259	5.919095	4.108361	7.729830
260	4.935236	3.125655	6.744817
261	5.046687	3.237206	6.856167
262	5.188532	3.379095	6.997970
263	5.472224	3.662587	7.281861
264	5.918025	4.107305	7.728745
265	5.123261	3.313770	6.932752
266	5.234711	3.425306	7.044117
267	5.376557	3.567176	7.185939
268	5.660249	3.850630	7.469868

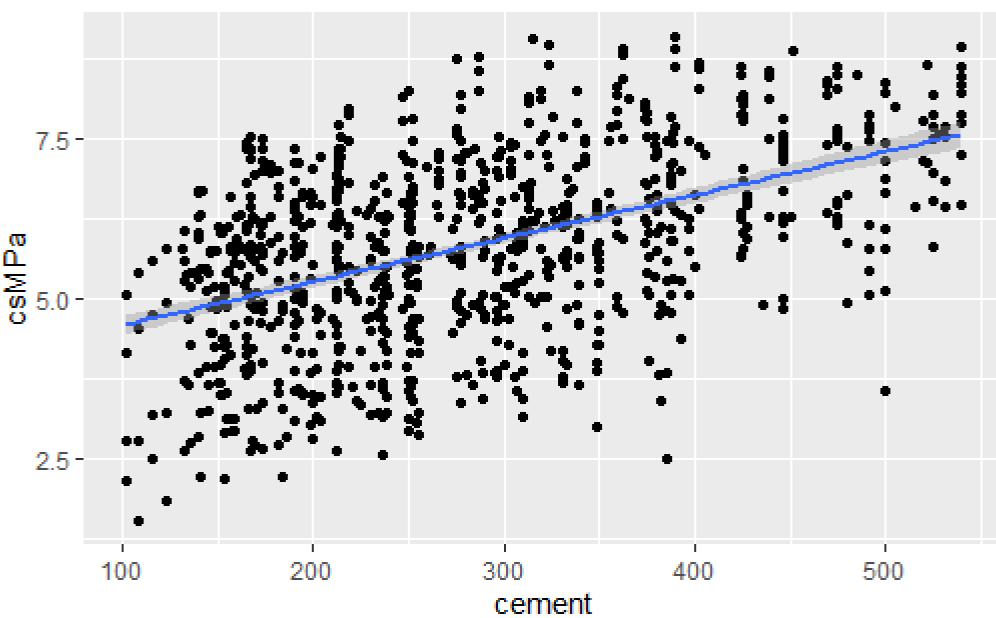
269	6.106050	4.295287	7.916813
270	4.984389	3.175706	6.793073
271	5.095840	3.287308	6.904371
272	5.237686	3.429263	7.046108
273	5.521377	3.712887	7.329868
274	5.967178	4.157811	7.776546
275	4.852981	3.043932	6.662030
276	4.964431	3.155600	6.773263
277	5.106277	3.297637	6.914917
278	5.389969	3.581425	7.198512
279	5.835770	4.026608	7.644931
280	4.852981	3.043932	6.662030
281	4.964431	3.155600	6.773263
282	5.106277	3.297637	6.914917
283	5.389969	3.581425	7.198512
284	5.835770	4.026608	7.644931
285	4.936245	3.126017	6.746473
286	5.047695	3.237571	6.857820
287	5.189541	3.379463	6.999619
288	5.473233	3.662962	7.283503
289	5.919034	4.107692	7.730376
290	4.944543	3.135826	6.753261
291	5.055993	3.247389	6.864598
292	5.197839	3.389295	7.006384
293	5.481531	3.672819	7.290243
294	5.927332	4.117588	7.737076
295	5.054180	3.244524	6.863837
296	5.165630	3.356036	6.975225
297	5.307476	3.497876	7.117077
298	5.591168	3.781269	7.401066
299	6.036969	4.225833	7.848105
300	5.472158	3.663878	7.280437
301	5.583608	3.775477	7.391739
302	5.725454	3.917427	7.533481
303	6.009145	4.201040	7.817251
304	6.454947	4.645948	8.263945
305	5.505978	3.697316	7.314640
306	5.617429	3.808882	7.425976
307	5.759274	3.950788	7.567760
308	6.042966	4.234316	7.851616
309	6.488767	4.679090	8.298444
310	5.449413	3.641197	7.257628
311	5.560863	3.752811	7.368915
312	5.702709	3.894780	7.510637
313	5.986400	4.178432	7.794369
314	6.432202	4.623401	8.241002
315	5.576694	3.766346	7.387042
316	5.688144	3.877846	7.498442
317	5.829990	4.019670	7.640310
318	6.113682	4.303033	7.924330
319	6.559483	4.747549	8.371417
320	5.299094	3.490005	7.108182
321	5.410544	3.601556	7.219532
322	5.552390	3.743445	7.361335

```
323  5.836082 4.026936  7.645227
324  6.281883 4.471652  8.092113
325  5.569058 3.758731  7.379385
326  5.680508 3.870232  7.490784
327  5.822354 4.012058  7.632650
328  6.106046 4.295425  7.916666
329  6.551847 4.739947  8.363747
330  5.777327 3.966637  7.588017
331  5.888777 4.078111  7.699444
332  6.030623 4.219902  7.841344
333  6.314315 4.503199  8.125430
 [ reached getOption("max.print") -- omitted 697 rows ]
```

Confidence/Prediction Interval Curves for Reduced Model

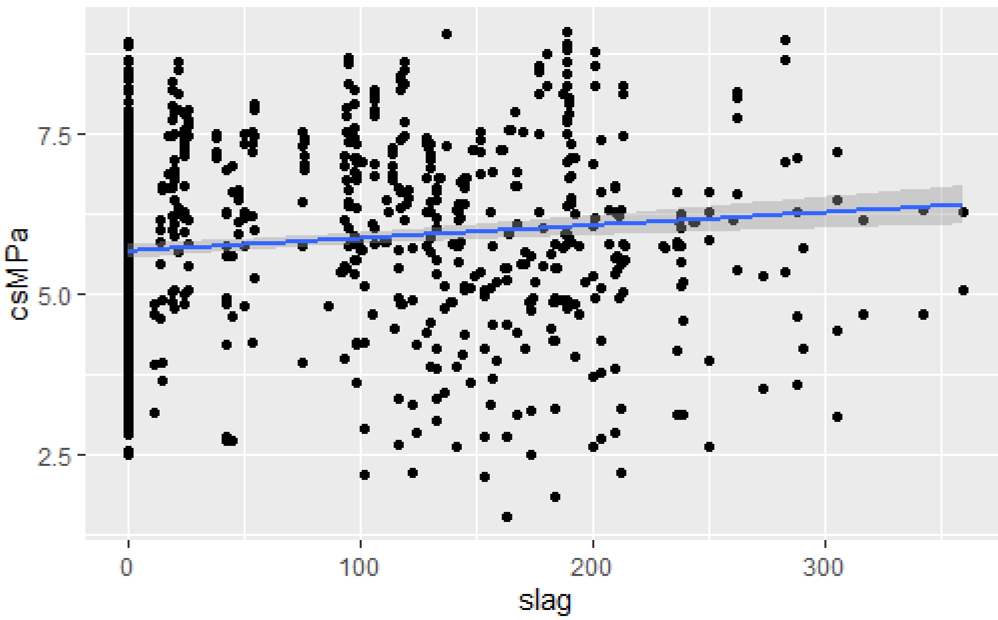
Hide

```
#merge data points and prediction outcome object
merged2 <- cbind(conc, predout2)

#cement
#confidence interval curve
p0 <- ggplot(merged2, aes(cement, csMPa)) + geom_point() + stat_smooth(method = lm)
p0
```



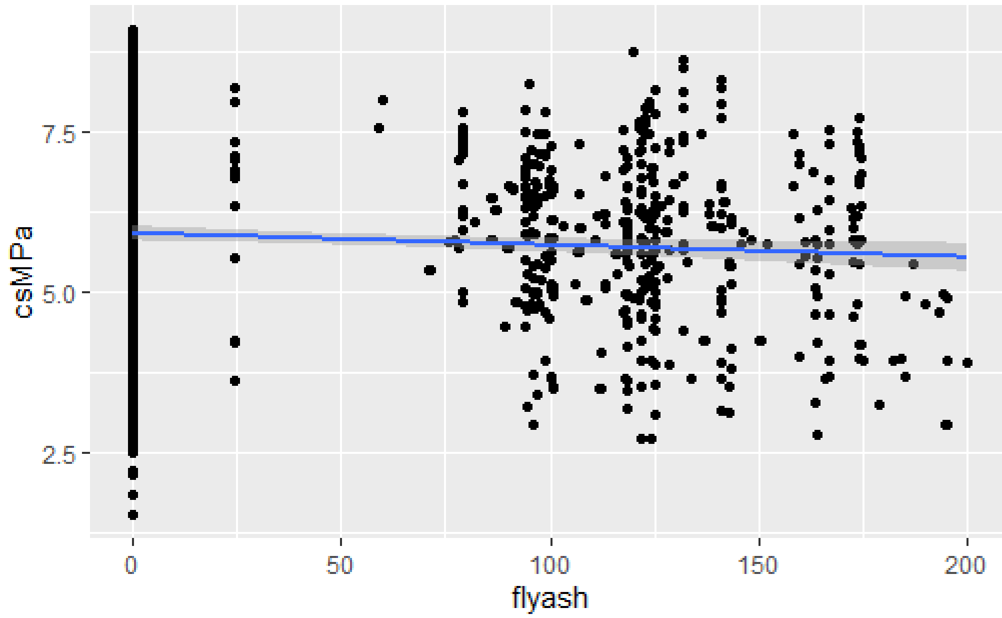
Hide

```
#prediction interval curve
p00 <- p1 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#slag
#confidence interval curve
p1 <- ggplot(merged2, aes(slag, csMPa)) + geom_point() + stat_smooth(method = lm)
p1
```



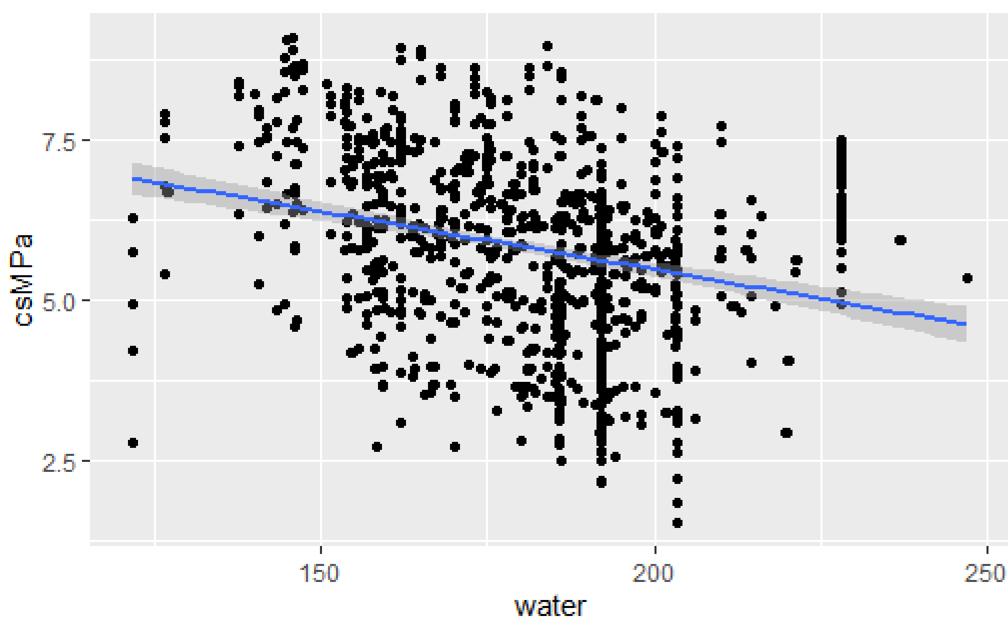
Hide

```
#prediction interval curve
p11 <- p1 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#flyash
#confidence interval curve
p2 <- ggplot(merged2, aes(flyash, csMPa)) + geom_point() + stat_smooth(method = lm)
p2
```



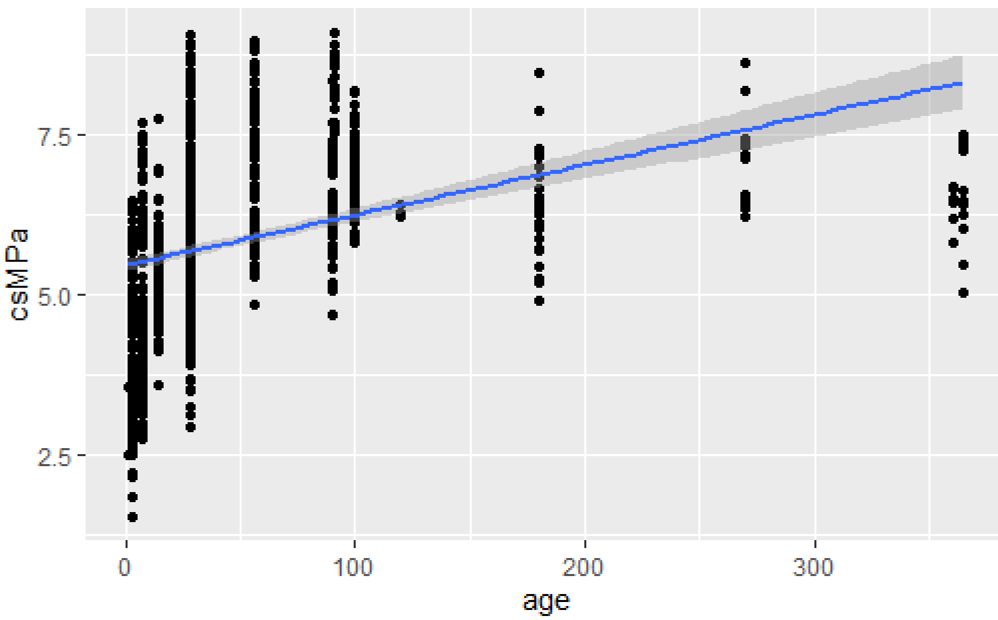
Hide

```
#prediction interval curve
p22 <- p2 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#water
#confidence interval curve
p3 <- ggplot(merged2, aes(water, csMPa)) + geom_point() + stat_smooth(method = lm)
p3
```



Hide

```
#prediction interval curve
p33 <- p3 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#age
#confidence interval curve
p7 <- ggplot(merged2, aes(age, csMPa)) + geom_point() + stat_smooth(method = lm)
p7
```



Hide

```
#prediction interval curve
p77 <- p7 + geom_line(aes(y = lwr), color = "red", linetype = "dashed")+
geom_line(aes(y = upr), color = "red", linetype = "dashed")

#grid.arrange(p0, p00, p1, p11, p2, p22, p3, p33, p7, p77, nrow = 7)
```

