Diamond Price Prediction using Multiple Linear Regression

Joon Soh

3/11/2022

Diamond Prediction

1. Load the data.

- Import libraries that will be used for the project.

```
library("tidyverse")
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.2     v purrr   0.3.4
## v tibble  3.0.2     v dplyr   1.0.0
## v tidyr   1.1.0     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
# library(plyr)
library(dplyr)
library(faraway) # for VIF
library(multcomp)
```

```
## Loading required package: mvtnorm

## Loading required package: survival

##
## Attaching package: 'survival'

## The following objects are masked from 'package:faraway':
##
##     rats, solder

## Loading required package: TH.data

## Loading required package: MASS
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select

##
## Attaching package: 'TH.data'

## The following object is masked from 'package:MASS':
##
##     geyser
```

```
library(lawstat) # for levene's test
library(MASS) # qq plot
```

- Set the directory to where the files are.

```
# setwd("C:/Users/joony/Documents/myGit/STAT_6021_Project_1")
```

- Load the data file.

```
data <- read.csv("clean_diamond_data.csv")

# if you want to use the columns without calling the table, attach the table
attach(data)
```

2. Examine the data

- Display the first few rows of the table

```
head(data)
```

```
##   carat clarity color       cut price
## 1  0.30     VS1     I      Good   229
## 2  0.30     SI2     F Very Good   262
## 3  0.31     SI2     G Very Good   262
## 4  0.29     SI2     E Very Good   263
## 5  0.30     SI1     J Very Good   269
## 6  0.32     SI2     F Very Good   272
```

- Check if there is any missing values

```
table(is.na(data))
```

```
##
##   FALSE
## 1053190
```

- Look at the count tables for categorical variables.

```
table(data$color)
```

```
##
##     D     E     F     G     H     I     J
## 33954 35991 36971 34359 27431 26018 15914
```

```
table(data$clarity)
```

```
##
##    FL    IF   SI1   SI2   VS1   VS2  VVS1  VVS2
##   990  9738 42456 24813 37805 36731 28512 29593
```

```
table(data$cut)
```

```
##
## Astor Ideal        Good       Ideal   Very Good
##        3372       14406      128756       64104
```

- Check the range for the numerical variables.

```
range(data$carat)
```

```
## [1]  0.23 20.45
```

```
range(data$price)
```

```
## [1]     229 2317596
```

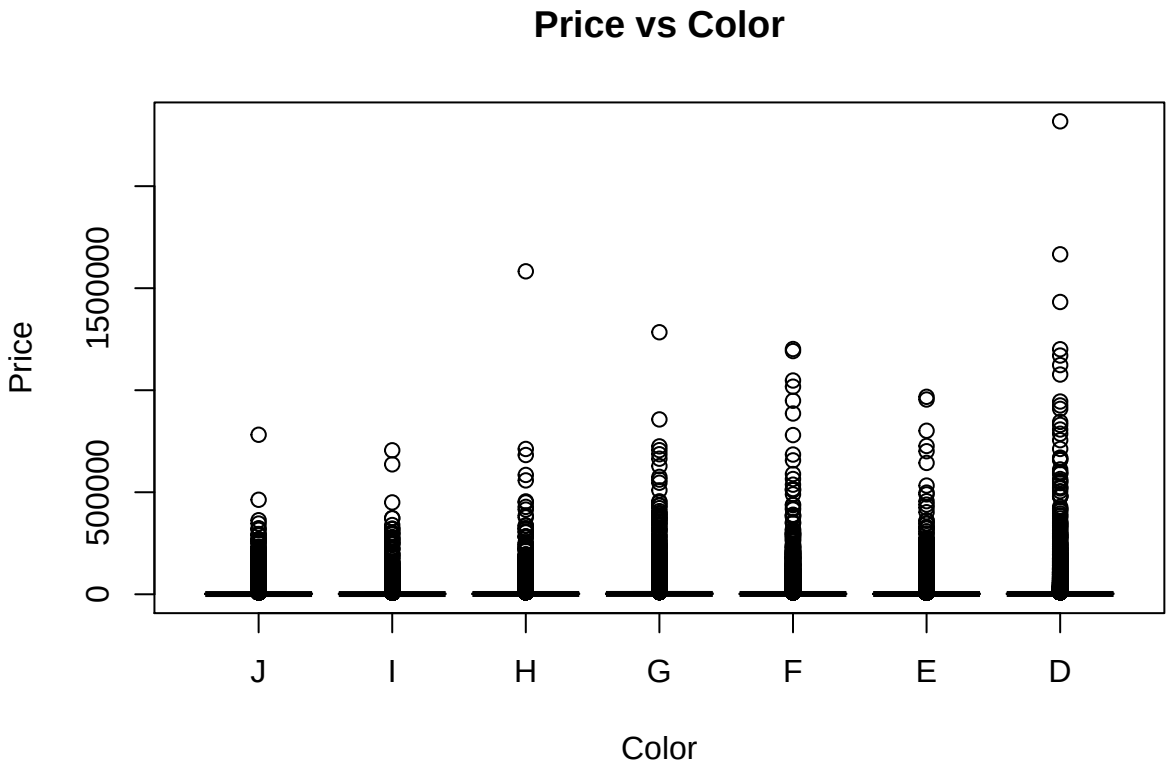
Reorder color from worst class to best class.

```
#reorder color from worst class to best class
data$color <- factor(data$color, levels=c("J","I","H","G","F","E","D"))

#reorder clarity from worst to best class
data$clarity <- factor(data$clarity, levels=c("SI2","SI1","VS2","VS1","VVS2","VVS1","IF", "FL"))

#reorder cut from worst to best class
data$cut <- factor(data$cut, levels=c("Good","Very Good","Ideal","Astor Ideal"))
```

3. Preliminary analysis

- Plot boxplots and perform levene's test.

```
boxplot(price~color,data=data, main="Price vs Color", xlab="Color", ylab="Price")
```

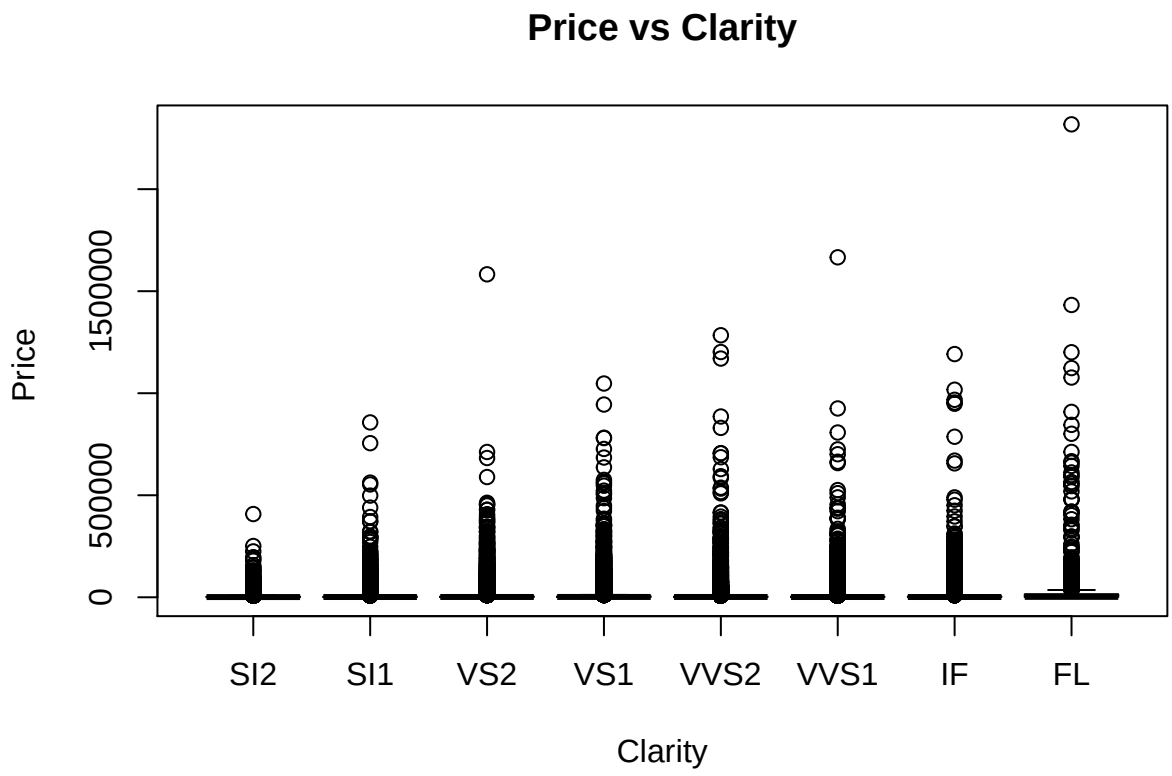



```
# is variance of the response same for every categories?
# null is that variance is same
levene.test(price,color)
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
##
## data:  price
## Test Statistic = 29.557, p-value < 2.2e-16
```

- Ascending order of the colors : “J”,“I”,“H”,“G”,“F”,“E”,“D”
- Every color class has lots of outliers for high prices - the better the color, the more spread in the outliers.

```
boxplot(price~clarity,data=data, main="Price vs Clarity", xlab="Clarity", ylab="Price ")
```