Residual Analysis for Reduced Model

Hide

```
#View(lm2)
library(MASS)

#standardized residuals
print("standardized residuals:")
```

```
[1] "standardized residuals:"
```

Hide

```
stdres(lm2)
```

```
           1            2            3            4 
 1.5653912087  0.3911821745 -1.5486592202 -2.5514853641 
           5            6            7            8 
-1.5248209547  1.9437730003 -2.4146103483  0.7087807216 
           9           10           11           12 
 2.5349411810  0.7878693510  0.9430551083  0.6725115141 
          13           14           15           16 
-1.4912203153  1.7007740881  2.6217835142  2.1905907976 
          17           18           19           20 
 1.0100636563 -0.5450785445  0.3847381128 -0.6107272944 
          21           22           23           24 
-0.5886502884  0.6487823938 -1.7719982111  0.4263446093 
          25           26           27           28 
-0.8860481908  0.2318859307 -1.5603829655  1.2069015507 
          29           30           31           32 
 0.7101845980  0.9603855540 -0.5397203610 -0.6455480567 
          33           34           35           36 
 0.2656987539 -1.6537363698 -0.4467316175 -1.5384445226 
          37           38           39           40 
 0.3668728944  0.2241414322  0.3528837901 -0.7295280818 
          41           42           43           44 
 2.0731588537 -2.5030778138 -2.5583461259  1.2115837922 
          45           46           47           48 
 0.3813874891  0.7297081533 -1.0206175808 -0.5930540842 
          49           50           51           52 
 0.2061710157  0.6045868588 -0.5902613621  1.0836006399 
          53           54           55           56 
-0.0235203139  2.0440170981 -0.7475741760 -0.6927314815 
          57           58           59           60 
-2.7418265863 -1.5245244201  1.1873349387  0.4781422805 
          61           62           63           64 
 0.4519728135  0.3227242226 -1.4173476867  0.3809435221 
          65           66           67           68 
 1.0831030898  0.4325096536 -1.5419373735  0.4447117218 
          69           70           71           72 
 2.2621014625  1.2855186818 -1.2310067962 -1.6512733593 
          73           74           75           76 
-1.5101775618 -1.2891138699 -1.9086891460 -1.1285214961 
          77           78           79           80 
-1.8023191588 -1.5101775618 -1.4740474354 -1.2608185327 
          81           82           83           84 
-1.5101775618 -2.0953327936 -0.6149818905 -1.1421661078 
          85           86           87           88 
-1.8063028342 -1.8827891291 -1.1421661078 -1.9880239827 
          89           90           91           92 
-1.1421661078 -1.0142384041 -1.3798315987 -1.1421661078 
          93           94           95           96 
-1.7869569859 -0.2601192666 -0.4137148994 -0.2089867416 
          97           98           99          100 
-0.4441261197 -0.4517044753  0.2532732755 -0.6796543012 
         101          102          103          104 
-0.2089867416 -0.8576831505 -0.8444783595 -0.2089867416 
         105          106          107          108 
```

```
-1.3119922768  0.3696991852  0.4858462847  0.0449574640 
          109           110           111           112 
-0.2766029667  0.4858462847 -0.6966534871  0.4858462847 
          113           114           115           116 
 0.2728484863  0.0104604810 -2.4453169805 -0.7256757493 
          117           118           119           120 
 0.6178687479  0.6525918964  0.3766256101  0.4355545082 
          121           122           123           124 
 0.1564233148  0.9016258911 -0.0716965083  0.3766256101 
          125           126           127           128 
 0.2309099590 -0.3544055151  0.3766256101  0.2766376213 
          129           130           131           132 
 1.1414545419  1.3075412187  1.5431224623 -0.1140309647 
          133           134           135           136 
 1.3075412187  1.3215786120  1.3075412187  0.7320066694 
          137           138           139           140 
 0.8083807073  1.3075412187  0.2831161905  0.4683769785 
          141           142           143           144 
 0.6954945292  0.3443859281  0.3387041968  0.0966518983 
          145           146           147           148 
 0.8523848250 -0.2226527482  0.3443859281  0.2587768737 
          149           150           151           152 
-0.4915261663  0.3443859281  0.7090044546  1.1685147230 
          153           154           155           156 
 1.3778022140  1.5746175343 -0.2221017014  1.3778022140 
          157           158           159           160 
 1.3564682019  1.3778022140  0.7971980135  0.8037723736 
          161           162           163           164 
 1.3778022140  0.7089252243  0.1842214057  0.4233367320 
          165           166           167           168 
 0.0190203928  0.0732670855 -0.1303558784  0.5864470147 
          169           170           171           172 
-0.5187049881  0.0190203928  0.0467184022 -0.8505966562 
          173           174           175           176 
 0.0190203928  0.4557911536  0.8960881424  1.1151032791 
          177           178           179           180 
-0.4918466234  1.1151032791  1.2104900796  1.1151032791 
          181           182           183           184 
 0.5131988531  0.6111955225  1.1151032791  0.8622490316 
          185           186           187           188 
-1.0790623923  0.4772700964  0.3710892354  0.5387020031 
          189           190           191           192 
 1.0914984467 -1.1881824846  0.3052295885  0.2311472558 
          193           194           195           196 
 0.4448762788  0.6340093819 -1.2085620931  0.2707634825 
          197           198           199           200 
 0.1952673896  0.7093980549  0.5326281520 -1.0697834050 
          201           202           203           204 
-0.4171507059  0.0260056261  0.5953023942  0.5726976241 
          205           206           207           208 
-1.2367617210 -0.2235966621  0.0748440800  0.6997445257 
          209           210           211           212 
 0.6997980244 -1.4575648593 -0.1484445090  0.2050549835 
          213           214           215           216 
```

```
 0.6235795067  0.4962914389 -1.9436503708 -0.2226071457
          217           218           219           220
 0.2425412965  0.8851229667  0.5587114138 -1.4606539035
          221           222           223           224
 0.3427081696 -0.2545223123  0.2092076624  0.2037311981
          225           226           227           228
-3.6062764678 -2.1580348253 -1.5463190499 -0.9738499902
          229           230           231           232
-0.8807146261 -0.4878585230  0.7725129817  1.9757964718
          233           234           235           236
 2.0635132883  1.8146565562 -1.1549226159 -0.6306357215
          237           238           239           240
 1.5198831141  1.7794889296  1.5168809311 -0.9288745142
          241           242           243           244
 0.1137338145  0.2089809881  0.6024712104  0.9806417843
          245           246           247           248
-0.1236268826  0.4124489280  0.7254545975  1.2803155533
          249           250           251           252
 1.1914884061 -1.0578956100  0.2073677381  0.5028815671
          253           254           255           256
 1.0486968177  0.9084353296 -1.3678537208  0.0887854165
          257           258           259           260
 0.4738352742  1.1426888546  0.6886370038 -1.3978628671
          261           262           263           264
-0.0106912417  1.0089831009  1.2965631544  1.0798129431
          265           266           267           268
-0.7674818553  0.3966061872  0.9014829568  1.1472123180
          269           270           271           272
 0.8813415387 -1.1478094986  0.0849988771  0.6201197464
          273           274           275           276
 1.1021422875  0.8743391282 -0.7652965331  0.5509876073
          277           278           279           280
 0.3687046368  0.7509884579  0.8333198730 -1.3393593628
          281           282           283           284
-0.0236757864  0.6621322087  0.7214008545  0.8850606902
          285           286           287           288
-1.3564525052 -0.4356578513  0.0873041317  0.5344700816
          289           290           291           292
 0.8898433095 -2.4359759024 -0.4560344898  0.4287519458
          293           294           295           296
 1.2119190852  1.1420031613 -2.5405444109 -0.3449696023
          297           298           299           300
 0.2950457685  0.7248828206  0.9827349629 -0.7926615654
          301           302           303           304
 0.3311983614  0.1833746912  0.7667840638  0.5907668331
          305           306           307           308
-0.7567446788  0.9299372494  1.2935556468  1.1981043209
          309           310           311           312
 1.0563980168 -0.7165566150  0.4074314116  0.6710984887
          313           314           315           316
 1.0805334895  0.8504836082 -1.0801854858  0.0954642474
          317           318           319           320
-0.0045576080  0.5773713666  0.1920925774 -1.5016218468
          321           322           323           324
```

```
-0.0600359835  0.0020540855  0.7040605937  0.9405280773
          325           326           327           328
-0.9824029510  0.8957129121  1.4058293989  1.4876472831
          329           330           331           332
 1.3680567498 -1.0103013228  0.6632049708  1.3234400600
          333           334           335           336
 1.5821615968  1.5151936565 -0.8848705885  0.4606386541
          337           338           339           340
 1.3267998986  1.4267450073  1.0683315198 -0.9602924018
          341           342           343           344
 0.4427384712  1.1616863874  1.2050791649  1.0733703795
          345           346           347           348
-1.5388563411  0.1000866343  0.5214150588  0.7494923122
          349           350           351           352
 0.5337063836 -1.5630993760  0.0990854830  1.0041334122
          353           354           355           356
 1.1240351532  1.2157696203 -0.2227954851  1.1672023642
          357           358           359           360
 2.1429756699  2.0828756806  1.6074046933 -0.8051128671
          361           362           363           364
-0.0983933095  1.3307936714  1.4828018299  1.1038958019
          365           366           367           368
-1.4995556808  0.5206213707  1.4675877920  1.2905514382
          369           370           371           372
 1.0014727280 -1.3904870451 -0.2195283640  0.0541986834
          373           374           375           376
 0.4068234700  0.6777969779 -0.6348572623  0.3629552006
          377           378           379           380
 0.8540363528  0.9485955047  1.0479343539  0.7080476844
          381           382           383           384
-0.1909519826  2.4642732332  1.1356543171  2.4851405903
          385           386           387           388
-0.9226824351  0.6643532003  0.6668396367  0.0978152746
          389           390           391           392
 0.3418598017  0.3135792157  0.0042079375  0.0924632758
          393           394           395           396
 0.0802179357  0.3591722599  1.3936669332  1.9095969031
          397           398           399           400
-0.9226824351  0.3263657559  0.9521500122  1.0956194884
          401           402           403           404
 1.4183007635  0.8325159677  0.8421170188  1.0390601856
          405           406           407           408
 1.5550333385  1.0999864494 -1.0060845032 -1.0999095874
          409           410           411           412
-0.8695185010 -1.6885553913 -0.7015385080 -0.6523598982
          413           414           415           416
-1.7075618272 -1.6497508800 -1.3296998481 -1.8355417608
          417           418           419           420
-1.6973709986 -1.1487490490 -1.4176659283 -0.7857195980
          421           422           423           424
 0.2433982497  0.4221820392  0.1218522989  0.0923118934
          425           426           427           428
 0.2513054598  0.1271902603 -0.1829884979 -0.5103516207
          429           430           431           432
```

```
 0.2760730137 -0.1973845125  0.2944114075 -0.3506082269 
          433           434           435           436 
 0.1596046565  1.2412195391  0.7099145087  0.8149411140 
          437           438           439           440 
 0.3189960241  0.5707412836  0.7341312747  0.4388537935 
          441           442           443           444 
-0.0354876313  0.3952088383  1.0003718793  1.4213277270 
          445           446           447           448 
 0.8171462519  0.8611150933  1.4968238017  1.1769781208 
          449           450           451           452 
 1.3475563480  0.2095519596  1.5167654188  1.3800036120 
          453           454           455           456 
 1.0558997316  0.3600148440  1.2599771986  1.2125095746 
          457           458           459           460 
 1.6374180108  1.0508676178  0.5008641258  1.1081971790 
          461           462           463           464 
 0.8008101403  1.0083940809 -0.1117993006  1.2003486702 
          465           466           467           468 
 1.1409970747  0.7211331025  0.0501179350  0.9053932667 
          469           470           471           472 
 0.8557785506  1.2260414618  0.6419878943  0.1669347721 
          473           474           475           476 
-0.7991237220 -0.2785172876 -0.0998783986 -1.3058673353 
          477           478           479           480 
-2.3346217537 -2.5196001776  0.0283369419 -1.1107602852 
          481           482           483           484 
-0.9986377929  0.1443068976 -0.2064891553 -0.2714369452 
          485           486           487           488 
-0.3066821839  0.0770112832 -0.2013598411 -0.2013598411 
          489           490           491           492 
-2.1709301266 -1.8649882119 -0.9441937572 -0.7999801899 
          493           494           495           496 
-0.0321608774 -0.3801969093  0.2232045647 -0.4081377841 
          497           498           499           500 
 0.5864097103 -0.3631232254  0.5199042019  0.2698767445 
          501           502           503           504 
 0.2420388400 -2.0739821392 -1.3223637584  0.2507420555 
          505           506           507           508 
-1.8607123123 -1.1148332025  0.2101689167  0.6830952621 
          509           510           511           512 
-1.4612696048  1.1312542054 -0.8649114661  0.6227693753 
          513           514           515           516 
-1.6723877323 -0.9741181765  0.9659854062  0.1628217309 
          517           518           519           520 
-1.2488231292 -0.4827012115  0.0004087999  0.7730599302 
          521           522           523           524 
-2.1643961535 -0.8461929954  0.5290603381  0.8430268940 
          525           526           527           528 
 0.6028276729 -2.0636478601 -2.2269338248 -1.0541807627 
          529           530           531           532 
-0.7986529349  0.9242199365  0.7938483082 -0.5373323956 
          533           534           535           536 
 0.5873560633 -0.9027343325 -0.9326704117  0.9462073857 
          537           538           539           540 
```

```
 0.8720476793  0.3307635835 -0.2536134283  0.4541339446 
          541           542           543           544 
-1.2339007570 -0.7745289475 -0.1332490916 -0.8280471938 
          545           546           547           548 
-0.5027044388  0.1748188760  0.8025394175  0.1450791633 
          549           550           551           552 
 0.6111641530  0.9914119816 -0.0130842237 -1.1471204344 
          553           554           555           556 
-2.1175925779 -1.8967008800 -1.3244845608 -0.5086408309 
          557           558           559           560 
-0.3149336345 -1.3957960395 -1.3558250471 -0.7754495854 
          561           562           563           564 
-0.0634808064  0.1020543998 -0.4353720285 -1.6222772609 
          565           566           567           568 
-0.7273512197 -0.6786457618  0.0147312268 -1.3116107026 
          569           570           571           572 
-0.4356407975 -0.8335578330  0.3632794114 -0.4815669909 
          573           574           575           576 
-1.4167967727 -0.3555042051 -1.9712803624  0.0624892818 
          577           578           579           580 
-0.3147008824 -0.5406129562 -1.7895177486 -0.1296023812 
          581           582           583           584 
-1.3878908076 -2.2047997930  0.3896294729 -0.2417317900 
          585           586           587           588 
-2.0176717155 -0.4520436665 -1.6136709298 -0.2215439024 
          589           590           591           592 
-1.7175592093  0.5920284101 -0.7706682521  0.1883367448 
          593           594           595           596 
 0.6529500085 -0.7326926571 -1.5146385907 -0.4610705210 
          597           598           599           600 
-1.3351115624 -0.3300110796 -1.0712207633 -0.0880638690 
          601           602           603           604 
 0.5105157892  0.8571718949  0.4672417657 -0.4094408260 
          605           606           607           608 
-2.2591028382 -1.2536389427 -0.2418429804  0.3757001332 
          609           610           611           612 
 0.1196871563 -0.6528739215 -2.6183033981  0.3833946487 
          613           614           615           616 
 0.7572399489 -0.8462762007  0.6111882547 -0.2778807243 
          617           618           619           620 
-2.1589409815 -0.7997259804  0.5705576807 -0.3512787924 
          621           622           623           624 
-2.1989071200 -0.3431620161 -2.2581455382 -0.9289415707 
          625           626           627           628 
 0.6525139735  0.5027889938 -0.6472604082 -0.9526541980 
          629           630           631           632 
-0.4210836564 -0.6000302853  0.0641028047 -0.6549704240 
          633           634           635           636 
 0.5730949913 -0.6128967878  0.4421103954 -0.6566581071 
          637           638           639           640 
 0.4558379505 -0.1341515927  0.8058834872  1.0344590873 
          641           642           643           644 
 0.0464136207 -0.5926081862  0.2656308002 -0.5282893711 
          645           646           647           648 
```

```
 0.7121323700 -1.3337410131  1.1652110099  0.9401114545
          649           650           651           652
 1.0296403477 -2.3853930549  1.1027311481 -1.9136197424
          653           654           655           656
-1.6593245628  0.5504725449  0.8799373209  0.8264984817
          657           658           659           660
-1.1564388190  0.7886391474 -0.7898891754  1.0510160956
          661           662           663           664
 0.8027202213 -1.1836054102  0.7694509900  0.7605574408
          665           666           667           668
-0.6495002784 -0.7763740026 -2.1940869270  0.4677221836
          669           670           671           672
-1.6985177795 -1.8893349537  0.6100891720 -0.5401959844
          673           674           675           676
-1.5387516690 -0.6001189819 -1.4048509593  0.9269062746
          677           678           679           680
-0.9667635837 -1.0126480204  0.2461579028  1.2011929701
          681           682           683           684
 0.2661837458  0.6825329311  0.7405110080  0.9149890388
          685           686           687           688
 0.7118893120 -0.7326264525 -2.1923403268  1.1490060873
          689           690           691           692
-2.2183477776 -0.8421798681 -1.0234034240 -1.9356925819
          693           694           695           696
 1.1228350628  0.2609480932  0.5505130118  0.5695877848
          697           698           699           700
-0.7910332897 -0.8972406525  0.6555767025 -2.7395538646
          701           702           703           704
-1.8576776918  0.5197046812 -0.3669524187  0.8963484486
          705           706           707           708
-1.9983459677 -2.2298623292  0.5488038771  1.3655617528
          709           710           711           712
-1.5756929097  0.8024070936  0.9480431204  0.8002855660
          713           714           715           716
-1.0841051988 -1.8842937263 -0.9724860468  1.2501005998
          717           718           719           720
-0.8890073308 -2.2573028637 -0.7533074134  0.9856192820
          721           722           723           724
 0.7835895590 -1.0898720665 -0.3611287845  0.6301621591
          725           726           727           728
 0.7132314449  0.6448780441 -0.9380736220 -0.5539702692
          729           730           731           732
 0.8012230886  0.6869788081  0.4850143737 -0.9070780697
          733           734           735           736
-2.0202803952  0.7915432216  0.7380515566  0.4244509544
          737           738           739           740
-0.4842972593  0.0649618566 -0.1336787930  0.3634787880
          741           742           743           744
 1.1795925560  0.3266536118  0.4511775439  0.4638074322
          745           746           747           748
-0.5660553919  0.1920890393 -2.7549124750 -1.0866762470
          749           750           751           752
-0.4132406525 -0.1470009245  0.3113398053  0.1971848169
          753           754           755           756
```

```
 0.6402004755  1.0020781979  0.4719865084 -0.3959686818 
          757           758           759           760 
-1.2342268454 -0.4203491552  0.0346096385  0.4051685454 
          761           762           763           764 
 0.3647287810  0.1244061106 -0.7375129535 -3.0038036006 
          765           766           767           768 
-1.5778153193 -0.5499708126 -0.1207353614  0.0679097074 
          769           770           771           772 
-0.2101301131 -2.0258443477 -1.0290454196 -1.0533797906 
          773           774           775           776 
-0.4313076862  0.6630064633 -2.0774715030  0.2141704229 
          777           778           779           780 
-0.3304338043  0.5728794099 -0.6914214721  0.3518342673 
          781           782           783           784 
 0.0428653127 -0.6330945951  0.0985772849  0.2511068398 
          785           786           787           788 
-1.0533797906 -0.7104807519  0.7731451013  0.6266088980 
          789           790           791           792 
-0.6526045610  0.7074403007  0.6374833124 -0.2214617915 
          793           794           795           796 
-2.1396336189  0.0032383746 -0.8349683473 -0.5330520522 
          797           798           799           800 
-0.1209525296 -0.8189912679 -1.5112587472 -0.6315360298 
          801           802           803           804 
-0.4002937288  0.1682834604  0.5545289506 -0.9438655178 
          805           806           807           808 
 0.8703178133  0.9415346682 -0.4533781694  0.6409301845 
          809           810           811           812 
-0.7224580957  0.1682834604 -0.6664663686  0.6394403945 
          813           814           815           816 
 0.6141876907 -0.1381896230 -2.0783171159 -0.8179908691 
          817           818           819           820 
-0.0994886200  0.3073001323  0.7220461840  0.2415543952 
          821           822           823           824 
-1.1804668505  0.1207280630  0.4677380202 -0.7509146911 
          825           826           827           828 
 0.2906340854  0.6315029529 -1.2350040274 -0.3716304823 
          829           830           831           832 
 1.0903602929  0.7253291624 -0.3917414103 -0.6130661339 
          833           834           835           836 
-0.0511545846 -0.1139347580 -1.4739912372 -1.3081682387 
          837           838           839           840 
 0.5247901816  0.9781860940 -0.4282084368  0.2877621147 
          841           842           843           844 
 0.4541366467  0.1738410799 -1.2359941586  1.0000306009 
          845           846           847           848 
 1.1116707387  1.5508615722  1.5110943088  0.7321087956 
          849           850           851           852 
 0.3634875401 -0.4413710500  0.7930293547  0.1067756657 
          853           854           855           856 
 1.1013919111  1.0492150333  0.2693291981  1.4128554278 
          857           858           859           860 
 0.2131382849 -0.3763182918  1.2288393052 -1.2623286058 
          861           862           863           864 
```

```
  0.1748848393  0.1365023161  1.6522449536  0.8099923968
           865           866           867           868
  0.6695937974  0.7714751938  0.6099153899  0.6574913736
           869           870           871           872
  0.4772593477 -0.0316925071 -0.2114414978  0.7316305899
           873           874           875           876
  0.2871049300  1.3140201224  0.2146035587 -0.3939124306
           877           878           879           880
  1.1004908439  0.8909387658  1.0802482060  0.5522554610
           881           882           883           884
 -0.7700825545 -0.4637979054  1.4111598955  0.4335318102
           885           886           887           888
 -0.2458793556 -0.3921541261 -0.6969561397  0.6758097405
           889           890           891           892
 -0.2853939255  0.1084040294 -1.3486734732 -1.5462006783
           893           894           895           896
  0.8629771992 -0.1297734301 -0.0966814681  1.1088431779
           897           898           899           900
  1.0446360003  0.5606660043  1.6862391525 -0.7897340987
           901           902           903           904
  0.7811238993  0.0042608573  1.4625363830 -0.8162847810
           905           906           907           908
  0.2616295128 -0.9595608141  0.1877956697 -0.2229935640
           909           910           911           912
 -0.5644159626  0.1930908777 -0.1725258979 -0.8856873533
           913           914           915           916
  0.6345467626  0.0269037458  0.2742965552 -0.3583999692
           917           918           919           920
  1.4213186112  0.2564016672 -1.1215222625  0.0008657395
           921           922           923           924
 -0.3073650837 -1.2616538927  0.2339953373  0.6301517289
           925           926           927           928
  0.0123349588 -0.2615099867 -0.5227918212 -0.1824027181
           929           930           931           932
 -0.9623276411 -0.6068785534 -0.4225807386 -1.2165374755
           933           934           935           936
 -0.3516779014 -1.6851946970 -0.4372719679 -0.0430011842
           937           938           939           940
  1.3112712821  0.2225096364 -0.3873712310  1.0760023903
           941           942           943           944
  0.9023124780  0.8628973922  0.2720049527 -0.7562583894
           945           946           947           948
 -0.4538046351  1.4198051966  0.4238912698 -0.2531700123
           949           950           951           952
 -0.3821609608 -0.6911852105  0.4940396614 -0.2774735190
           953           954           955           956
  0.1217423816 -1.3586235849 -1.5522065142  0.8647794277
           957           958           959           960
 -0.1260579731 -0.1032672605  1.1012004167  1.0419018998
           961           962           963           964
  0.5698560500  1.6796280824 -0.7887508028  0.7784301210
           965           966           967           968
  0.0001483908  1.4696846212 -0.8059247491  0.2669013832
           969           970           971           972
```