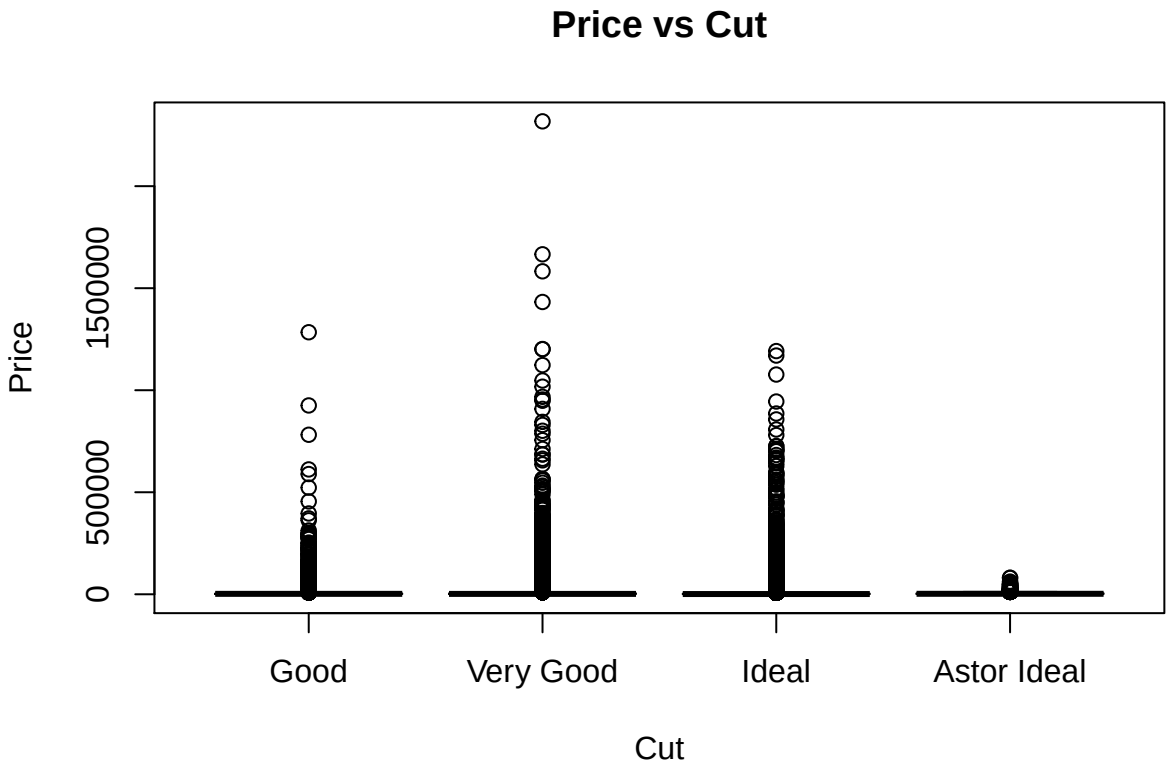



```
levene.test(price,clarity)
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
##
## data:  price
## Test Statistic = 355.73, p-value < 2.2e-16
```

- Ascending order of the clarity : “SI2”,“SI1”,“VS2”,“VS1”,“VVS2”,“VVS1”,“IF”, “FL”
- Every clarity class has lots of outliers for high prices.

```
boxplot(price~cut,data=data, main="Price vs Cut", xlab="Cut", ylab="Price")
```



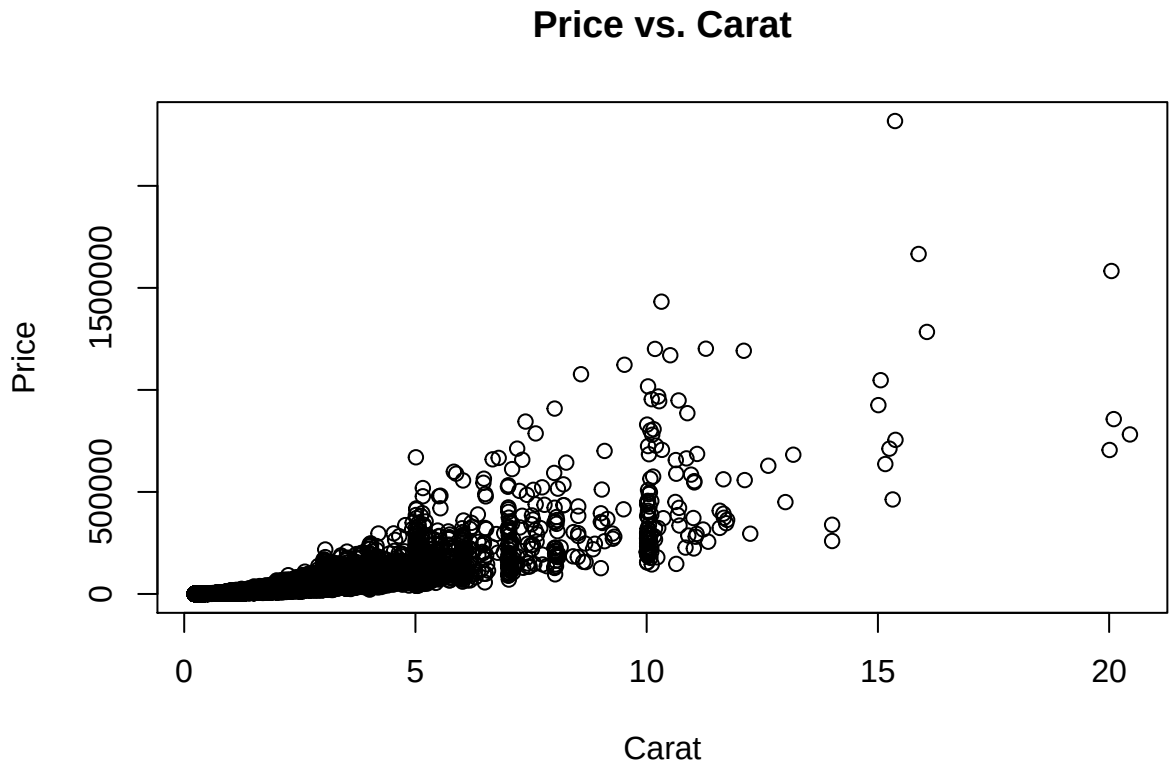

```
levene.test(price,cut)
```

```
##
##  Modified robust Brown-Forsythe Levene-type test based on the absolute
##  deviations from the median
##
## data:  price
## Test Statistic = 109.36, p-value < 2.2e-16
```

- Ascending order of the cuts : "Good","Very Good","Ideal","Astor Ideal"
- Every cut class has lots of outliers for high prices - the better the cut, the more spread in the outliers.
- The variances of the response for each categories are not same for different categories.
- The ratio of the sizes of the largest and smallest categories are bigger than 1.5
- Need to watch out for overestimating and underestimating of p-values.
- Could consider using Welch Test instead.
- Now, let's look a scatter plots of the data.

```
title = "Price vs. Carat"
xlab = "Carat"
ylab ="Price"
x = carat
```

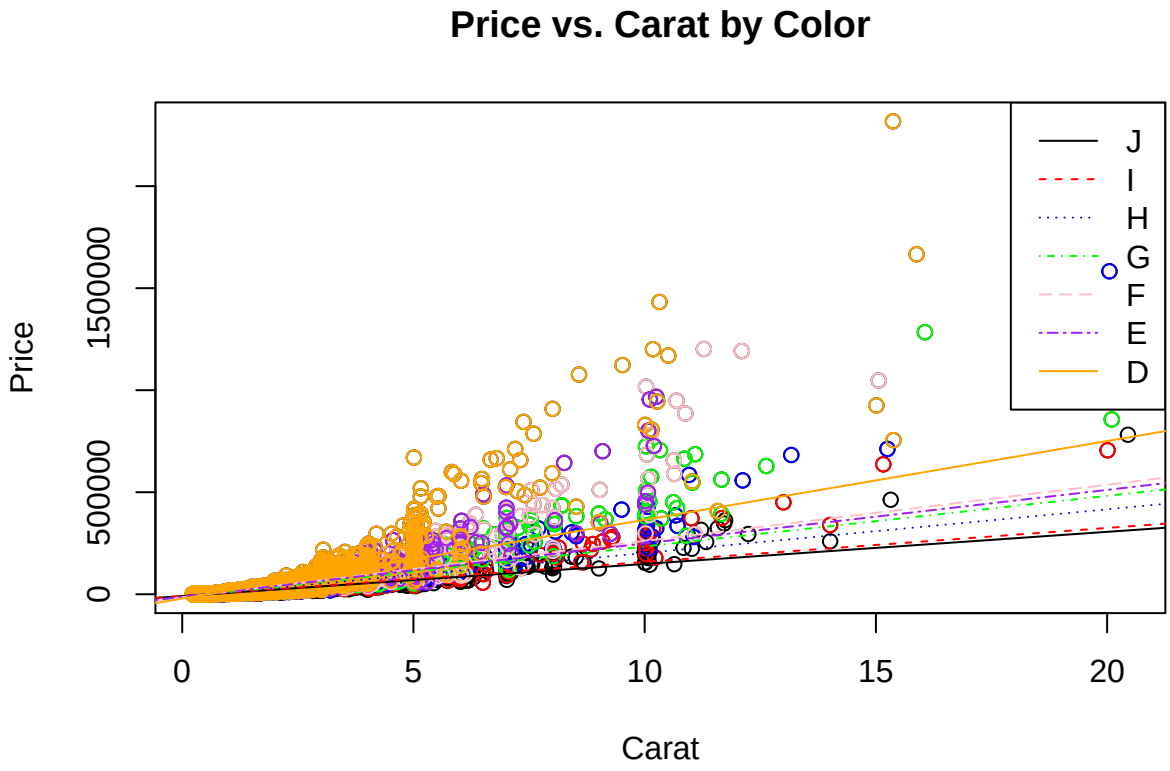
```
y = price

plot(x, y, main=title, xlab=xlab, ylab=ylab)
```



- Check if there is a differential correlation.

```
#let's plot carat vs price by colorscore
d1 <- subset(data, color=="J")
d2 <- subset(data, color=="I")
d3 <- subset(data, color=="H")
d4 <- subset(data, color=="G")
d5 <- subset(data, color=="F")
d6 <- subset(data, color=="E")
d7 <- subset(data, color=="D")
reg1 <- lm(price~carat, data=d1)
reg2 <- lm(price~carat, data=d2)
reg3 <- lm(price~carat, data=d3)
reg4 <- lm(price~carat, data=d4)
reg5 <- lm(price~carat, data=d5)
reg6 <- lm(price~carat, data=d6)
reg7 <- lm(price~carat, data=d7)
plot(carat, price, main="Price vs. Carat by Color", xlab=xlab, ylab=ylab)
points(d2$carat, d2$price, col='red')
points(d3$carat, d3$price, col='blue')
points(d4$carat, d4$price, col='green')
points(d5$carat, d5$price, col='pink')
```

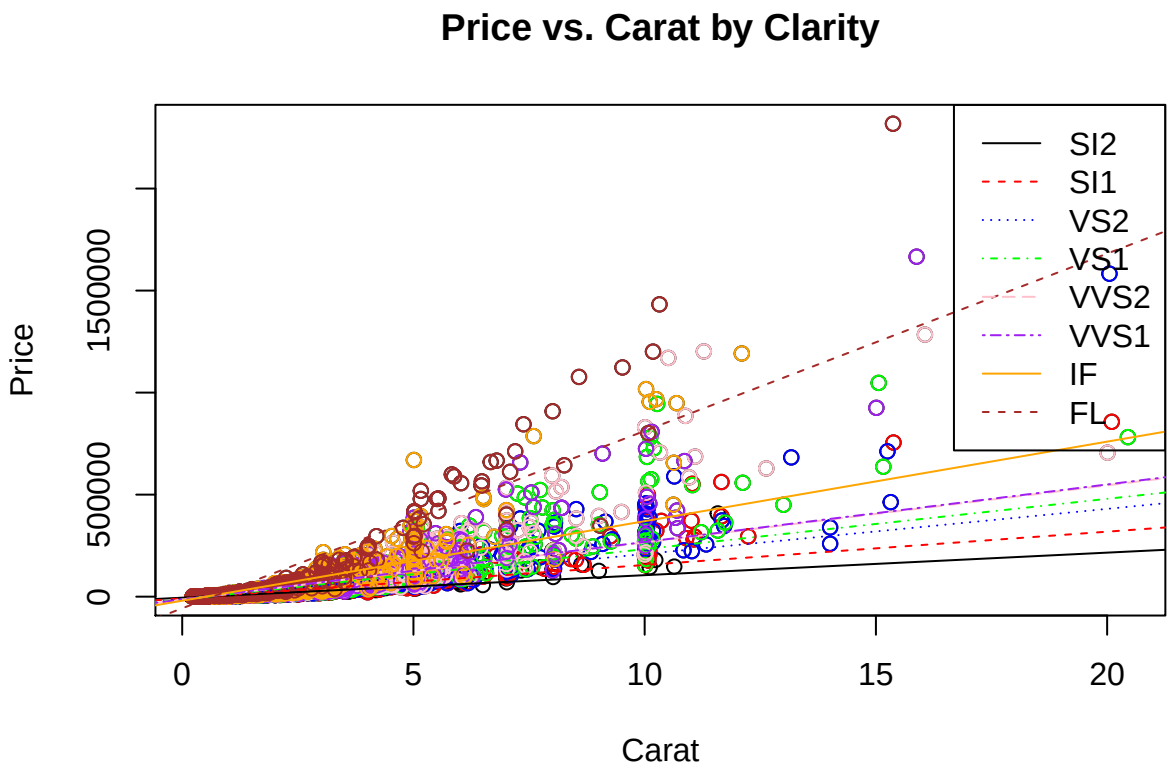
```
points(d6$carat, d6$price, col='purple')
points(d7$carat, d7$price, col='orange')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
abline(reg5, lty=5, col='pink')
abline(reg6, lty=6, col='purple')
abline(reg7, lty=7, col='orange')
legend("topright", c("J","I","H","G","F","E","D"), lty=c(1,2,3,4,5,6,7), col=c('black','red','blue','gr
```



The slopes are not same for each categories. There still may be interaction.

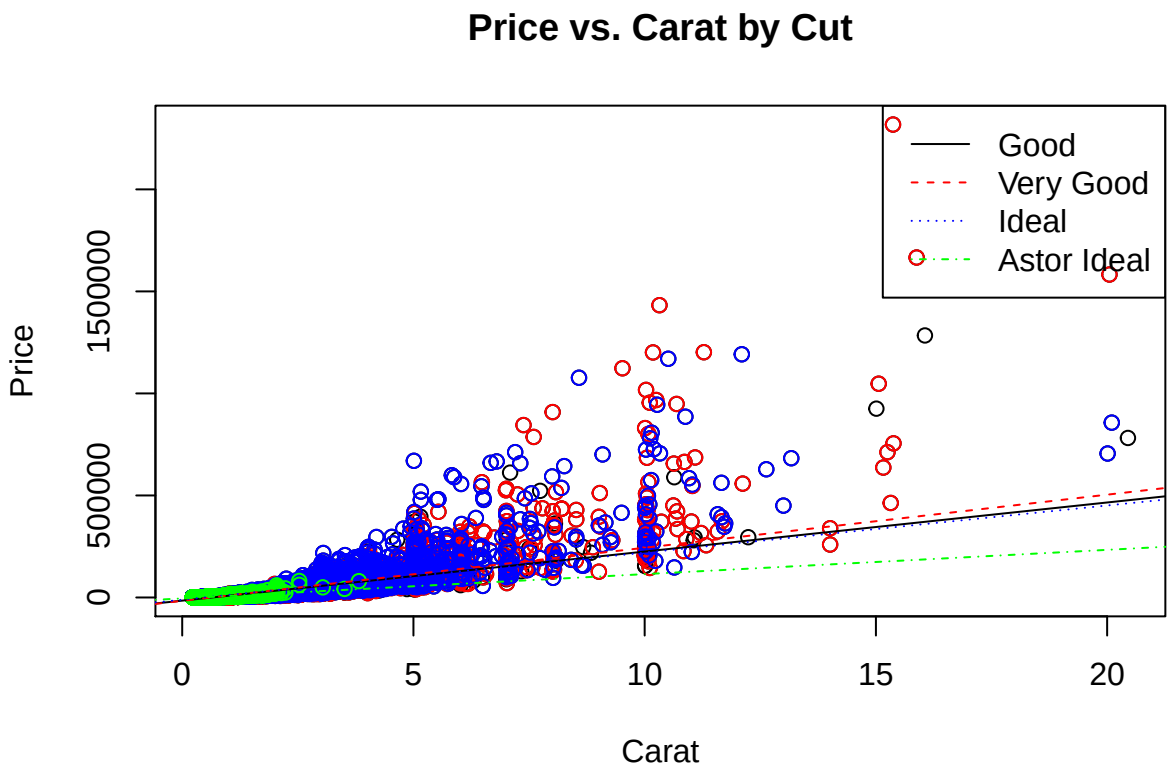
```
#let's plot carat vs price by claritycore
d1 <- subset(data, clarity=="SI2")
d2 <- subset(data, clarity=="SI1")
d3 <- subset(data, clarity=="VS2")
d4 <- subset(data, clarity=="VS1")
d5 <- subset(data, clarity=="VVS2")
d6 <- subset(data, clarity=="VVS1")
d7 <- subset(data, clarity=="IF")
d8 <- subset(data, clarity=="FL")
reg1 <- lm(price~carat, data=d1)
reg2 <- lm(price~carat, data=d2)
reg3 <- lm(price~carat, data=d3)
reg4 <- lm(price~carat, data=d4)
```

```
reg5 <- lm(price~carat, data=d5)
reg6 <- lm(price~carat, data=d6)
reg7 <- lm(price~carat, data=d7)
reg8 <- lm(price~carat, data=d8)
plot(carat, price, main="Price vs. Carat by Clarity", xlab=xlab, ylab=ylab)
points(d2$carat, d2$price, col='red')
points(d3$carat, d3$price, col='blue')
points(d4$carat, d4$price, col='green')
points(d5$carat, d5$price, col='pink')
points(d6$carat, d6$price, col='purple')
points(d7$carat, d7$price, col='orange')
points(d8$carat, d8$price, col='brown')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
abline(reg5, lty=5, col='pink')
abline(reg6, lty=6, col='purple')
abline(reg7, lty=7, col='orange')
abline(reg8, lty=8, col='brown')
legend("topright", c("SI2","SI1","VS2","VS1","VVS2","VVS1","IF", "FL"), lty=c(1,2,3,4,5,6,7,8), col=c('
```



The slopes are not same for each categories. There still may be interaction.

```r
#let's plot carat vs price by cutscore
d1 <- subset(data, cut=="Good")
d2 <- subset(data, cut=="Very Good")
d3 <- subset(data, cut=="Ideal")
d4 <- subset(data, cut=="Astor Ideal")
reg1 <- lm(price~carat, data=d1)
reg2 <- lm(price~carat, data=d2)
reg3 <- lm(price~carat, data=d3)
reg4 <- lm(price~carat, data=d4)
plot(carat, price, main="Price vs. Carat by Cut", xlab=xlab, ylab=ylab)
points(d2$carat, d2$price, col='red')
points(d3$carat, d3$price, col='blue')
points(d4$carat, d4$price, col='green')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
legend("topright", c("Good","Very Good","Ideal","Astor Ideal"), lty=c(1,2,3,4), col=c('black','red','blu
```



The slopes are not same for each categories. There still may be interaction.