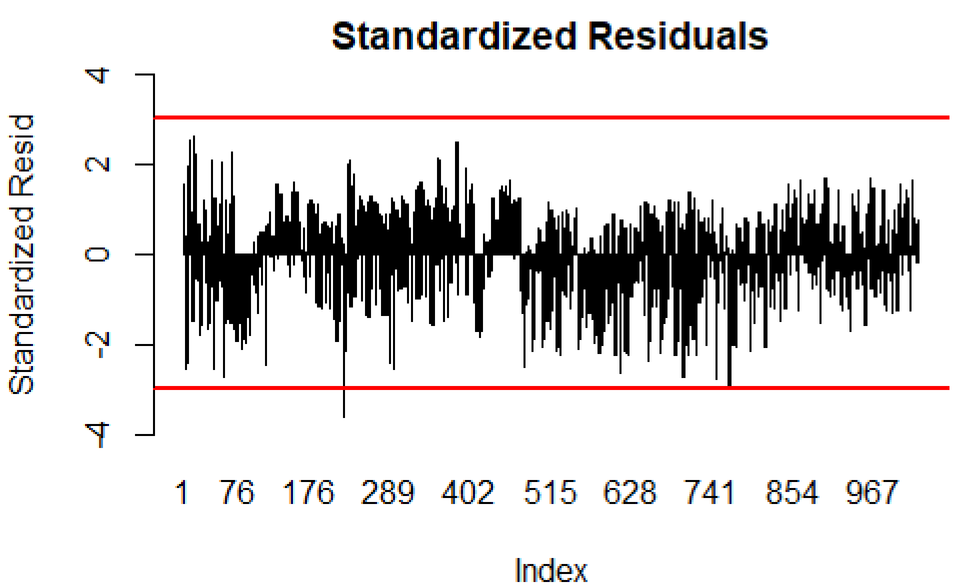
```
-0.9495268761  0.1767942252 -0.2294457576 -0.5520195892 
          973           974           975           976 
 0.1974562842 -0.1714062972 -0.8773481032  0.6282528218 
          977           978           979           980 
 0.0138077709  0.2821980577 -0.3657076484  1.4224849608 
          981           982           983           984 
 0.2620465193 -1.1314753671  0.0062020066 -0.3152709158 
          985           986           987           988 
-1.2512989487  0.2237657482  0.7215652729 -0.3978555897 
          989           990           991           992 
-0.6109011081 -0.0471932452 -0.1212697708 -1.0657053161 
          993           994           995           996 
-1.2943065830  0.5187606397  0.9803475728 -0.4209705570 
          997           998           999          1000 
 0.2945204062  0.4536506403  0.1792366106 -1.2429659823 
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = stdres(lm2), names.arg = 1:1030,
        main = "Standardized Residuals", xlab = "Index",
        ylab = "Standardized Resid", ylim=c(-4,4))
#Add cutoff values. Either 2 or 3 can be chosen.
abline(h=3, col = "Red", lwd=2)
```

Hide

```
abline(h=-3, col = "Red", lwd=2)
```



Hide

```
#studentized residuals
print("studentized residuals:")
```

```
[1] "studentized residuals:"
```