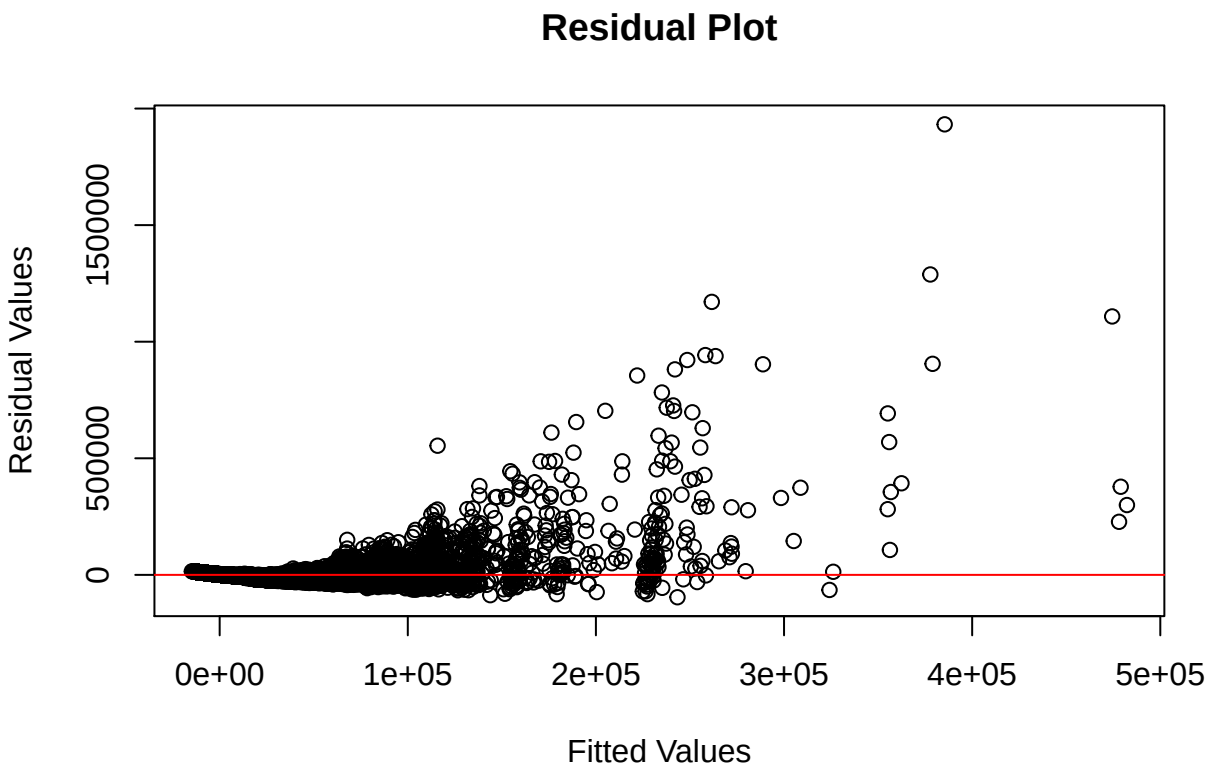
4. Linear Regression Analysis

Now, Let's look at basic linear regression results.

```r
lmodel <- lm(price~.,data)
summary(lmodel)
```

```
##
## Call:
## lm(formula = price ~ ., data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -95976   -4234    1186    4379 1932205
##
## Coefficients:
##                 Estimate Std. Error  t value Pr(>|t|)
## (Intercept)    -20968.64     191.69 -109.391  < 2e-16 ***
## carat           24512.88      45.76  535.640  < 2e-16 ***
## claritySI1        541.12     118.41    4.570 4.88e-06 ***
## clarityVS2       1180.71     121.85    9.690  < 2e-16 ***
## clarityVS1       1957.14     121.21   16.147  < 2e-16 ***
## clarityVVS2      3063.35     127.61   24.006  < 2e-16 ***
## clarityVVS1      3613.57     128.79   28.058  < 2e-16 ***
## clarityIF        5184.88     177.44   29.221  < 2e-16 ***
## clarityFL       23752.02     483.99   49.076  < 2e-16 ***
## colorI           1982.71     149.00   13.307  < 2e-16 ***
## colorH           2201.61     147.49   14.927  < 2e-16 ***
## colorG           3194.09     142.08   22.480  < 2e-16 ***
## colorF           4465.53     140.60   31.761  < 2e-16 ***
## colorE           5071.39     141.39   35.868  < 2e-16 ***
## colorD           5311.58     142.94   37.159  < 2e-16 ***
## cutVery Good      532.73     136.47    3.904 9.48e-05 ***
## cutIdeal         3500.79     130.60   26.805  < 2e-16 ***
## cutAstor Ideal   1866.38     283.59    6.581 4.68e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14790 on 210620 degrees of freedom
## Multiple R-squared:  0.5829, Adjusted R-squared:  0.5829
## F-statistic: 1.732e+04 on 17 and 210620 DF,  p-value: < 2.2e-16
```

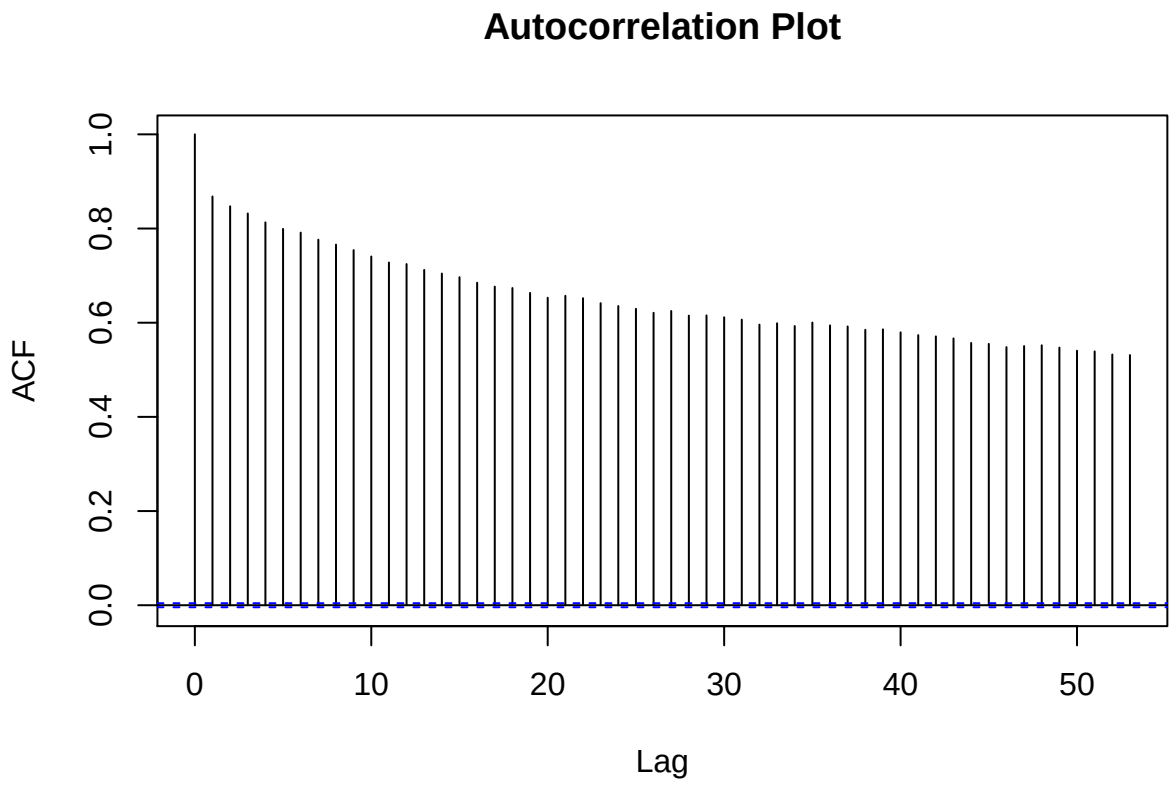
```r
##residual plot
plot(lmodel$fitted.values,lmodel$residuals,main="Residual Plot",xlab="Fitted Values", ylab="Residual Va
abline(h=0,col="red")
```



The errors don't seem to have mean of 0 or equal variance.

Let's look at ACF plot of residuals to check the independence of the error terms and check if there is correlation between the error terms.

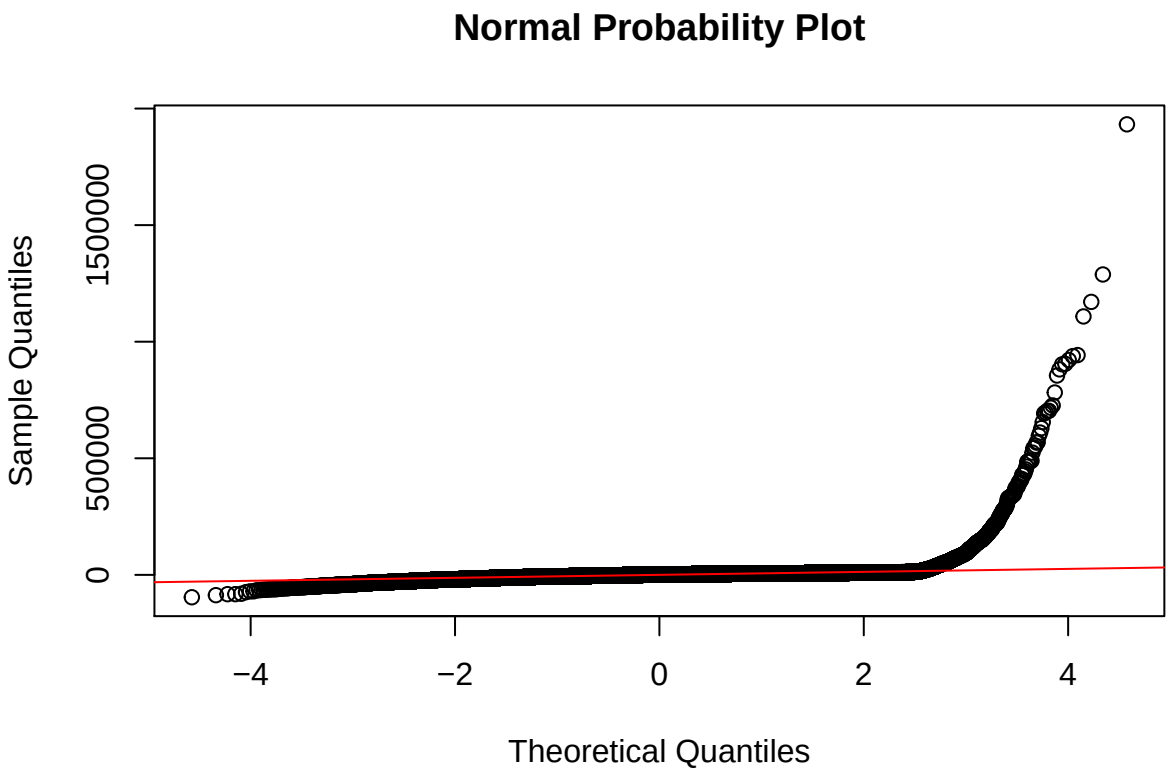
```
acf(lmodel$residuals, main="Autocorrelation Plot")
```



Blue lines represent the significant correlation threshold. It seems to have autocorrelation.

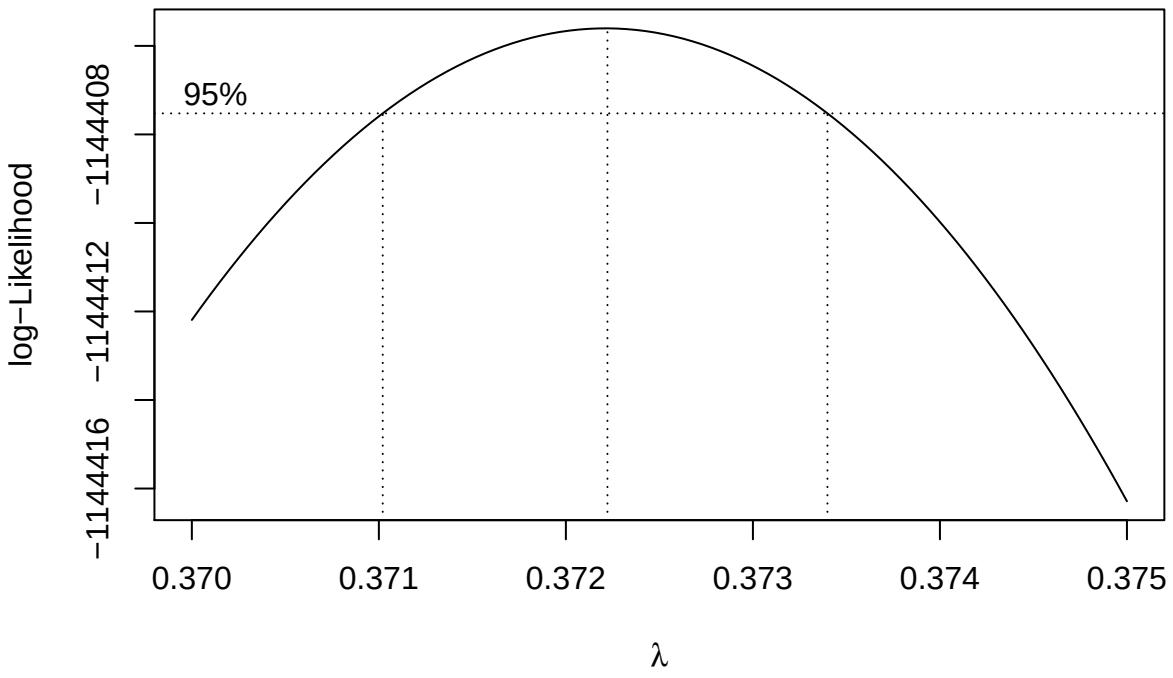
Now let's check if ther normality assumtion is met through QQ plot.

```
## Normal probability or QQ plot of residuals
qqnorm(lmodel$residuals, main="Normal Probability Plot")
# add expected line based on the normality assumtion.
qqline(lmodel$residuals, col="red")
```




```
# boxcox plotting and transformation
boxcox(lmodel, lambda=seq(.37,0.375,by=0.001), main ="Box-cox plot")
```

```
## Warning: In lm.fit(x, y, offset = offset, singular.ok = singular.ok, ...) :
##  extra argument 'main' will be disregarded
```




```
lamb <- 0.372


newPrice <- price^lamb

data_fixed <- data
data_fixed$price <- newPrice

attach(data_fixed)
```

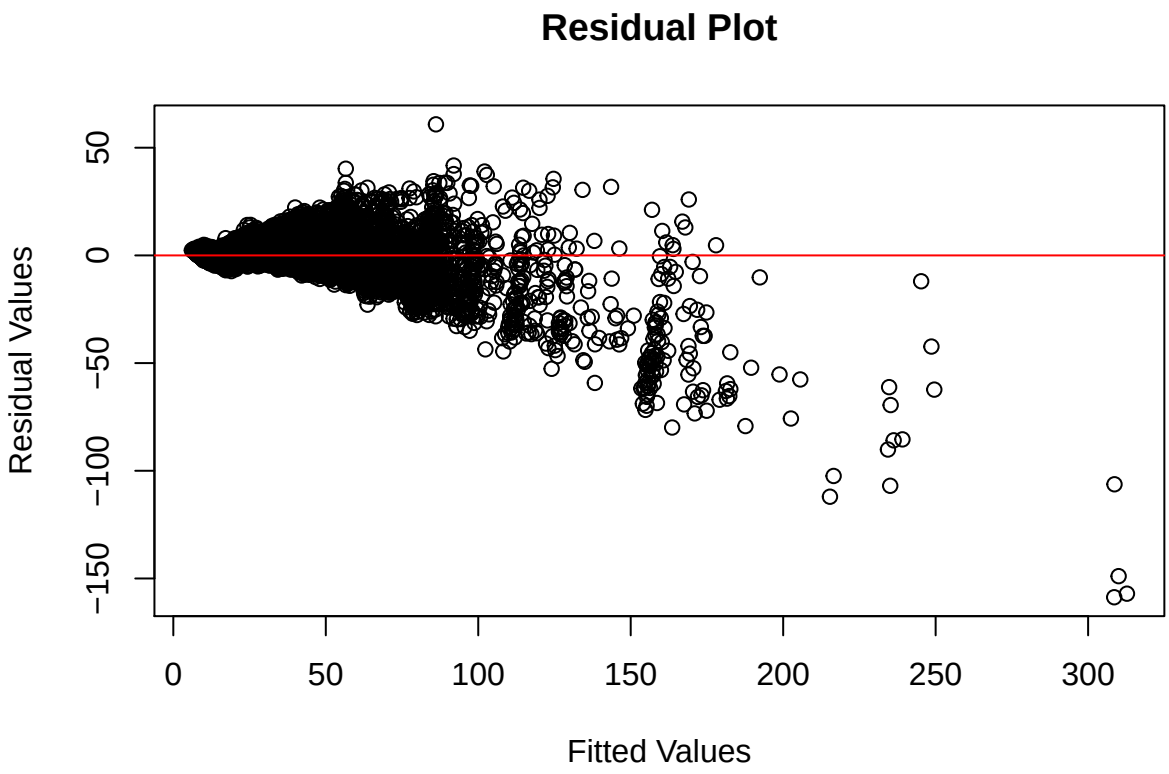
```
## The following objects are masked from data:
##
##     carat, clarity, color, cut, price
```

```
lmodel_fixed <- lm(price~.,data_fixed)
summary(lmodel_fixed)
```

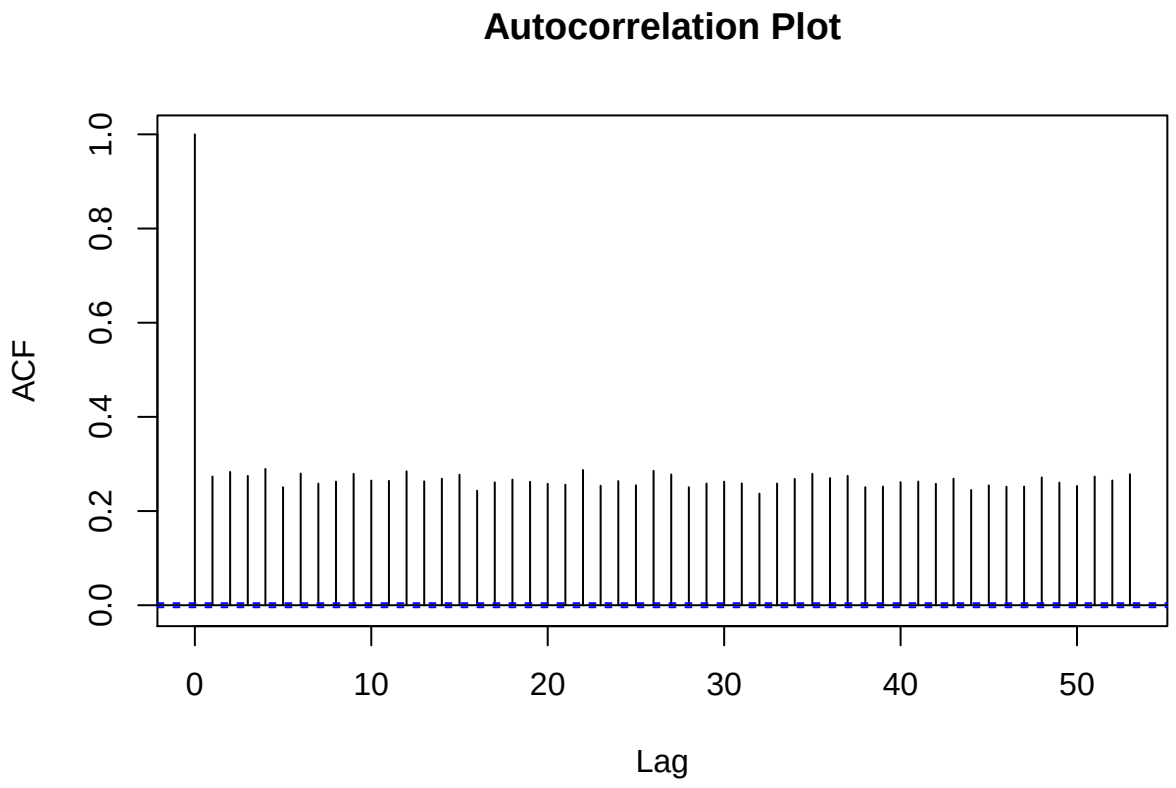
```
##
## Call:
## lm(formula = price ~ ., data = data_fixed)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -158.715   -1.511   -0.327    1.123   60.845
##
```

```
## Coefficients:
##                  Estimate Std. Error  t value Pr(>|t|)
## (Intercept)     2.058248   0.039853   51.645   <2e-16 ***
## carat          15.088046   0.009515 1585.755   <2e-16 ***
## claritySI1      0.893113   0.024619   36.278   <2e-16 ***
## clarityVS2      1.652116   0.025333   65.216   <2e-16 ***
## clarityVS1      2.130598   0.025200   84.547   <2e-16 ***
## clarityVVS2     2.397127   0.026531   90.353   <2e-16 ***
## clarityVVS1     2.850126   0.026777  106.441   <2e-16 ***
## clarityIF       3.617313   0.036891   98.055   <2e-16 ***
## clarityFL       7.177996   0.100626   71.333   <2e-16 ***
## colorI          1.199304   0.030978   38.715   <2e-16 ***
## colorH          2.187692   0.030665   71.341   <2e-16 ***
## colorG          2.784849   0.029541   94.272   <2e-16 ***
## colorF          3.089913   0.029232  105.703   <2e-16 ***
## colorE          3.208832   0.029397  109.157   <2e-16 ***
## colorD          3.864306   0.029719  130.027   <2e-16 ***
## cutVery Good    0.242484   0.028373    8.546   <2e-16 ***
## cutIdeal        1.001158   0.027154   36.870   <2e-16 ***
## cutAstor Ideal  2.156584   0.058962   36.576   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.075 on 210620 degrees of freedom
## Multiple R-squared:  0.9247, Adjusted R-squared:  0.9247
## F-statistic: 1.522e+05 on 17 and 210620 DF,  p-value: < 2.2e-16
```