Hide

```
studres(lm2)
```

```
            1             2             3             4 
 1.5665021268  0.3910203385 -1.5497187427 -2.5583846463 
            5             6             7             8 
-1.5258094557  1.9464178286 -2.4203312004  0.7086083943 
            9            10            11            12 
 2.5416906251  0.7877233462  0.9430041123  0.6723315504 
           13            14            15            16 
-1.4921130337  1.7023495592  2.6293428162  2.1946693009 
           17            18            19            20 
 1.0100736429 -0.5448913829  0.3845780037 -0.6105402184 
           21            22            23            24 
-0.5884623639  0.6485988462 -1.7738545143  0.4261742090 
           25            26            27            28 
-0.8859551321  0.2317787630 -1.5614783651  1.2071709884 
           29            30            31            32 
 0.7100126203  0.9603491029 -0.5395335075 -0.6453641044 
           33            34            35            36 
 0.2655781413 -1.6551403916 -0.4465569508 -1.5394732974 
           37            38            39            40 
 0.3667178152  0.2240374573  0.3527328898 -0.7293613427 
           41            42            43            44 
 2.0765087210 -2.5095444798 -2.5653081537  1.2118609854 
           45            46            47            48 
 0.3812282964  0.7295414667 -1.0206383630 -0.5928662609 
           49            50            51            52 
 0.2060745988  0.6043994605 -0.5900734708  1.0836929062 
           53            54            55            56 
-0.0235088330  2.0471994405 -0.7474130456 -0.6925554461 
           57            58            59            60 
-2.7506027396 -1.5255120538  1.1875728046  0.4779621138 
           61            62            63            64 
 0.4517971368  0.3225830093 -1.4180470926  0.3807844518 
           65            66            67            68 
 1.0831947429  0.4323379073 -1.5429766089  0.4445374539 
           69            70            71            72 
 2.2666672058  1.2859288859 -1.2313169982 -1.6526687036 
           73            74            75            76 
-1.5111237034 -1.2895310588 -1.9111596455 -1.1286724155 
           77            78            79            80 
-1.8043030024 -1.5111237034 -1.4748931217 -1.2611820616 
           81            82            83            84 
-1.5111237034 -2.0988136168 -0.6147950773 -1.1423361551 
           85            86            87            88 
-1.8083037962 -1.8851353944 -1.1423361551 -1.9908987903 
           89            90            91            92 
-1.1423361551 -1.0142526213 -1.3804416210 -1.1423361551 
           93            94            95            96 
-1.7888756049 -0.2600008143 -0.4135474042 -0.2088891272 
           97            98            99           100 
-0.4439519684 -0.4515288495  0.2531575062 -0.6794756319 
          101           102           103           104 
-0.2088891272 -0.8575723440 -0.8443599856 -0.2088891272 
          105           106           107           108 
```

```
-1.3124550685  0.3695432870  0.4856649767  0.0449355511 
          109           110           111           112 
-0.2764782025  0.4856649767 -0.6964783091  0.4856649767 
          113           114           115           116 
 0.2727251409  0.0104553726 -2.4512902328 -0.7255079038 
          117           118           119           120 
 0.6176821316  0.6524088510  0.3764677415  0.4353821148 
          121           122           123           124 
 0.1563487855  0.9015434646 -0.0716616716  0.3764677415 
          125           126           127           128 
 0.2308031915 -0.3542541503  0.3764677415  0.2765128441 
          129           130           131           132 
 1.1416235763  1.3079949812  1.5441652594 -0.1139759956 
          133           134           135           136 
 1.3079949812  1.3220611102  1.3079949812  0.7318406590 
          137           138           139           140 
 0.8082438307  1.3079949812  0.2829889922  0.4681983780 
          141           142           143           144 
 0.6953190946  0.3442376655  0.3385577386  0.0966051341 
          145           146           147           148 
 0.8522709299 -0.2225493916  0.3442376655  0.2586589447 
          149           150           151           152 
-0.4913440709  0.3442376655  0.7088321826  1.1687234819 
          153           154           155           156 
 1.3784075655  1.5757573441 -0.2219985740  1.3784075655 
          157           158           159           160 
 1.3570254568  1.3784075655  0.7970560382  0.8036333602 
          161           162           163           164 
 1.3784075655  0.7087529328  0.1841344832  0.4231670058 
          165           166           167           168 
 0.0190111065  0.0732314938 -0.1302932936  0.5862590522 
          169           170           171           172 
-0.5185197771  0.0190111065  0.0466956347 -0.8504817345 
          173           174           175           176 
 0.0190111065  0.4556147641  0.8960018632  1.1152359899 
          177           178           179           180 
-0.4916644849  1.1152359899  1.2107654542  1.1152359899 
          181           182           183           184 
 0.5130141845  0.6110084738  1.1152359899  0.8621409435 
          185           186           187           188 
-1.0791490946  0.4770900642  0.3709329376  0.5385152134 
          189           190           191           192 
 1.0916005523 -1.1884216902  0.3050943935  0.2310403909 
          193           194           195           196 
 0.4447019783  0.6338241464 -1.2088342724  0.2706409298 
          197           198           199           200 
 0.1951756547  0.7092258807  0.5324417761 -1.0698589339 
          201           202           203           204 
-0.4169824010  0.0259929335  0.5951146355  0.5725096117 
          205           206           207           208 
-1.2370819644 -0.2234929134  0.0748077307  0.6995700456 
          209           210           211           212 
 0.6996235565 -1.4583666078 -0.1483736051  0.2049590426 
          213           214           215           216 
```

```
  0.6233933243  0.4961087186 -1.9462945775 -0.2225038080 
           217           218           219           220 
  0.2424298028  0.8850292964  0.5585236761 -1.4614637973 
           221           222           223           224 
  0.3425604365 -0.2544060509  0.2091099542  0.2036358228 
           225           226           227           228 
 -3.6276249510 -2.1619025690 -1.5473714862 -0.9738254230 
           229           230           231           232 
 -0.8806180725 -0.4876769308  0.7723607806  1.9786065914 
           233           234           235           236 
  2.0668071337  1.8166936902 -1.1551111110 -0.6304501578 
           237           238           239           240 
  1.5208572242  1.7813762910  1.5178463449 -0.9288122358 
           241           242           243           244 
  0.1136789849  0.2088833761  0.6022837167  0.9806234077 
           245           246           247           248 
 -0.1235674253  0.4122817348  0.7252866895  1.2807157349 
           249           250           251           252 
  1.1917328614 -1.0579572190  0.2072708116  0.5026980372 
           253           254           255           256 
  1.0487479570  0.9083577517 -1.3684364160  0.0887423953 
           257           258           259           260 
  0.4736557820  1.1428596471  0.6884601067 -1.3985151269 
           261           262           263           264 
 -0.0106860206  1.0089920008  1.2969949722  1.0799005612 
           265           266           267           268 
 -0.7673277408  0.3964429345  0.9014004298  1.1473895973 
           269           270           271           272 
  0.8812453921 -1.1479876394  0.0849576633  0.6199332940 
           273           274           275           276 
  1.1022579702  0.8742384935 -0.7651416053  0.5508001592 
           277           278           279           280 
  0.3685490258  0.7508284684  0.8331954413 -1.3398793601 
           281           282           283           284 
 -0.0236642296  0.6619505431  0.7212318182  0.8849669788 
           285           286           287           288 
 -1.3570097254 -0.4354854361  0.0872618171  0.5342835741 
           289           290           291           292 
  0.8897527825 -2.4418716525 -0.4558580555  0.4285810142 
           293           294           295           296 
  1.2121968368  1.1421729765 -2.5473443707 -0.3448211562 
           297           298           299           300 
  0.2949142039  0.7247147512  0.9827185210 -0.7925176053 
           301           302           303           304 
  0.3310543360  0.1832881404  0.7666296885  0.5905789530 
           305           306           307           308 
 -0.7565866709  0.9298757975  1.2939815331  1.1983593971 
           309           310           311           312 
  1.0564579034 -0.7163862759  0.4072654341  0.6709182809 
           313           314           315           316 
  1.0806219882  0.8503686218 -1.0802735589  0.0954180472 
           317           318           319           320 
 -0.0045553821  0.5771833352  0.1920022187 -1.5025436810 
           321           322           323           324 
```

```
-0.0600067675  0.0020530823  0.7038871208  0.9404750302
          325           326           327           328
-0.9823862013  0.8956263748  1.4065007448  1.4885301097
          329           330           331           332
 1.3686399035 -1.0103115488  0.6630234713  1.3239264261
          333           334           335           336
 1.5833253239  1.5161542005 -0.8847767517  0.4604613877
          337           338           339           340
 1.3272932802  1.4274677158  1.0684053250 -0.9602558703
          341           342           343           344
 0.4425645981  1.1618848875  1.2053456051  1.0734501955
          345           346           347           348
-1.5398863464  0.1000382412  0.5212295976  0.7493318196
          349           350           351           352
 0.5335199299 -1.5642031783  0.0990375644  1.0041374778
          353           354           355           356
 1.1241799186  1.2160538129 -0.2226920692  1.1674091390
          357           358           359           360
 2.1467482221  2.0862825607  1.6086503857 -0.8049744701
          361           362           363           364
-0.0983457190  1.3312954495  1.4836713314  1.1040137563
          365           366           367           368
-1.5004716935  0.5204359816  1.4684161190  1.2909714338
          369           370           371           372
 1.0014741708 -1.3911218667 -0.2194263098  0.0541722905
          373           374           375           376
 0.4066576418  0.6776179623 -0.6346721126  0.3628012709
          377           378           379           380
 0.8539234129  0.9485490675  1.0479846370  0.7078751761
          381           382           383           384
-0.1908621197  2.4704057153  1.1358151583  2.4914513993
          385           386           387           388
-0.9226154027  0.6641718812  0.6666587169  0.0977679584
          389           390           391           392
 0.3417123374  0.3134411132  0.0042058824  0.0924185025
          393           394           395           396
 0.0801790091  0.3590194555  1.3943092454  1.9120718252
          397           398           399           400
-0.9226154027  0.3262233257  0.9521065447  1.0957268075
          401           402           403           404
 1.4190025159  0.8323911115  0.8419973373  1.0391006361
          405           406           407           408
 1.5561122891  1.1000993526 -1.0060905054 -1.1000223918
          409           410           411           412
-0.8694148498 -1.6900852717 -0.7013644419 -0.6521768214
          413           414           415           416
-1.7091629479 -1.6511408751 -1.3301993204 -1.8376709683
          417           418           419           420
-1.6989336969 -1.1489285477 -1.4183661172 -0.7855726932
          421           422           423           424
 0.2432864115  0.4220125747  0.1217936692  0.0922671921
          425           426           427           428
 0.2511904682  0.1271291447 -0.1829021167 -0.5101672504
          429           430           431           432
```

```
 0.2759484491 -0.1972918630  0.2942800720 -0.3504580257
          433           434           435           436
 0.1595286898  1.2415476435  0.7097424633  0.8148073664
          437           438           439           440
 0.3188560696  0.5705532901  0.7339658995  0.4386807122
          441           442           443           444
-0.0354703209  0.3950459473  1.0003722430  1.4220369572
          445           446           447           448
 0.8170135790  0.8610063252  1.4977321460  1.1771998174
          449           450           451           452
 1.3480940509  0.2094541054  1.5177304988  1.3806140310
          453           454           455           456
 1.0559590467  0.3598617877  1.2603391777  1.2127883105
          457           458           459           460
 1.6387650893  1.0509212042  0.5006808369  1.1083207484
          461           462           463           464
 0.8006697798  1.0084023900 -0.1117453798  1.2006073843
          465           466           467           468
 1.1411654589  0.7209639928  0.0500935188  0.9053135075
          469           470           471           472
 0.8556666257  1.2263430964  0.6418035194  0.1668555115
          473           474           475           476
-0.7989826038 -0.2783918044 -0.0998301043 -1.3063177219
          477           478           479           480
-2.3397166520 -2.5262125251  0.0283231132 -1.1108872292
          481           482           483           484
-0.9986364640  0.1442378847 -0.2063926029 -0.2713141361
          485           486           487           488
-0.3065464786  0.0769738937 -0.2012654815 -0.2012654815
          489           490           491           492
-2.1748805353 -1.8672512581 -0.9441436912 -0.7998394557
          493           494           495           496
-0.0321451863 -0.3800380453  0.2231009788 -0.4079716336
          497           498           499           500
 0.5862217473 -0.3629692460  0.5197188788  0.2697545300
          501           502           503           504
 0.2419275485 -2.0773368146 -1.3228478864  0.2506272871
          505           506           507           508
-1.8629556293 -1.1149655529  0.2100708010  0.6829172526
          509           510           511           512
-1.4620811270  1.1314089060 -0.8648049875  0.6225831278
          513           514           515           516
-1.6738584292 -0.9740938513  0.9659538351  0.1627443154
          517           518           519           520
-1.2491648092 -0.4825203593  0.0004086002  0.7729079406
          521           522           523           524
-2.1683045430 -0.8460755796  0.5288742322  0.8429077148
          525           526           527           528
 0.6026401947 -2.0669424832 -2.2312557349 -1.0542381121
          529           530           531           532
-0.7985116063  0.9241540748  0.7937048627 -0.5371456941
          533           534           535           536
 0.5871681155 -0.9026526868 -0.9326110994  0.9461589730
          537           538           539           540
```

```
 0.8719456034  0.3306197006 -0.2534975248  0.4539578621
          541           542           543           544
-1.2342159935 -0.7743775291 -0.1331851673 -0.8279200058
          545           546           547           548
-0.5025209298  0.1747361019  0.8023998409  0.1450097968
          549           550           551           552
 0.6109771025  0.9914036946 -0.0130778345 -1.1472975813
          553           554           555           556
-2.1212079312 -1.8991134085 -1.3249731031 -0.5084566457
          557           558           559           560
-0.3147950665 -1.3964433903 -1.3563808804 -0.7752985276
          561           562           563           564
-0.0634499272  0.1020050751 -0.4351996735 -1.6235726551
          565           566           567           568
-0.7271838515 -0.6784669036  0.0147240336 -1.3120727173
          569           570           571           572
-0.4354683859 -0.8334335273  0.3631253859 -0.4813863065
          573           574           575           576
-1.4174948239 -0.3553525064 -1.9740668113  0.0624588811
          577           578           579           580
-0.3145623943 -0.5404260482 -1.7914471533 -0.1295401458
          581           582           583           584
-1.3885195440 -2.2089724322  0.3894680487 -0.2416206222
          585           586           587           588
-2.0207070302 -0.4518679765 -1.6149374346 -0.2214410073
          589           590           591           592
-1.7191985313  0.5918405602 -0.7705153428  0.1882480214
          593           594           595           596
 0.6527670117 -0.7325268507 -1.5155975354 -0.4608931779
          597           598           599           600
-1.3356224887 -0.3298674439 -1.0712980052 -0.0880211918
          601           602           603           604
 0.5103314014  0.8570607873  0.4670633558 -0.4092743580
          605           606           607           608
-2.2636474689 -1.2539893307 -0.2417317677  0.3755425248
          609           610           611           612
 0.1196295378 -0.6526909144 -2.6258291268  0.3832349056
          613           614           615           616
 0.7570821150 -0.8461588315  0.6110012056 -0.2777554798
          617           618           619           620
-2.1628144993 -0.7995851321  0.5703696893 -0.3511283846
          621           622           623           624
-2.2030405601 -0.3430141395 -2.2626834416 -0.9288793445
          625           626           627           628
 0.6523309176  0.5026054748 -0.6470766677 -0.9526111546
          629           630           631           632
-0.4209144423 -0.5998426912  0.0640716254 -0.6547877062
          633           634           635           636
 0.5729069759 -0.6127098417  0.4419366490 -0.6564756283
          637           638           639           640
 0.4556615524 -0.1340872513  0.8057454465  1.0344945346
          641           642           643           644
 0.0463910011 -0.5924203512  0.2655102137 -0.5281033260
          645           646           647           648
```

```
 0.7119608841 -1.3342490277  1.1654147855  0.9400580710
          649           650           651           652
 1.0296706239 -2.3908800288  1.1028475925 -1.9161143195
          653           654           655           656
-1.6607483826  0.5502851195  0.8798402641  0.8263704970
          657           658           659           660
-1.1566295433  0.7884934675 -0.7897440260  1.0510698499
          661           662           663           664
 0.8025807270 -1.1838374105  0.7692976176  0.7604007860
          665           666           667           668
-0.6493168233 -0.7762233087 -2.1981884706  0.4675436928
          669           670           671           672
-1.7000847756 -1.8917122629  0.6099020594 -0.5400091017
          673           674           675           676
-1.5397813615 -0.5999313913 -1.4055199469  0.9268424739
          677           678           679           680
-0.9667326978 -1.0126606198  0.2460449589  1.2014530574
          681           682           683           684
 0.2660629465  0.6823548121  0.7403475983  0.9149162441
          685           686           687           688
 0.7117177643 -0.7324606264 -2.1964303499  1.1491859579
          689           690           691           692
-2.2226114017 -0.8420602213 -1.0234271115 -1.9382966372
          693           694           695           696
 1.1229781932  0.2608293185  0.5503255846  0.5693998054
          697           698           699           700
-0.7908886289 -0.8971551684  0.6553940700 -2.7483059022
          701           702           703           704
-1.8599070678  0.5195193766 -0.3667973163  0.8962623487
          705           706           707           708
-2.0012760662 -2.2342042306  0.5486165283  1.3661392850
          709           710           711           712
-1.5768361127  0.8022674568  0.9479962248  0.8001449691
          713           714           715           716
-1.0841980877 -1.8866471061 -0.9724602523  1.2504445814
          717           718           719           720
-0.8889162429 -2.2618348503 -0.7531482134  0.9856055267
          721           722           723           724
 0.7834417731 -1.0899721296 -0.3609753962  0.6299765510
          725           726           727           728
 0.7130602401  0.6446940104 -0.9380185996 -0.5537826977
          729           730           731           732
 0.8010829147  0.6868015717  0.4848331849 -0.9069995155
          733           734           735           736
-2.0233300827  0.7913987797  0.7378873787  0.4242809771
          737           738           739           740
-0.4841161741  0.0649302630 -0.1336146701  0.3633247036
          741           742           743           744
 1.1798182992  0.3265110859  0.4510020181  0.4636296096
          745           746           747           748
-0.5658674695  0.1919986821 -2.7638283049 -1.0867723213
          749           750           751           752
-0.4130732701 -0.1469306795  0.3112024764  0.1970922536
          753           754           755           756
```

```
  0.6400158975  1.0020802358  0.4718073136 -0.3958055938 
           757           758           759           760 
 -1.2345426511 -0.4201801095  0.0345927553  0.4050031260 
           761           762           763           764 
  0.3645743289  0.1243462903 -0.7373486091 -3.0156519405 
           765           766           767           768 
 -1.5789652349 -0.5497834098 -0.1206772531  0.0678766931 
           769           770           771           772 
 -0.2100320137 -2.0289248263 -1.0290750622 -1.0534362271 
           773           774           775           776 
 -0.4311361985  0.6628249329 -2.0808466028  0.2140706165 
           777           778           779           780 
 -0.3302900297  0.5726913961 -0.6912451574  0.3516836888 
           781           782           783           784 
  0.0428444157 -0.6329092685  0.0985296072  0.2509919269 
           785           786           787           788 
 -1.0534362271 -0.7103088484  0.7729931446  0.6264229701 
           789           790           791           792 
 -0.6524215173  0.7072676433  0.6372984370 -0.2213589306 
           793           794           795           796 
 -2.1433852410  0.0032367929 -0.8348447913 -0.5328656455 
           797           798           799           800 
 -0.1208943199 -0.8188595032 -1.5122079837 -0.6313505516 
           801           802           803           804 
 -0.4001295324  0.1682035966  0.5543413577 -0.9438151833 
           805           806           807           808 
  0.8702146582  0.9414824360 -0.4532022281  0.6407456887 
           809           810           811           812 
 -0.7222893502  0.1682035966 -0.6662853881  0.6392557319 
           813           814           815           816 
  0.6140008260 -0.1381234190 -2.0816971767 -0.8178586109 
           817           818           819           820 
 -0.0994405103  0.3071642104  0.7218773249  0.2414432988 
           821           822           823           824 
 -1.1806939522  0.1206699582  0.4675595268 -0.7507546766 
           825           826           827           828 
  0.2905041214  0.6313174716 -1.2353211912 -0.3714740294 
           829           830           831           832 
  1.0904609683  0.7251612190 -0.3915794266 -0.6128791984 
           833           834           835           836 
 -0.0511296660 -0.1138798341 -1.4748367717 -1.3086232685 
           837           838           839           840 
  0.5246044247  0.9781654639 -0.4280376245  0.2876332016 
           841           842           843           844 
  0.4539605637  0.1737587399 -1.2363130558  1.0000306308 
           845           846           847           848 
  1.1117988865  1.5519277864  1.5120430743  0.7319428155 
           849           850           851           852 
  0.3633334531 -0.4411974534  0.7928855538  0.1067241105 
           853           854           855           856 
  1.1015066246  1.0492667554  0.2692071929  1.4135438244 
           857           858           859           860 
  0.2130389136 -0.3761605094  1.2291457564 -1.2626949228 
           861           862           863           864 
```

```
 0.1748020360  0.1364368896  1.6536437174  0.8098562794
          865           866           867           868
 0.6694133340  0.7713225934  0.6097282674  0.6573090149
          869           870           871           872
 0.4770793173 -0.0316770440 -0.2113428433  0.7314644681
          873           874           875           876
 0.2869762585  1.3144870531  0.2145035699 -0.3937498772
          877           878           879           880
 1.1006043960  0.8908489766  1.0803363558  0.5520679587
          881           882           883           884
-0.7699294220 -0.4636200844  1.4118441587  0.4333598453
          885           886           887           888
-0.2457665231 -0.3919920337 -0.6967810292  0.6756303619
          889           890           891           892
-0.2852658843  0.1083517066 -1.3492136097 -1.5472527569
          893           894           895           896
 0.8628695495 -0.1297111153 -0.0966346899  1.1089675959
          897           898           899           900
 1.0446826007  0.5604782088  1.6877604744 -0.7895888832
          901           902           903           904
 0.7809751062  0.0042587763  1.4633512608 -0.8161516868
          905           906           907           908
 0.2615104734 -0.9595236517  0.1877071826 -0.2228900657
          909           910           911           912
-0.5642280737  0.1930000856 -0.1724441425 -0.8855940558
          913           914           915           916
 0.6343615814  0.0268906155  0.2741726613 -0.3582473965
          917           918           919           920
 1.4220278188  0.2562846675 -1.1216636099  0.0008653166
          921           922           923           924
-0.3072291391 -1.2620189630  0.2338873070  0.6299661198
          925           926           927           928
 0.0123289354 -0.2613909937 -0.5226062373 -0.1823165943
          929           930           931           932
-0.9622928724 -0.6066912675 -0.4224111835 -1.2168229589
          933           934           935           936
-0.3515273708 -1.6867121684 -0.4370992147 -0.0429802212
          937           938           939           940
 1.3117326061  0.2224063394 -0.3872104105  1.0760853779
          941           942           943           944
 0.9022305348  0.8627896944  0.2718819276 -0.7561002113
          945           946           947           948
-0.4536286141  1.4205106608  0.4237214184 -0.2530542838
          949           950           951           952
-0.3820015554 -0.6910088458  0.4938572323 -0.2773484275
          953           954           955           956
 0.1216838031 -1.3591856161 -1.5532768258  0.8646728688
          957           958           959           960
-0.1259973839 -0.1032173622  1.1013148832  1.0419454728
          961           962           963           964
 0.5696680672  1.6811251232 -0.7886051701  0.7782802436
          965           966           967           968
 0.0001483183  1.4705185633 -0.8057867275  0.2667803081
          969           970           971           972
```