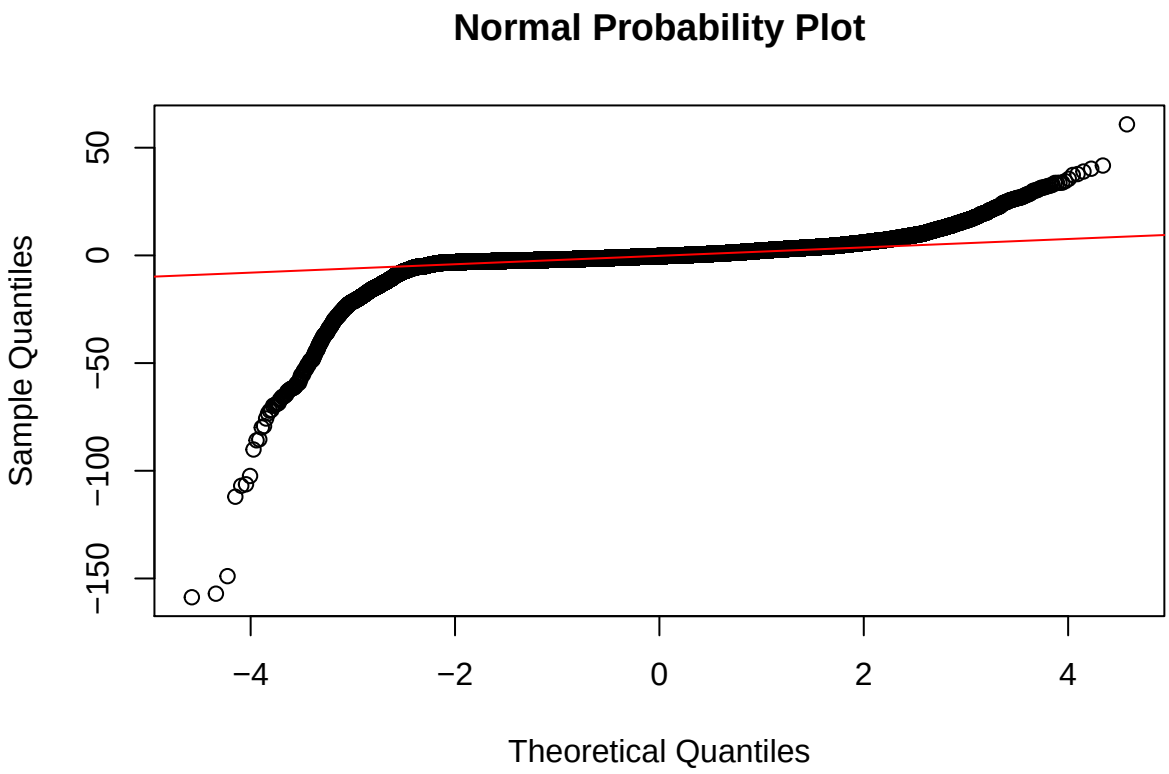
```
plot(lmodel_fixed$fitted.values,lmodel_fixed$residuals,main="Residual Plot",xlab="Fitted Values",ylab="
abline(h=0,col="red")
```




```
##acf plot of residuals
acf(lmodel_fixed$residuals, main="Autocorrelation Plot")
```




```r
##QQ plot of residuals
qqnorm(lmodel_fixed$residuals, main="Normal Probability Plot")
qqline(lmodel_fixed$residuals, col="red")
```

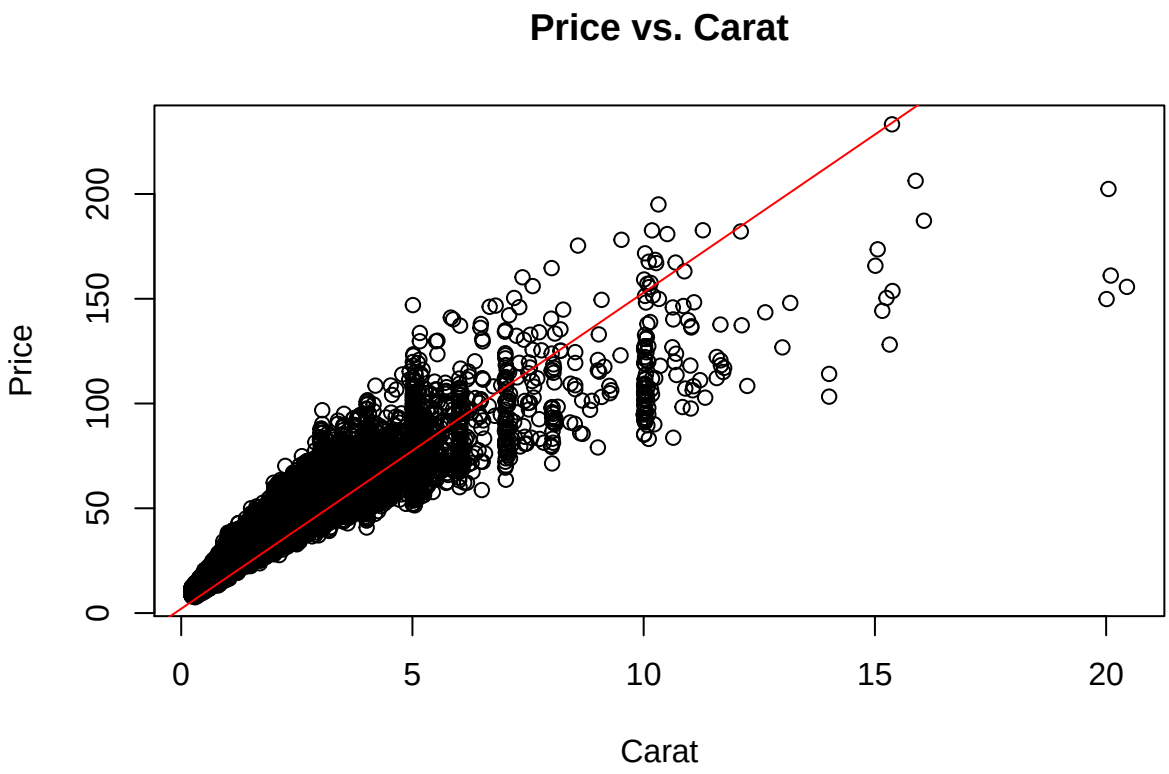


Now that we transformed the response variable, we can transform the predictor variables.

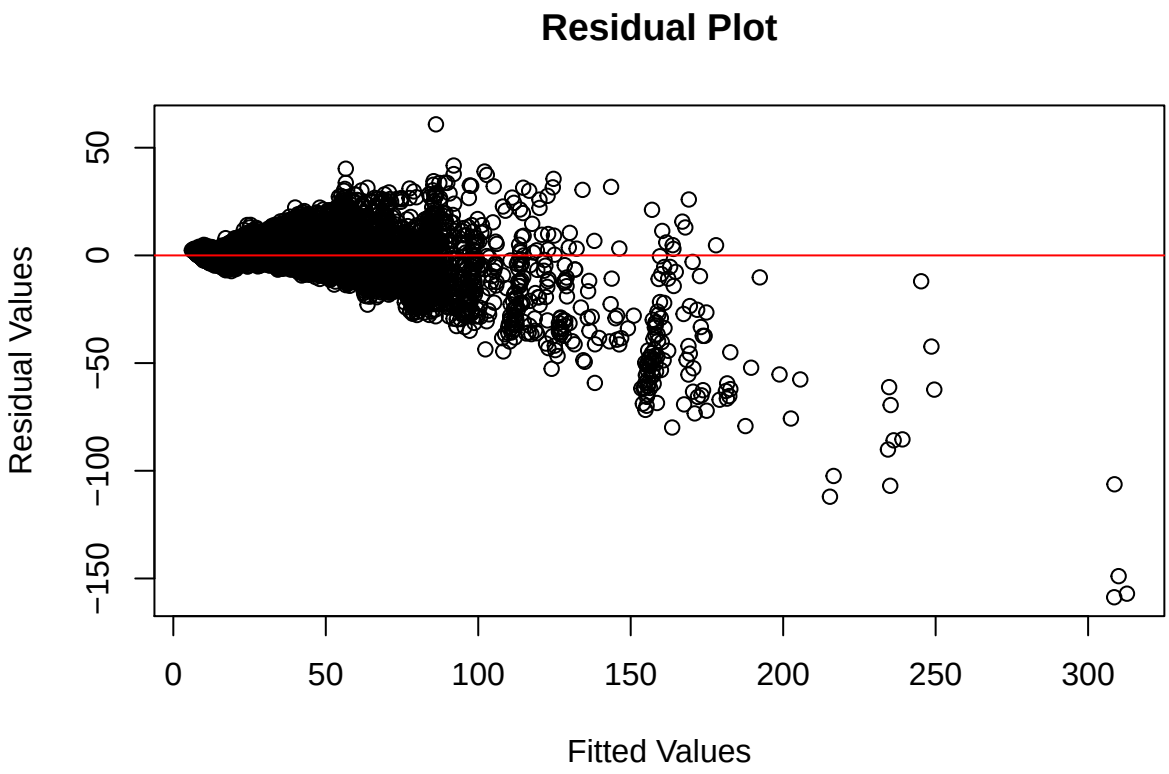
Let's look at the Carat variable.

```
title = "Price vs. Carat"
xlab = "Carat"
ylab ="Price"
x = carat
y = price

# Produce a plot.
plot(x, y, main=title, xlab=xlab, ylab=ylab)

abline(lmodel_fixed, col="red")
```

```
## Warning in abline(lmodel_fixed, col = "red"): only using the first two of 18
## regression coefficients
```




```
plot(lmodel_fixed$fitted.values,lmodel_fixed$residuals,main="Residual Plot",xlab="Fitted Values",ylab="
abline(h=0,col="red")
```



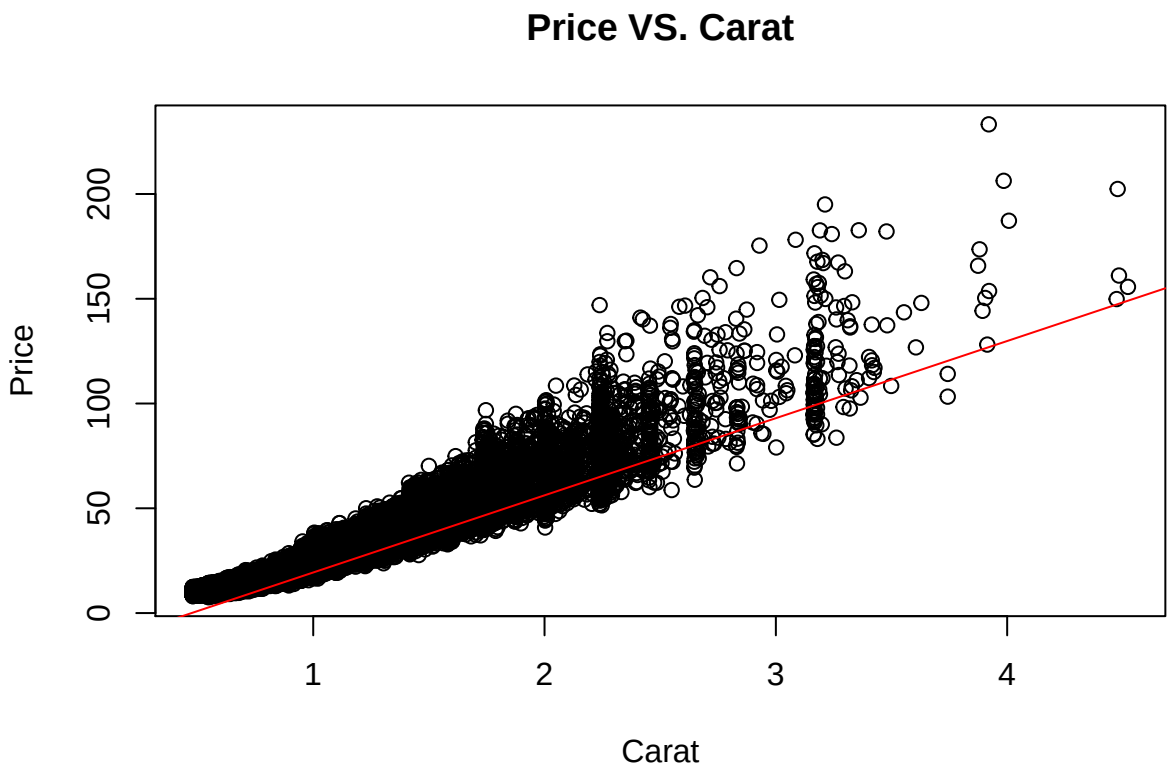

```
############ x ^ 1/2 section
lamb2 <- 1/2

newCaratSqrt <- carat^lamb2

datFormatted_fixed_sqrt <- data_fixed
datFormatted_fixed_sqrt$carat <- newCaratSqrt

lmodel_fixed_sqrt <- lm(price~.,datFormatted_fixed_sqrt)
summary(lmodel_fixed_sqrt)
```

```
##
## Call:
## lm(formula = price ~ ., data = datFormatted_fixed_sqrt)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -21.061  -1.129  -0.148   0.966  93.680
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -17.45377    0.03573 -488.50   <2e-16 ***
## carat           36.82030    0.01846 1994.80   <2e-16 ***
## claritySI1       0.89097    0.01985   44.87   <2e-16 ***
## clarityVS2       1.74698    0.02043   85.51   <2e-16 ***
```

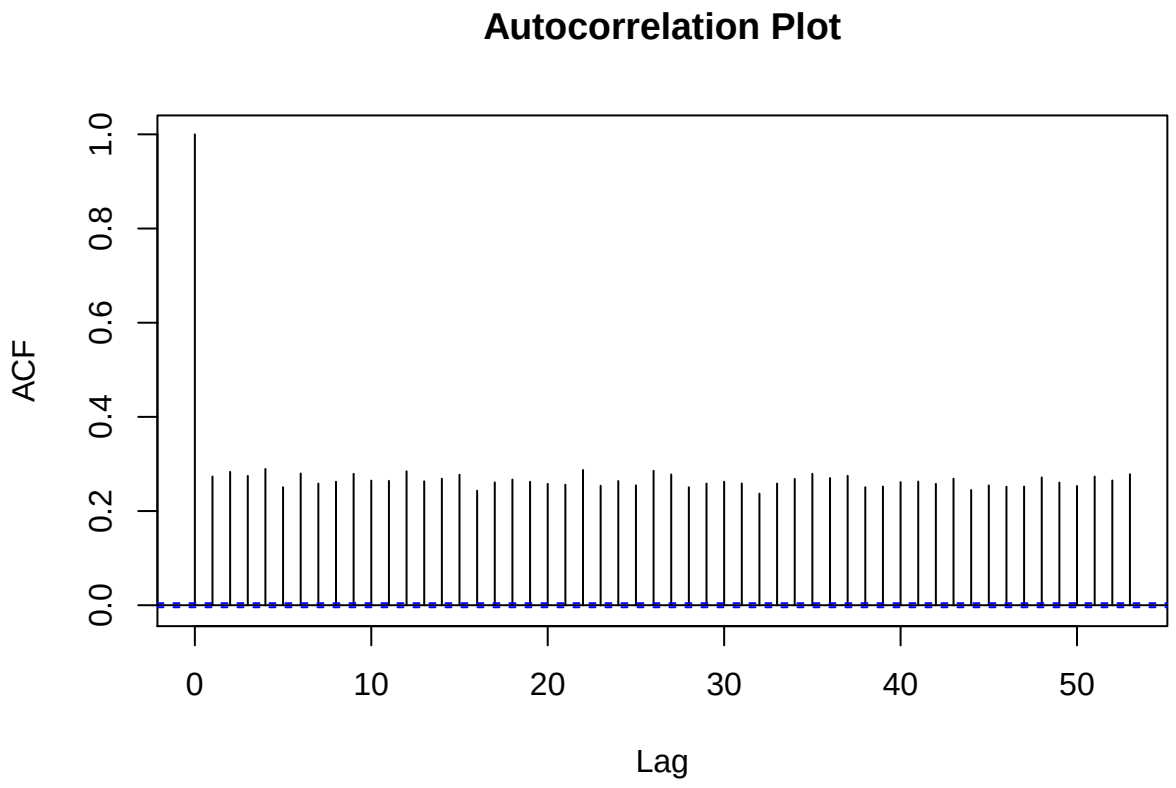
```
## clarityVS1       2.28518    0.02032  112.45   <2e-16 ***
## clarityVVS2      2.71474    0.02140  126.87   <2e-16 ***
## clarityVVS1      3.24684    0.02160  150.32   <2e-16 ***
## clarityIF        4.16243    0.02975  139.89   <2e-16 ***
## clarityFL        8.34260    0.08113  102.83   <2e-16 ***
## colorI           1.17421    0.02498   47.00   <2e-16 ***
## colorH           1.82526    0.02473   73.81   <2e-16 ***
## colorG           2.44821    0.02382  102.79   <2e-16 ***
## colorF           3.03226    0.02357  128.63   <2e-16 ***
## colorE           3.33724    0.02371  140.75   <2e-16 ***
## colorD           3.81199    0.02397  159.06   <2e-16 ***
## cutVery Good     0.50195    0.02288   21.93   <2e-16 ***
## cutIdeal         2.09649    0.02194   95.54   <2e-16 ***
## cutAstor Ideal   2.14059    0.04755   45.02   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.48 on 210620 degrees of freedom
## Multiple R-squared:  0.951,  Adjusted R-squared:  0.951
## F-statistic: 2.407e+05 on 17 and 210620 DF,  p-value: < 2.2e-16
```

```
title = "Price VS. Carat"
xlab = "Carat"
ylab ="Price"
x = datFormatted_fixed_sqrt$carat
y = datFormatted_fixed_sqrt$price

# Produce a plot.
plot(x, y, main=title, xlab=xlab, ylab=ylab)

abline(lmodel_fixed_sqrt, col="red")
```

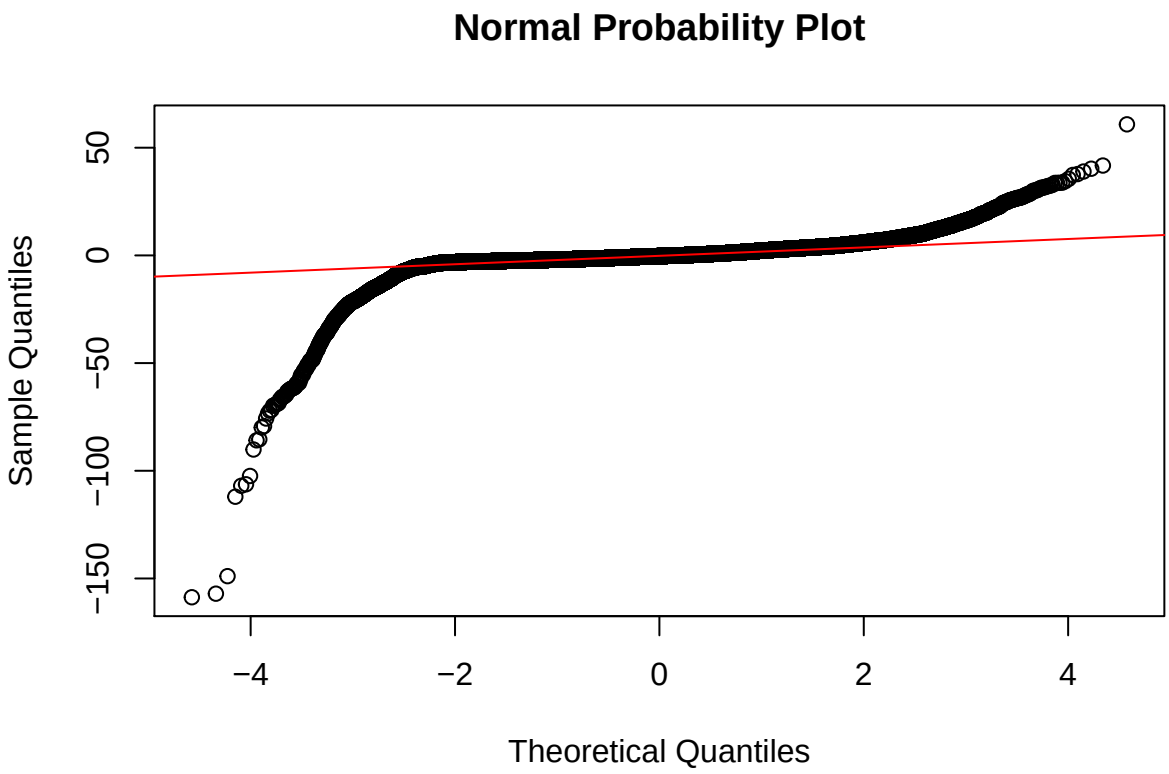
```
## Warning in abline(lmodel_fixed_sqrt, col = "red"): only using the first two of
## 18 regression coefficients
```




```
##acf plot of residuals
acf(lmodel_fixed$residuals, main="Autocorrelation Plot")
```




```
##QQ plot of residuals
qqnorm(lmodel_fixed$residuals, main="Normal Probability Plot")
qqline(lmodel_fixed$residuals, col="red")
```