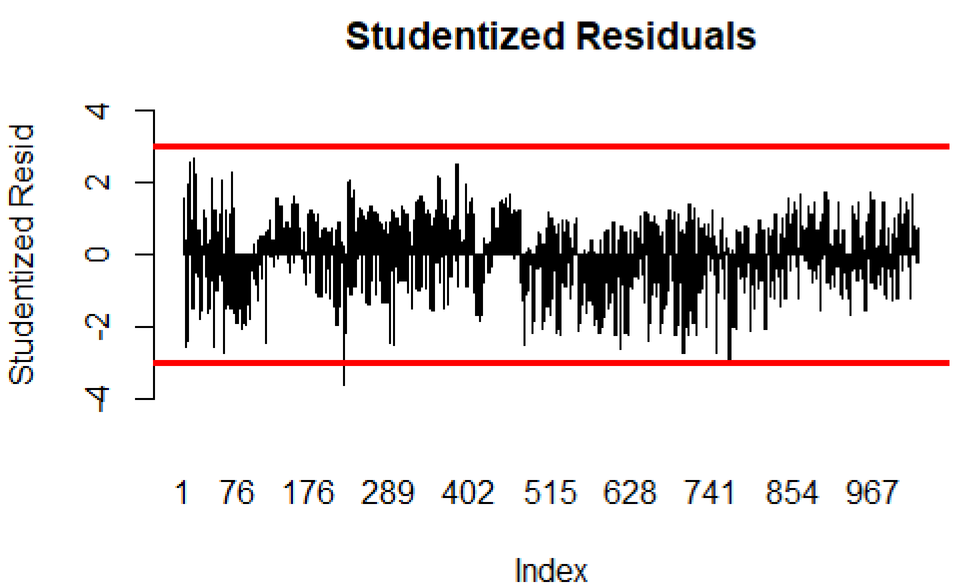
```
-0.9494812136  0.1767105757 -0.2293395916 -0.5518320968
          973           974           975           976
 0.1973636038 -0.1713250401 -0.8772493816  0.6280670389
          977           978           979           980
 0.0138010284  0.2820712005 -0.3655529094  1.4231970598
          981           982           983           984
 0.2619273180 -1.1316303749  0.0061989776 -0.3151322320
          985           986           987           988
-1.2516450949  0.2236619292  0.7213962817 -0.3976920154
          989           990           991           992
-0.6107140422 -0.0471702473 -0.1212114130 -1.0657760200
          993           994           995           996
-1.2947339471  0.5185754234  0.9803289254 -0.4208013688
          997           998           999          1000
 0.2943890313  0.4534746481  0.1791518817 -1.2432971861
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = studres(lm2), names.arg = 1:1030,
        main = "Studentized Residuals", xlab = "Index",
        ylab = "Studentized Resid", ylim=c(-5,5))
#Add cutoff values. Either 2 or 3 can be chosen.
abline(h=3, col = "Red", lwd=3)
```

Hide

```
abline(h=-3, col = "Red", lwd=3)
```



Hide

```
#R-student residuals
print("R-student residuals:")
```

```
[1] "R-student residuals:"
```

Hide

```
RStudent <- rstudent(lm2)
RStudent
```

```
           1            2            3            4 
 1.5665021268  0.3910203385 -1.5497187427 -2.5583846463 
           5            6            7            8 
-1.5258094557  1.9464178286 -2.4203312004  0.7086083943 
           9           10           11           12 
 2.5416906251  0.7877233462  0.9430041123  0.6723315504 
          13           14           15           16 
-1.4921130337  1.7023495592  2.6293428162  2.1946693009 
          17           18           19           20 
 1.0100736429 -0.5448913829  0.3845780037 -0.6105402184 
          21           22           23           24 
-0.5884623639  0.6485988462 -1.7738545143  0.4261742090 
          25           26           27           28 
-0.8859551321  0.2317787630 -1.5614783651  1.2071709884 
          29           30           31           32 
 0.7100126203  0.9603491029 -0.5395335075 -0.6453641044 
          33           34           35           36 
 0.2655781413 -1.6551403916 -0.4465569508 -1.5394732974 
          37           38           39           40 
 0.3667178152  0.2240374573  0.3527328898 -0.7293613427 
          41           42           43           44 
 2.0765087210 -2.5095444798 -2.5653081537  1.2118609854 
          45           46           47           48 
 0.3812282964  0.7295414667 -1.0206383630 -0.5928662609 
          49           50           51           52 
 0.2060745988  0.6043994605 -0.5900734708  1.0836929062 
          53           54           55           56 
-0.0235088330  2.0471994405 -0.7474130456 -0.6925554461 
          57           58           59           60 
-2.7506027396 -1.5255120538  1.1875728046  0.4779621138 
          61           62           63           64 
 0.4517971368  0.3225830093 -1.4180470926  0.3807844518 
          65           66           67           68 
 1.0831947429  0.4323379073 -1.5429766089  0.4445374539 
          69           70           71           72 
 2.2666672058  1.2859288859 -1.2313169982 -1.6526687036 
          73           74           75           76 
-1.5111237034 -1.2895310588 -1.9111596455 -1.1286724155 
          77           78           79           80 
-1.8043030024 -1.5111237034 -1.4748931217 -1.2611820616 
          81           82           83           84 
-1.5111237034 -2.0988136168 -0.6147950773 -1.1423361551 
          85           86           87           88 
-1.8083037962 -1.8851353944 -1.1423361551 -1.9908987903 
          89           90           91           92 
-1.1423361551 -1.0142526213 -1.3804416210 -1.1423361551 
          93           94           95           96 
-1.7888756049 -0.2600008143 -0.4135474042 -0.2088891272 
          97           98           99          100 
-0.4439519684 -0.4515288495  0.2531575062 -0.6794756319 
         101          102          103          104 
-0.2088891272 -0.8575723440 -0.8443599856 -0.2088891272 
         105          106          107          108 
```

```
-1.3124550685  0.3695432870  0.4856649767  0.0449355511
          109           110           111           112
-0.2764782025  0.4856649767 -0.6964783091  0.4856649767
          113           114           115           116
 0.2727251409  0.0104553726 -2.4512902328 -0.7255079038
          117           118           119           120
 0.6176821316  0.6524088510  0.3764677415  0.4353821148
          121           122           123           124
 0.1563487855  0.9015434646 -0.0716616716  0.3764677415
          125           126           127           128
 0.2308031915 -0.3542541503  0.3764677415  0.2765128441
          129           130           131           132
 1.1416235763  1.3079949812  1.5441652594 -0.1139759956
          133           134           135           136
 1.3079949812  1.3220611102  1.3079949812  0.7318406590
          137           138           139           140
 0.8082438307  1.3079949812  0.2829889922  0.4681983780
          141           142           143           144
 0.6953190946  0.3442376655  0.3385577386  0.0966051341
          145           146           147           148
 0.8522709299 -0.2225493916  0.3442376655  0.2586589447
          149           150           151           152
-0.4913440709  0.3442376655  0.7088321826  1.1687234819
          153           154           155           156
 1.3784075655  1.5757573441 -0.2219985740  1.3784075655
          157           158           159           160
 1.3570254568  1.3784075655  0.7970560382  0.8036333602
          161           162           163           164
 1.3784075655  0.7087529328  0.1841344832  0.4231670058
          165           166           167           168
 0.0190111065  0.0732314938 -0.1302932936  0.5862590522
          169           170           171           172
-0.5185197771  0.0190111065  0.0466956347 -0.8504817345
          173           174           175           176
 0.0190111065  0.4556147641  0.8960018632  1.1152359899
          177           178           179           180
-0.4916644849  1.1152359899  1.2107654542  1.1152359899
          181           182           183           184
 0.5130141845  0.6110084738  1.1152359899  0.8621409435
          185           186           187           188
-1.0791490946  0.4770900642  0.3709329376  0.5385152134
          189           190           191           192
 1.0916005523 -1.1884216902  0.3050943935  0.2310403909
          193           194           195           196
 0.4447019783  0.6338241464 -1.2088342724  0.2706409298
          197           198           199           200
 0.1951756547  0.7092258807  0.5324417761 -1.0698589339
          201           202           203           204
-0.4169824010  0.0259929335  0.5951146355  0.5725096117
          205           206           207           208
-1.2370819644 -0.2234929134  0.0748077307  0.6995700456
          209           210           211           212
 0.6996235565 -1.4583666078 -0.1483736051  0.2049590426
          213           214           215           216
```

```
 0.6233933243  0.4961087186 -1.9462945775 -0.2225038080
          217           218           219           220
 0.2424298028  0.8850292964  0.5585236761 -1.4614637973
          221           222           223           224
 0.3425604365 -0.2544060509  0.2091099542  0.2036358228
          225           226           227           228
-3.6276249510 -2.1619025690 -1.5473714862 -0.9738254230
          229           230           231           232
-0.8806180725 -0.4876769308  0.7723607806  1.9786065914
          233           234           235           236
 2.0668071337  1.8166936902 -1.1551111110 -0.6304501578
          237           238           239           240
 1.5208572242  1.7813762910  1.5178463449 -0.9288122358
          241           242           243           244
 0.1136789849  0.2088833761  0.6022837167  0.9806234077
          245           246           247           248
-0.1235674253  0.4122817348  0.7252866895  1.2807157349
          249           250           251           252
 1.1917328614 -1.0579572190  0.2072708116  0.5026980372
          253           254           255           256
 1.0487479570  0.9083577517 -1.3684364160  0.0887423953
          257           258           259           260
 0.4736557820  1.1428596471  0.6884601067 -1.3985151269
          261           262           263           264
-0.0106860206  1.0089920008  1.2969949722  1.0799005612
          265           266           267           268
-0.7673277408  0.3964429345  0.9014004298  1.1473895973
          269           270           271           272
 0.8812453921 -1.1479876394  0.0849576633  0.6199332940
          273           274           275           276
 1.1022579702  0.8742384935 -0.7651416053  0.5508001592
          277           278           279           280
 0.3685490258  0.7508284684  0.8331954413 -1.3398793601
          281           282           283           284
-0.0236642296  0.6619505431  0.7212318182  0.8849669788
          285           286           287           288
-1.3570097254 -0.4354854361  0.0872618171  0.5342835741
          289           290           291           292
 0.8897527825 -2.4418716525 -0.4558580555  0.4285810142
          293           294           295           296
 1.2121968368  1.1421729765 -2.5473443707 -0.3448211562
          297           298           299           300
 0.2949142039  0.7247147512  0.9827185210 -0.7925176053
          301           302           303           304
 0.3310543360  0.1832881404  0.7666296885  0.5905789530
          305           306           307           308
-0.7565866709  0.9298757975  1.2939815331  1.1983593971
          309           310           311           312
 1.0564579034 -0.7163862759  0.4072654341  0.6709182809
          313           314           315           316
 1.0806219882  0.8503686218 -1.0802735589  0.0954180472
          317           318           319           320
-0.0045553821  0.5771833352  0.1920022187 -1.5025436810
          321           322           323           324
```

```
-0.0600067675  0.0020530823  0.7038871208  0.9404750302
          325           326           327           328
-0.9823862013  0.8956263748  1.4065007448  1.4885301097
          329           330           331           332
 1.3686399035 -1.0103115488  0.6630234713  1.3239264261
          333           334           335           336
 1.5833253239  1.5161542005 -0.8847767517  0.4604613877
          337           338           339           340
 1.3272932802  1.4274677158  1.0684053250 -0.9602558703
          341           342           343           344
 0.4425645981  1.1618848875  1.2053456051  1.0734501955
          345           346           347           348
-1.5398863464  0.1000382412  0.5212295976  0.7493318196
          349           350           351           352
 0.5335199299 -1.5642031783  0.0990375644  1.0041374778
          353           354           355           356
 1.1241799186  1.2160538129 -0.2226920692  1.1674091390
          357           358           359           360
 2.1467482221  2.0862825607  1.6086503857 -0.8049744701
          361           362           363           364
-0.0983457190  1.3312954495  1.4836713314  1.1040137563
          365           366           367           368
-1.5004716935  0.5204359816  1.4684161190  1.2909714338
          369           370           371           372
 1.0014741708 -1.3911218667 -0.2194263098  0.0541722905
          373           374           375           376
 0.4066576418  0.6776179623 -0.6346721126  0.3628012709
          377           378           379           380
 0.8539234129  0.9485490675  1.0479846370  0.7078751761
          381           382           383           384
-0.1908621197  2.4704057153  1.1358151583  2.4914513993
          385           386           387           388
-0.9226154027  0.6641718812  0.6666587169  0.0977679584
          389           390           391           392
 0.3417123374  0.3134411132  0.0042058824  0.0924185025
          393           394           395           396
 0.0801790091  0.3590194555  1.3943092454  1.9120718252
          397           398           399           400
-0.9226154027  0.3262233257  0.9521065447  1.0957268075
          401           402           403           404
 1.4190025159  0.8323911115  0.8419973373  1.0391006361
          405           406           407           408
 1.5561122891  1.1000993526 -1.0060905054 -1.1000223918
          409           410           411           412
-0.8694148498 -1.6900852717 -0.7013644419 -0.6521768214
          413           414           415           416
-1.7091629479 -1.6511408751 -1.3301993204 -1.8376709683
          417           418           419           420
-1.6989336969 -1.1489285477 -1.4183661172 -0.7855726932
          421           422           423           424
 0.2432864115  0.4220125747  0.1217936692  0.0922671921
          425           426           427           428
 0.2511904682  0.1271291447 -0.1829021167 -0.5101672504
          429           430           431           432
```

```
 0.2759484491 -0.1972918630  0.2942800720 -0.3504580257 
          433           434           435           436 
 0.1595286898  1.2415476435  0.7097424633  0.8148073664 
          437           438           439           440 
 0.3188560696  0.5705532901  0.7339658995  0.4386807122 
          441           442           443           444 
-0.0354703209  0.3950459473  1.0003722430  1.4220369572 
          445           446           447           448 
 0.8170135790  0.8610063252  1.4977321460  1.1771998174 
          449           450           451           452 
 1.3480940509  0.2094541054  1.5177304988  1.3806140310 
          453           454           455           456 
 1.0559590467  0.3598617877  1.2603391777  1.2127883105 
          457           458           459           460 
 1.6387650893  1.0509212042  0.5006808369  1.1083207484 
          461           462           463           464 
 0.8006697798  1.0084023900 -0.1117453798  1.2006073843 
          465           466           467           468 
 1.1411654589  0.7209639928  0.0500935188  0.9053135075 
          469           470           471           472 
 0.8556666257  1.2263430964  0.6418035194  0.1668555115 
          473           474           475           476 
-0.7989826038 -0.2783918044 -0.0998301043 -1.3063177219 
          477           478           479           480 
-2.3397166520 -2.5262125251  0.0283231132 -1.1108872292 
          481           482           483           484 
-0.9986364640  0.1442378847 -0.2063926029 -0.2713141361 
          485           486           487           488 
-0.3065464786  0.0769738937 -0.2012654815 -0.2012654815 
          489           490           491           492 
-2.1748805353 -1.8672512581 -0.9441436912 -0.7998394557 
          493           494           495           496 
-0.0321451863 -0.3800380453  0.2231009788 -0.4079716336 
          497           498           499           500 
 0.5862217473 -0.3629692460  0.5197188788  0.2697545300 
          501           502           503           504 
 0.2419275485 -2.0773368146 -1.3228478864  0.2506272871 
          505           506           507           508 
-1.8629556293 -1.1149655529  0.2100708010  0.6829172526 
          509           510           511           512 
-1.4620811270  1.1314089060 -0.8648049875  0.6225831278 
          513           514           515           516 
-1.6738584292 -0.9740938513  0.9659538351  0.1627443154 
          517           518           519           520 
-1.2491648092 -0.4825203593  0.0004086002  0.7729079406 
          521           522           523           524 
-2.1683045430 -0.8460755796  0.5288742322  0.8429077148 
          525           526           527           528 
 0.6026401947 -2.0669424832 -2.2312557349 -1.0542381121 
          529           530           531           532 
-0.7985116063  0.9241540748  0.7937048627 -0.5371456941 
          533           534           535           536 
 0.5871681155 -0.9026526868 -0.9326110994  0.9461589730 
          537           538           539           540 
```

```
 0.8719456034  0.3306197006 -0.2534975248  0.4539578621 
          541           542           543           544 
-1.2342159935 -0.7743775291 -0.1331851673 -0.8279200058 
          545           546           547           548 
-0.5025209298  0.1747361019  0.8023998409  0.1450097968 
          549           550           551           552 
 0.6109771025  0.9914036946 -0.0130778345 -1.1472975813 
          553           554           555           556 
-2.1212079312 -1.8991134085 -1.3249731031 -0.5084566457 
          557           558           559           560 
-0.3147950665 -1.3964433903 -1.3563808804 -0.7752985276 
          561           562           563           564 
-0.0634499272  0.1020050751 -0.4351996735 -1.6235726551 
          565           566           567           568 
-0.7271838515 -0.6784669036  0.0147240336 -1.3120727173 
          569           570           571           572 
-0.4354683859 -0.8334335273  0.3631253859 -0.4813863065 
          573           574           575           576 
-1.4174948239 -0.3553525064 -1.9740668113  0.0624588811 
          577           578           579           580 
-0.3145623943 -0.5404260482 -1.7914471533 -0.1295401458 
          581           582           583           584 
-1.3885195440 -2.2089724322  0.3894680487 -0.2416206222 
          585           586           587           588 
-2.0207070302 -0.4518679765 -1.6149374346 -0.2214410073 
          589           590           591           592 
-1.7191985313  0.5918405602 -0.7705153428  0.1882480214 
          593           594           595           596 
 0.6527670117 -0.7325268507 -1.5155975354 -0.4608931779 
          597           598           599           600 
-1.3356224887 -0.3298674439 -1.0712980052 -0.0880211918 
          601           602           603           604 
 0.5103314014  0.8570607873  0.4670633558 -0.4092743580 
          605           606           607           608 
-2.2636474689 -1.2539893307 -0.2417317677  0.3755425248 
          609           610           611           612 
 0.1196295378 -0.6526909144 -2.6258291268  0.3832349056 
          613           614           615           616 
 0.7570821150 -0.8461588315  0.6110012056 -0.2777554798 
          617           618           619           620 
-2.1628144993 -0.7995851321  0.5703696893 -0.3511283846 
          621           622           623           624 
-2.2030405601 -0.3430141395 -2.2626834416 -0.9288793445 
          625           626           627           628 
 0.6523309176  0.5026054748 -0.6470766677 -0.9526111546 
          629           630           631           632 
-0.4209144423 -0.5998426912  0.0640716254 -0.6547877062 
          633           634           635           636 
 0.5729069759 -0.6127098417  0.4419366490 -0.6564756283 
          637           638           639           640 
 0.4556615524 -0.1340872513  0.8057454465  1.0344945346 
          641           642           643           644 
 0.0463910011 -0.5924203512  0.2655102137 -0.5281033260 
          645           646           647           648 
```

```
 0.7119608841 -1.3342490277  1.1654147855  0.9400580710
          649           650           651           652
 1.0296706239 -2.3908800288  1.1028475925 -1.9161143195
          653           654           655           656
-1.6607483826  0.5502851195  0.8798402641  0.8263704970
          657           658           659           660
-1.1566295433  0.7884934675 -0.7897440260  1.0510698499
          661           662           663           664
 0.8025807270 -1.1838374105  0.7692976176  0.7604007860
          665           666           667           668
-0.6493168233 -0.7762233087 -2.1981884706  0.4675436928
          669           670           671           672
-1.7000847756 -1.8917122629  0.6099020594 -0.5400091017
          673           674           675           676
-1.5397813615 -0.5999313913 -1.4055199469  0.9268424739
          677           678           679           680
-0.9667326978 -1.0126606198  0.2460449589  1.2014530574
          681           682           683           684
 0.2660629465  0.6823548121  0.7403475983  0.9149162441
          685           686           687           688
 0.7117177643 -0.7324606264 -2.1964303499  1.1491859579
          689           690           691           692
-2.2226114017 -0.8420602213 -1.0234271115 -1.9382966372
          693           694           695           696
 1.1229781932  0.2608293185  0.5503255846  0.5693998054
          697           698           699           700
-0.7908886289 -0.8971551684  0.6553940700 -2.7483059022
          701           702           703           704
-1.8599070678  0.5195193766 -0.3667973163  0.8962623487
          705           706           707           708
-2.0012760662 -2.2342042306  0.5486165283  1.3661392850
          709           710           711           712
-1.5768361127  0.8022674568  0.9479962248  0.8001449691
          713           714           715           716
-1.0841980877 -1.8866471061 -0.9724602523  1.2504445814
          717           718           719           720
-0.8889162429 -2.2618348503 -0.7531482134  0.9856055267
          721           722           723           724
 0.7834417731 -1.0899721296 -0.3609753962  0.6299765510
          725           726           727           728
 0.7130602401  0.6446940104 -0.9380185996 -0.5537826977
          729           730           731           732
 0.8010829147  0.6868015717  0.4848331849 -0.9069995155
          733           734           735           736
-2.0233300827  0.7913987797  0.7378873787  0.4242809771
          737           738           739           740
-0.4841161741  0.0649302630 -0.1336146701  0.3633247036
          741           742           743           744
 1.1798182992  0.3265110859  0.4510020181  0.4636296096
          745           746           747           748
-0.5658674695  0.1919986821 -2.7638283049 -1.0867723213
          749           750           751           752
-0.4130732701 -0.1469306795  0.3112024764  0.1970922536
          753           754           755           756
```

```
  0.6400158975  1.0020802358  0.4718073136 -0.3958055938 
           757           758           759           760 
 -1.2345426511 -0.4201801095  0.0345927553  0.4050031260 
           761           762           763           764 
  0.3645743289  0.1243462903 -0.7373486091 -3.0156519405 
           765           766           767           768 
 -1.5789652349 -0.5497834098 -0.1206772531  0.0678766931 
           769           770           771           772 
 -0.2100320137 -2.0289248263 -1.0290750622 -1.0534362271 
           773           774           775           776 
 -0.4311361985  0.6628249329 -2.0808466028  0.2140706165 
           777           778           779           780 
 -0.3302900297  0.5726913961 -0.6912451574  0.3516836888 
           781           782           783           784 
  0.0428444157 -0.6329092685  0.0985296072  0.2509919269 
           785           786           787           788 
 -1.0534362271 -0.7103088484  0.7729931446  0.6264229701 
           789           790           791           792 
 -0.6524215173  0.7072676433  0.6372984370 -0.2213589306 
           793           794           795           796 
 -2.1433852410  0.0032367929 -0.8348447913 -0.5328656455 
           797           798           799           800 
 -0.1208943199 -0.8188595032 -1.5122079837 -0.6313505516 
           801           802           803           804 
 -0.4001295324  0.1682035966  0.5543413577 -0.9438151833 
           805           806           807           808 
  0.8702146582  0.9414824360 -0.4532022281  0.6407456887 
           809           810           811           812 
 -0.7222893502  0.1682035966 -0.6662853881  0.6392557319 
           813           814           815           816 
  0.6140008260 -0.1381234190 -2.0816971767 -0.8178586109 
           817           818           819           820 
 -0.0994405103  0.3071642104  0.7218773249  0.2414432988 
           821           822           823           824 
 -1.1806939522  0.1206699582  0.4675595268 -0.7507546766 
           825           826           827           828 
  0.2905041214  0.6313174716 -1.2353211912 -0.3714740294 
           829           830           831           832 
  1.0904609683  0.7251612190 -0.3915794266 -0.6128791984 
           833           834           835           836 
 -0.0511296660 -0.1138798341 -1.4748367717 -1.3086232685 
           837           838           839           840 
  0.5246044247  0.9781654639 -0.4280376245  0.2876332016 
           841           842           843           844 
  0.4539605637  0.1737587399 -1.2363130558  1.0000306308 
           845           846           847           848 
  1.1117988865  1.5519277864  1.5120430743  0.7319428155 
           849           850           851           852 
  0.3633334531 -0.4411974534  0.7928855538  0.1067241105 
           853           854           855           856 
  1.1015066246  1.0492667554  0.2692071929  1.4135438244 
           857           858           859           860 
  0.2130389136 -0.3761605094  1.2291457564 -1.2626949228 
           861           862           863           864 
```

```
 0.1748020360  0.1364368896  1.6536437174  0.8098562794
          865           866           867           868
 0.6694133340  0.7713225934  0.6097282674  0.6573090149
          869           870           871           872
 0.4770793173 -0.0316770440 -0.2113428433  0.7314644681
          873           874           875           876
 0.2869762585  1.3144870531  0.2145035699 -0.3937498772
          877           878           879           880
 1.1006043960  0.8908489766  1.0803363558  0.5520679587
          881           882           883           884
-0.7699294220 -0.4636200844  1.4118441587  0.4333598453
          885           886           887           888
-0.2457665231 -0.3919920337 -0.6967810292  0.6756303619
          889           890           891           892
-0.2852658843  0.1083517066 -1.3492136097 -1.5472527569
          893           894           895           896
 0.8628695495 -0.1297111153 -0.0966346899  1.1089675959
          897           898           899           900
 1.0446826007  0.5604782088  1.6877604744 -0.7895888832
          901           902           903           904
 0.7809751062  0.0042587763  1.4633512608 -0.8161516868
          905           906           907           908
 0.2615104734 -0.9595236517  0.1877071826 -0.2228900657
          909           910           911           912
-0.5642280737  0.1930000856 -0.1724441425 -0.8855940558
          913           914           915           916
 0.6343615814  0.0268906155  0.2741726613 -0.3582473965
          917           918           919           920
 1.4220278188  0.2562846675 -1.1216636099  0.0008653166
          921           922           923           924
-0.3072291391 -1.2620189630  0.2338873070  0.6299661198
          925           926           927           928
 0.0123289354 -0.2613909937 -0.5226062373 -0.1823165943
          929           930           931           932
-0.9622928724 -0.6066912675 -0.4224111835 -1.2168229589
          933           934           935           936
-0.3515273708 -1.6867121684 -0.4370992147 -0.0429802212
          937           938           939           940
 1.3117326061  0.2224063394 -0.3872104105  1.0760853779
          941           942           943           944
 0.9022305348  0.8627896944  0.2718819276 -0.7561002113
          945           946           947           948
-0.4536286141  1.4205106608  0.4237214184 -0.2530542838
          949           950           951           952
-0.3820015554 -0.6910088458  0.4938572323 -0.2773484275
          953           954           955           956
 0.1216838031 -1.3591856161 -1.5532768258  0.8646728688
          957           958           959           960
-0.1259973839 -0.1032173622  1.1013148832  1.0419454728
          961           962           963           964
 0.5696680672  1.6811251232 -0.7886051701  0.7782802436
          965           966           967           968
 0.0001483183  1.4705185633 -0.8057867275  0.2667803081
          969           970           971           972
```

```
-0.9494812136  0.1767105757 -0.2293395916 -0.5518320968
          973           974           975           976
 0.1973636038 -0.1713250401 -0.8772493816  0.6280670389
          977           978           979           980
 0.0138010284  0.2820712005 -0.3655529094  1.4231970598
          981           982           983           984
 0.2619273180 -1.1316303749  0.0061989776 -0.3151322320
          985           986           987           988
-1.2516450949  0.2236619292  0.7213962817 -0.3976920154
          989           990           991           992
-0.6107140422 -0.0471702473 -0.1212114130 -1.0657760200
          993           994           995           996
-1.2947339471  0.5185754234  0.9803289254 -0.4208013688
          997           998           999          1000
 0.2943890313  0.4534746481  0.1791518817 -1.2432971861
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
barplot(height = RStudent, names.arg = 1:1030,
        main = "R Student Residuals", xlab = "Index",
        ylab = "R Student Resid", ylim=c(-5,5))
cor.level <- 0.05/(2*25)
cor.qt <- qt(cor.level, 21, lower.tail=F)
RStudent> cor.qt
```

```
    1     2     3     4     5     6     7     8     9    10 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   11    12    13    14    15    16    17    18    19    20 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   21    22    23    24    25    26    27    28    29    30 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   31    32    33    34    35    36    37    38    39    40 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   41    42    43    44    45    46    47    48    49    50 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   51    52    53    54    55    56    57    58    59    60 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   61    62    63    64    65    66    67    68    69    70 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   71    72    73    74    75    76    77    78    79    80 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   81    82    83    84    85    86    87    88    89    90 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
   91    92    93    94    95    96    97    98    99   100 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  101   102   103   104   105   106   107   108   109   110 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  111   112   113   114   115   116   117   118   119   120 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  121   122   123   124   125   126   127   128   129   130 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  131   132   133   134   135   136   137   138   139   140 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  141   142   143   144   145   146   147   148   149   150 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  151   152   153   154   155   156   157   158   159   160 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  161   162   163   164   165   166   167   168   169   170 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  171   172   173   174   175   176   177   178   179   180 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  181   182   183   184   185   186   187   188   189   190 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  191   192   193   194   195   196   197   198   199   200 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  201   202   203   204   205   206   207   208   209   210 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  211   212   213   214   215   216   217   218   219   220 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  221   222   223   224   225   226   227   228   229   230 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  231   232   233   234   235   236   237   238   239   240 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  241   242   243   244   245   246   247   248   249   250 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  251   252   253   254   255   256   257   258   259   260 
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE 
  261   262   263   264   265   266   267   268   269   270 
```

```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  271   272   273   274   275   276   277   278   279   280
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  281   282   283   284   285   286   287   288   289   290
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  291   292   293   294   295   296   297   298   299   300
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  301   302   303   304   305   306   307   308   309   310
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  311   312   313   314   315   316   317   318   319   320
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  321   322   323   324   325   326   327   328   329   330
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  331   332   333   334   335   336   337   338   339   340
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  341   342   343   344   345   346   347   348   349   350
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  351   352   353   354   355   356   357   358   359   360
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  361   362   363   364   365   366   367   368   369   370
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  371   372   373   374   375   376   377   378   379   380
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  381   382   383   384   385   386   387   388   389   390
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  391   392   393   394   395   396   397   398   399   400
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  401   402   403   404   405   406   407   408   409   410
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  411   412   413   414   415   416   417   418   419   420
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  421   422   423   424   425   426   427   428   429   430
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  431   432   433   434   435   436   437   438   439   440
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  441   442   443   444   445   446   447   448   449   450
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  451   452   453   454   455   456   457   458   459   460
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  461   462   463   464   465   466   467   468   469   470
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  471   472   473   474   475   476   477   478   479   480
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  481   482   483   484   485   486   487   488   489   490
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  491   492   493   494   495   496   497   498   499   500
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  501   502   503   504   505   506   507   508   509   510
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  511   512   513   514   515   516   517   518   519   520
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  521   522   523   524   525   526   527   528   529   530
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  531   532   533   534   535   536   537   538   539   540
```

```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  541   542   543   544   545   546   547   548   549   550
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  551   552   553   554   555   556   557   558   559   560
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  561   562   563   564   565   566   567   568   569   570
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  571   572   573   574   575   576   577   578   579   580
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  581   582   583   584   585   586   587   588   589   590
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  591   592   593   594   595   596   597   598   599   600
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  601   602   603   604   605   606   607   608   609   610
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  611   612   613   614   615   616   617   618   619   620
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  621   622   623   624   625   626   627   628   629   630
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  631   632   633   634   635   636   637   638   639   640
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  641   642   643   644   645   646   647   648   649   650
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  651   652   653   654   655   656   657   658   659   660
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  661   662   663   664   665   666   667   668   669   670
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  671   672   673   674   675   676   677   678   679   680
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  681   682   683   684   685   686   687   688   689   690
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  691   692   693   694   695   696   697   698   699   700
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  701   702   703   704   705   706   707   708   709   710
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  711   712   713   714   715   716   717   718   719   720
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  721   722   723   724   725   726   727   728   729   730
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  731   732   733   734   735   736   737   738   739   740
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  741   742   743   744   745   746   747   748   749   750
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  751   752   753   754   755   756   757   758   759   760
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  761   762   763   764   765   766   767   768   769   770
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  771   772   773   774   775   776   777   778   779   780
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  781   782   783   784   785   786   787   788   789   790
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  791   792   793   794   795   796   797   798   799   800
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  801   802   803   804   805   806   807   808   809   810
```

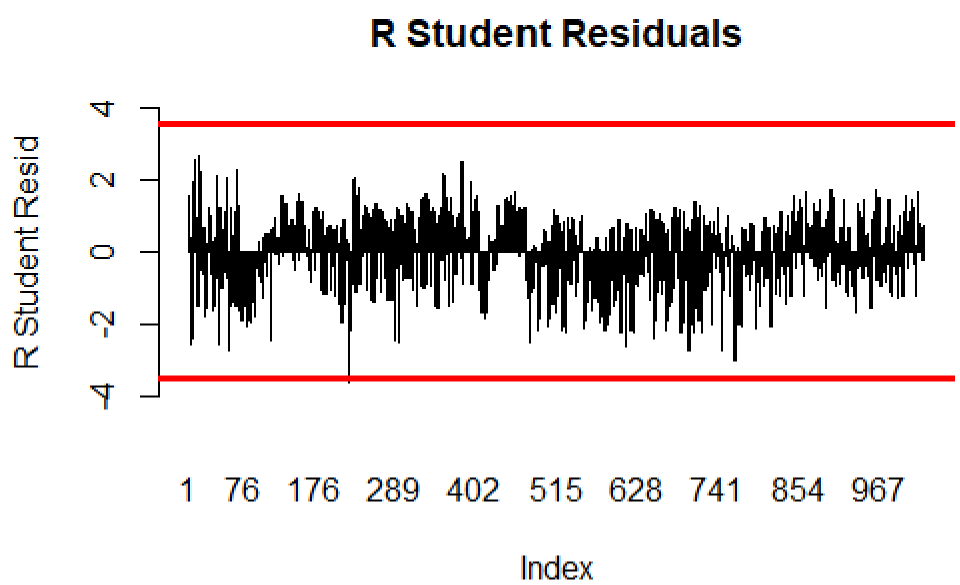
```
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  811   812   813   814   815   816   817   818   819   820
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  821   822   823   824   825   826   827   828   829   830
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  831   832   833   834   835   836   837   838   839   840
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  841   842   843   844   845   846   847   848   849   850
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  851   852   853   854   855   856   857   858   859   860
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  861   862   863   864   865   866   867   868   869   870
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  871   872   873   874   875   876   877   878   879   880
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  881   882   883   884   885   886   887   888   889   890
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  891   892   893   894   895   896   897   898   899   900
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  901   902   903   904   905   906   907   908   909   910
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  911   912   913   914   915   916   917   918   919   920
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  921   922   923   924   925   926   927   928   929   930
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  931   932   933   934   935   936   937   938   939   940
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  941   942   943   944   945   946   947   948   949   950
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  951   952   953   954   955   956   957   958   959   960
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  961   962   963   964   965   966   967   968   969   970
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  971   972   973   974   975   976   977   978   979   980
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  981   982   983   984   985   986   987   988   989   990
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
  991   992   993   994   995   996   997   998   999  1000
FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [ reached getOption("max.print") -- omitted 30 entries ]
```

Hide

```
abline(h=cor.qt , col = "Red", lwd=3)
```

Hide

```
abline(h=-cor.qt , col = "Red", lwd=3)
```



Diagnostics for Leverage and Influence for Reduced Model

Hide

```
#influential analysis
myInf2 <- influence.measures(lm2)
myInf2
```

```
Influence measures of
     lm(formula = csMPa ~ cement + slag + flyash + water + age, data = conc) :
```

	dfb.1_ <dbl>	dfb.cmnt <dbl>	dfb.slag <dbl>	dfb.flys <dbl>	dfb.watr <dbl>	dfb. <(
1	5.420496e-03	8.863119e-02	-1.016688e-02	-9.051527e-03	-3.016283e-02	-1.528248e
2	1.353030e-03	2.212356e-02	-2.537791e-03	-2.259385e-03	-7.529054e-03	-3.814717e
3	7.919186e-02	-4.151218e-02	-5.559326e-02	-3.310760e-02	-6.394200e-02	-1.510489e
4	1.142923e-01	-6.510597e-02	-1.031024e-01	-6.550161e-02	-7.375917e-02	-3.788891e
5	-5.928800e-02	6.195953e-02	-1.297396e-02	3.352497e-02	6.183624e-02	-2.463979e
6	-8.732852e-02	-2.792801e-03	7.195626e-03	-1.290517e-02	1.139812e-01	5.736140e
7	1.166549e-01	-8.191792e-02	-6.733000e-02	-6.156247e-02	-7.658742e-02	-3.528042e
8	-5.058559e-02	2.748470e-02	9.049390e-03	7.622751e-03	5.375776e-02	-2.222297e
9	-1.251446e-01	-1.182044e-03	2.498741e-03	-2.359905e-02	1.697130e-01	-7.459074e
10	-6.184623e-02	4.373173e-02	-9.412609e-03	8.233865e-03	6.426283e-02	-2.834565e

1-10 of 1,030 rows | 1-7 of 11 columns   Previous 1 2 3 4 5 6 ... 100 Next

Hide

```
summary(myInf2)
```

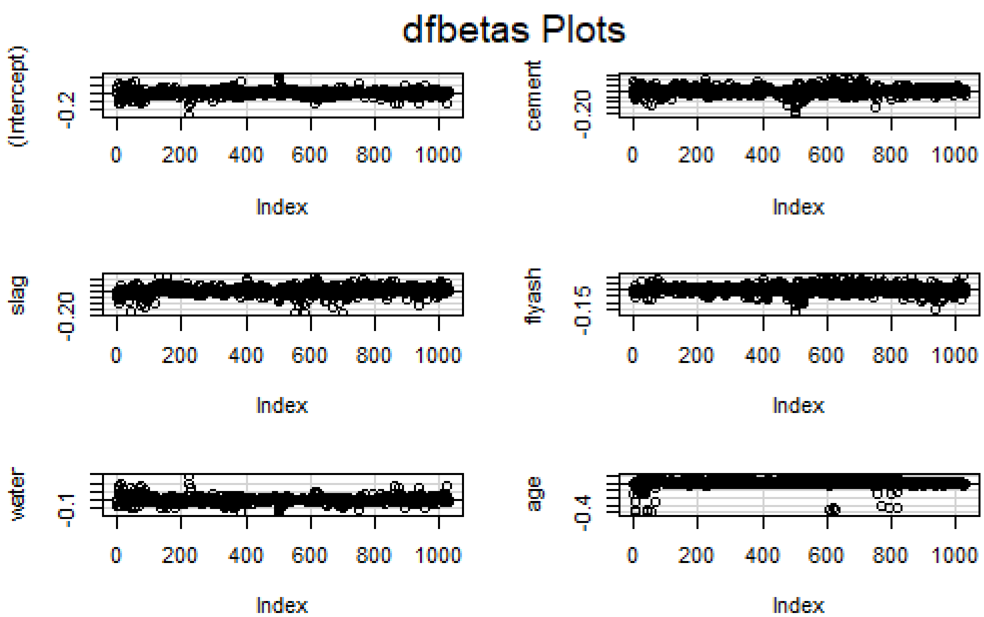
```
Potentially influential observations of
     lm(formula = csMPa ~ cement + slag + flyash + water + age, data = conc) :

    dfb.1_ dfb.cmnt dfb.slag dfb.flys dfb.watr dfb.age
4    0.11  -0.07    -0.10    -0.07    -0.07    -0.38
5   -0.06   0.06    -0.01     0.03     0.06    -0.25
7    0.12  -0.08    -0.07    -0.06    -0.08    -0.35
9   -0.13   0.00     0.00    -0.02     0.17    -0.07
15  -0.14   0.02    -0.02    -0.02     0.18    -0.08
18   0.02   0.00     0.00     0.00    -0.01    -0.08
25   0.03  -0.01     0.01     0.00    -0.03    -0.13
26  -0.01   0.00     0.00     0.00     0.01     0.02
31   0.02   0.00     0.00     0.00    -0.01    -0.08
32   0.02   0.00    -0.01     0.00    -0.01    -0.10
34   0.10  -0.09     0.00    -0.03    -0.08    -0.15
35   0.01   0.01    -0.02     0.00    -0.01    -0.07
36   0.07  -0.02    -0.09    -0.03    -0.05    -0.16
42   0.13  -0.11    -0.04    -0.06    -0.09    -0.36
43   0.10  -0.02    -0.17    -0.07    -0.06    -0.39
57   0.15  -0.14    -0.01    -0.07    -0.10    -0.39
61  -0.02   0.00     0.00     0.00     0.02     0.04
62  -0.01   0.00     0.00     0.00     0.01     0.03
64  -0.01  -0.01     0.01     0.00     0.01     0.04
66  -0.02   0.00     0.00     0.00     0.02     0.04
67  -0.06   0.07    -0.05     0.03     0.07    -0.26
115 -0.02  -0.07    -0.11     0.01     0.05     0.03
167 -0.01   0.00     0.00     0.00     0.01    -0.01
225 -0.28   0.11     0.02    -0.04     0.29    -0.03
290 -0.04   0.05     0.03    -0.02     0.02     0.03
295 -0.10   0.08     0.04    -0.01     0.07     0.02
357  0.09  -0.03    -0.01    -0.05    -0.08     0.00
382  0.14  -0.02     0.03    -0.08    -0.15     0.01
384  0.05   0.06    -0.05    -0.06    -0.05    -0.02
477  0.02  -0.13    -0.03    -0.07     0.02     0.04
478  0.02  -0.14    -0.03    -0.07     0.02     0.04
489 -0.01  -0.08    -0.01    -0.05     0.04     0.03
500 -0.03   0.03     0.01     0.02     0.02    -0.01
501 -0.02   0.02     0.01     0.02     0.02     0.00
502  0.22  -0.22    -0.08    -0.19    -0.17     0.07
504 -0.03   0.03     0.01     0.02     0.02     0.00
507 -0.02   0.02     0.01     0.02     0.01     0.00
521  0.04  -0.04     0.00    -0.09    -0.03     0.04
527  0.00  -0.09    -0.03    -0.10     0.04     0.02
605 -0.05   0.03     0.05     0.04     0.06    -0.35
611 -0.13   0.14     0.11     0.11     0.10    -0.42
617 -0.09   0.08     0.08     0.07     0.08    -0.34
621 -0.08   0.10     0.09     0.08     0.07    -0.34
623 -0.08   0.06     0.07     0.06     0.08    -0.36
650  0.03   0.04    -0.09     0.03    -0.06     0.06
700  0.08  -0.02    -0.19    -0.02    -0.08     0.07
718  0.01   0.08    -0.04     0.06    -0.05     0.06
747  0.12  -0.15     0.03    -0.01    -0.12     0.11
757 -0.01  -0.07    -0.01    -0.01     0.04    -0.14
```

```
764  0.00  -0.02     0.10     0.09    -0.03     0.10
770 -0.06   0.03     0.05     0.05     0.07    -0.31
793 -0.05   0.02     0.05     0.04     0.07    -0.33
815 -0.07   0.05     0.06     0.06     0.07    -0.32
821  0.02  -0.07     0.00    -0.02     0.01    -0.13
924 -0.05   0.02     0.05     0.06     0.05    -0.01
933  0.04  -0.01    -0.02    -0.04    -0.03     0.01
936  0.00   0.00     0.00     0.00     0.00     0.00
    dffit   cov.r   cook.d hat
4   -0.43_*  1.00    0.03   0.03_*
5   -0.26_*  1.02_*  0.01   0.03_*
7   -0.41_*  1.00    0.03   0.03_*
9    0.21    0.97_*  0.01   0.01
15   0.22    0.97_*  0.01   0.01
18  -0.09    1.03_*  0.00   0.03_*
25  -0.15    1.03_*  0.00   0.03_*
26   0.03    1.02_*  0.00   0.02
31  -0.09    1.03_*  0.00   0.03_*
32  -0.11    1.03_*  0.00   0.03_*
34  -0.23    1.01    0.01   0.02_*
35  -0.08    1.04_*  0.00   0.03_*
36  -0.21    1.01    0.01   0.02_*
42  -0.43_*  1.00    0.03   0.03_*
43  -0.46_*  1.00    0.04   0.03_*
57  -0.48_*  0.99    0.04   0.03_*
61   0.06    1.02_*  0.00   0.01
62   0.04    1.02_*  0.00   0.01
64   0.05    1.02_*  0.00   0.02
66   0.05    1.02_*  0.00   0.01
67  -0.28_*  1.02_*  0.01   0.03_*
115 -0.17    0.98_*  0.00   0.00
167 -0.01    1.02_*  0.00   0.01
225 -0.38_*  0.94_*  0.02   0.01
290 -0.13    0.97_*  0.00   0.00
295 -0.16    0.97_*  0.00   0.00
357  0.11    0.98_*  0.00   0.00
382  0.19    0.98_*  0.01   0.01
384  0.17    0.97_*  0.00   0.00
477 -0.17    0.98_*  0.00   0.01
478 -0.18    0.97_*  0.01   0.01
489 -0.14    0.98_*  0.00   0.00
500  0.03    1.02_*  0.00   0.02
501  0.03    1.02_*  0.00   0.01
502 -0.27_*  1.00    0.01   0.02
504  0.03    1.02_*  0.00   0.02
507  0.02    1.02_*  0.00   0.01
521 -0.13    0.98_*  0.00   0.00
527 -0.16    0.98_*  0.00   0.01
605 -0.38_*  1.00    0.02   0.03_*
611 -0.46_*  1.00    0.04   0.03_*
617 -0.37_*  1.01    0.02   0.03_*
621 -0.38_*  1.01    0.02   0.03_*
623 -0.38_*  1.00    0.02   0.03_*
650 -0.20    0.98_*  0.01   0.01
```

```
700 -0.26_*  0.97_*  0.01   0.01
718 -0.18    0.98_*  0.01   0.01
747 -0.25_*  0.97_*  0.01   0.01
757 -0.17    1.02    0.01   0.02_*
764 -0.19    0.96_*  0.01   0.00
770 -0.34_*  1.01    0.02   0.03_*
793 -0.35_*  1.01    0.02   0.03_*
815 -0.35_*  1.01    0.02   0.03_*
821 -0.16    1.02    0.00   0.02_*
924  0.08    1.02_*  0.00   0.01
933 -0.05    1.02_*  0.00   0.02_*
936 -0.01    1.02_*  0.00   0.02
```

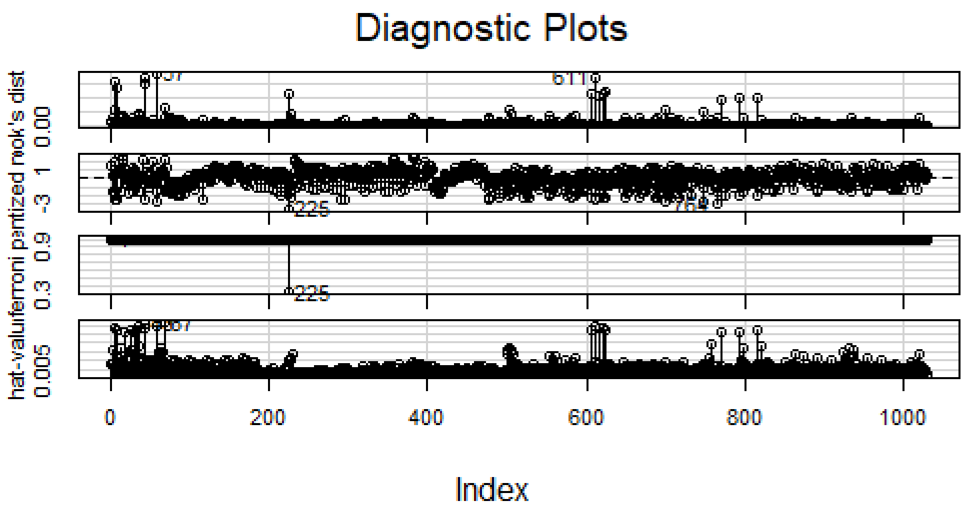
Hide

```
library(car)
dfbetasPlots(lm2,intercept=T)
```



Hide

```
influenceIndexPlot(lm2)
```



Hide

```
#variance inflation factors
vif(lm2)
```

```
  cement     slag   flyash    water      age 
1.594164 1.444858 1.748086 1.203434 1.106834 
```

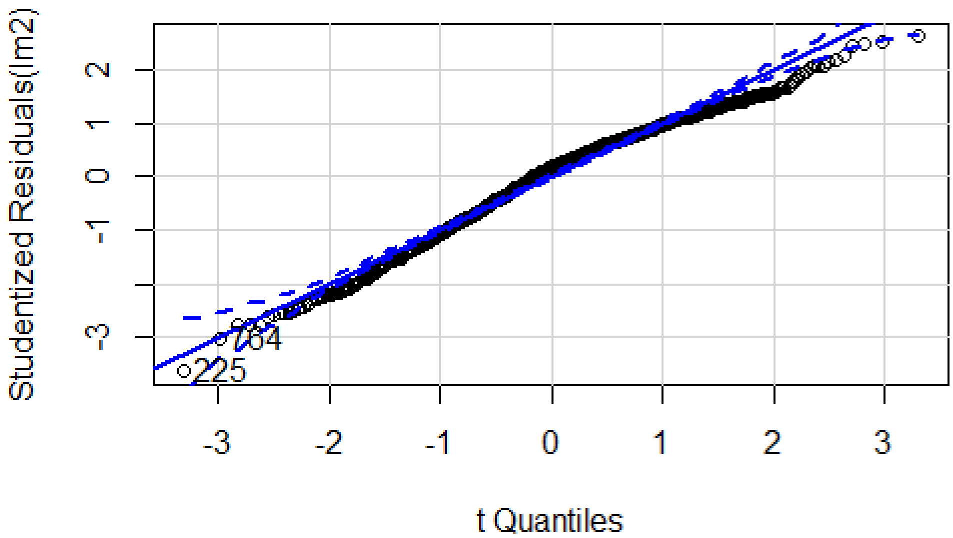
Hide

```
#normal probability plot of residuals
qqPlot(lm2)
```

```
[1] 225 764
```

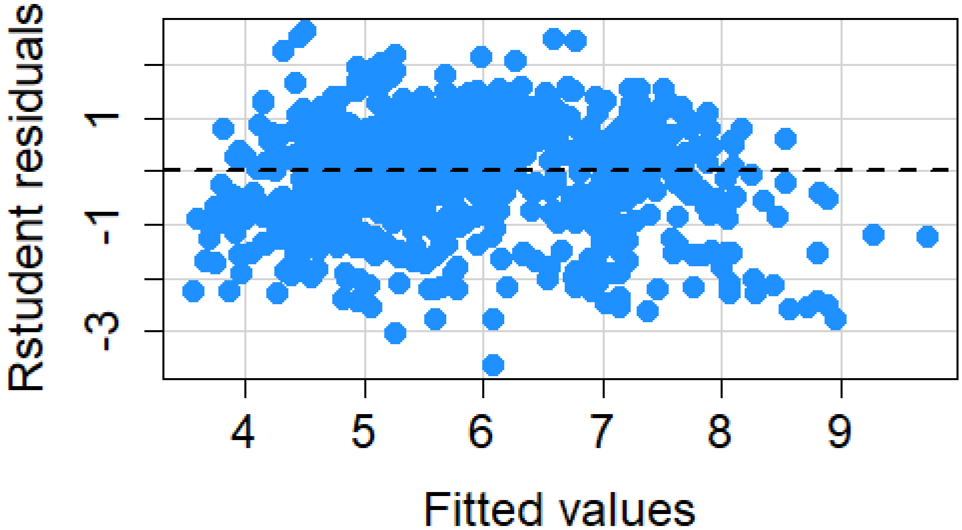
Hide

```
#plot of the residuals versus the fitted values
par(mfrow=c(1,1))
```



Hide

```
residualPlot(lm2, type="rstudent", quadratic=F, col = "dodgerblue",
             pch=16, cex=1.5, cex.axis=1.5, cex.lab=1.5)
```



ANOVA

Hide

```
anova(lm1, lm2)
```

```
Analysis of Variance Table

Model 1: csMPa ~ cement + slag + flyash + water + superplasticizer + coarseaggregate +
    fineaggregate + age
Model 2: csMPa ~ cement + slag + flyash + water + age
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   1021 858.41
2   1024 867.54 -3   -9.1322 3.6206 0.0128 *
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```