Looks like a minor increase in the power can help with more precise fitting.

```
lamb2 <- .69

newCarat <- carat^lamb2

datFormatted_fixed2 <- data_fixed
datFormatted_fixed2$carat <- newCarat
attach(datFormatted_fixed2)
```

```
## The following objects are masked from data_fixed:
##
##     carat, clarity, color, cut, price

## The following objects are masked from data:
##
##     carat, clarity, color, cut, price
```

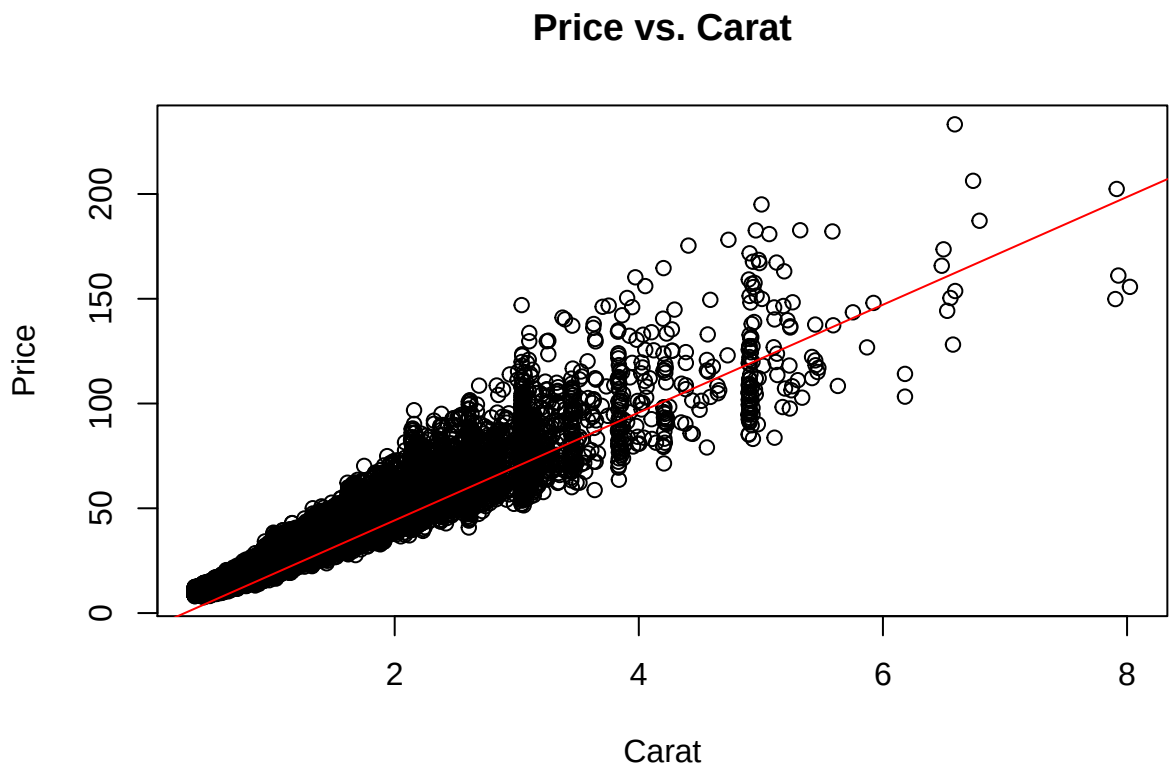
```
lmodel_fixed2 <- lm(price~.,datFormatted_fixed2)
summary(lmodel_fixed2)
```

```
##
## Call:
## lm(formula = price ~ ., data = datFormatted_fixed2)
##
```

```
## Residuals:
##     Min      1Q  Median      3Q     Max
## -51.828  -0.911  -0.107   0.807  66.400
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -7.19988    0.02999 -240.09   <2e-16 ***
## carat          25.72369    0.01148 2240.12   <2e-16 ***
## claritySI1      0.89425    0.01777   50.31   <2e-16 ***
## clarityVS2      1.69676    0.01829   92.78   <2e-16 ***
## clarityVS1      2.21034    0.01819  121.50   <2e-16 ***
## clarityVVS2     2.60361    0.01915  135.93   <2e-16 ***
## clarityVVS1     3.11588    0.01933  161.16   <2e-16 ***
## clarityIF       3.95267    0.02663  148.41   <2e-16 ***
## clarityFL       7.77057    0.07263  106.98   <2e-16 ***
## colorI          1.21381    0.02236   54.27   <2e-16 ***
## colorH          1.98527    0.02214   89.68   <2e-16 ***
## colorG          2.61038    0.02132  122.42   <2e-16 ***
## colorF          3.10530    0.02110  147.15   <2e-16 ***
## colorE          3.35230    0.02123  157.94   <2e-16 ***
## colorD          3.88496    0.02145  181.08   <2e-16 ***
## cutVery Good    0.39212    0.02048   19.14   <2e-16 ***
## cutIdeal        1.73664    0.01963   88.48   <2e-16 ***
## cutAstor Ideal  2.20014    0.04257   51.69   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.22 on 210620 degrees of freedom
## Multiple R-squared:  0.9608, Adjusted R-squared:  0.9608
## F-statistic: 3.034e+05 on 17 and 210620 DF,  p-value: < 2.2e-16
```

```
title = "Price vs. Carat"
xlab = "Carat"
ylab ="Price"
x = carat
y = price

# Produce a plot.
plot(x, y, main=title, xlab=xlab, ylab=ylab)

abline(lmodel_fixed2, col="red")
```

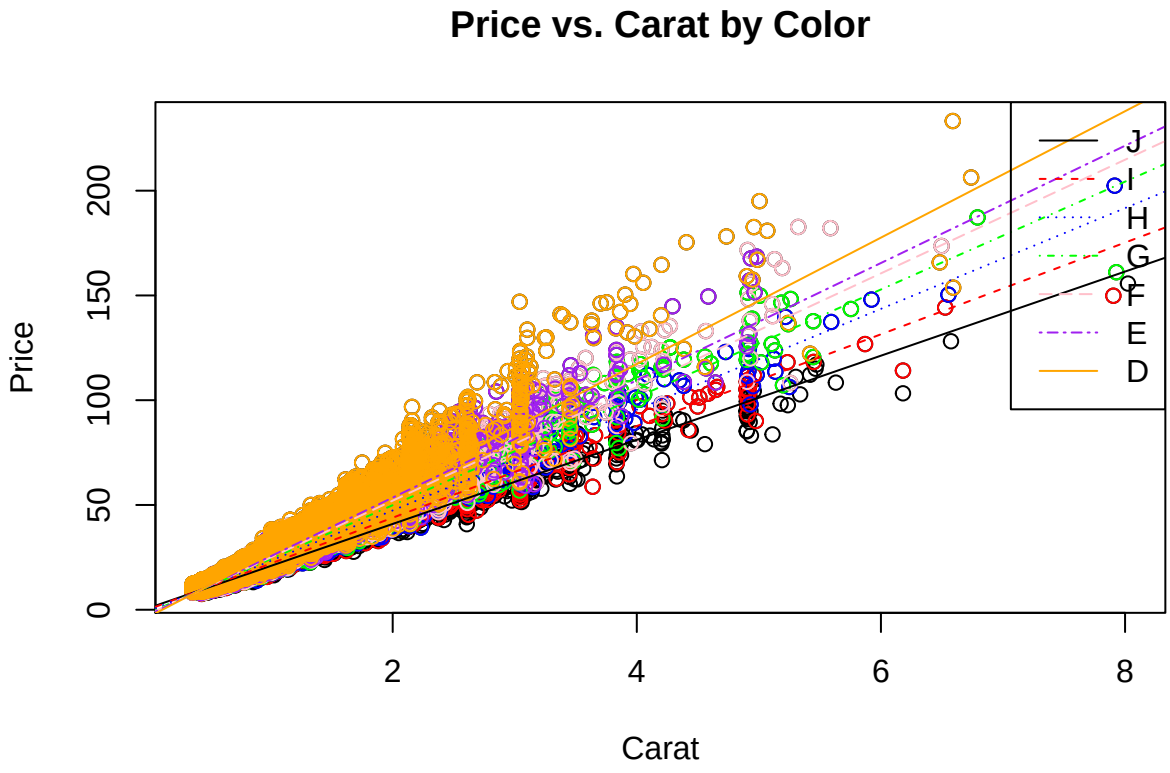
```
## Warning in abline(lmodel_fixed2, col = "red"): only using the first two of 18
## regression coefficients
```



The predictor transformation is applied.

```
#let's plot carat vs price by colorscore
a1 <- subset(datFormatted_fixed2, color=="J")
a2 <- subset(datFormatted_fixed2, color=="I")
a3 <- subset(datFormatted_fixed2, color=="H")
a4 <- subset(datFormatted_fixed2, color=="G")
a5 <- subset(datFormatted_fixed2, color=="F")
a6 <- subset(datFormatted_fixed2, color=="E")
a7 <- subset(datFormatted_fixed2, color=="D")
reg1 <- lm(price~carat, data=a1)
reg2 <- lm(price~carat, data=a2)
reg3 <- lm(price~carat, data=a3)
reg4 <- lm(price~carat, data=a4)
reg5 <- lm(price~carat, data=a5)
reg6 <- lm(price~carat, data=a6)
reg7 <- lm(price~carat, data=a7)
plot(carat, price, main="Price vs. Carat by Color", xlab="Carat", ylab="Price")
points(a2$carat, a2$price, col='red')
points(a3$carat, a3$price, col='blue')
points(a4$carat, a4$price, col='green')
points(a5$carat, a5$price, col='pink')
points(a6$carat, a6$price, col='purple')
points(a7$carat, a7$price, col='orange')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
```

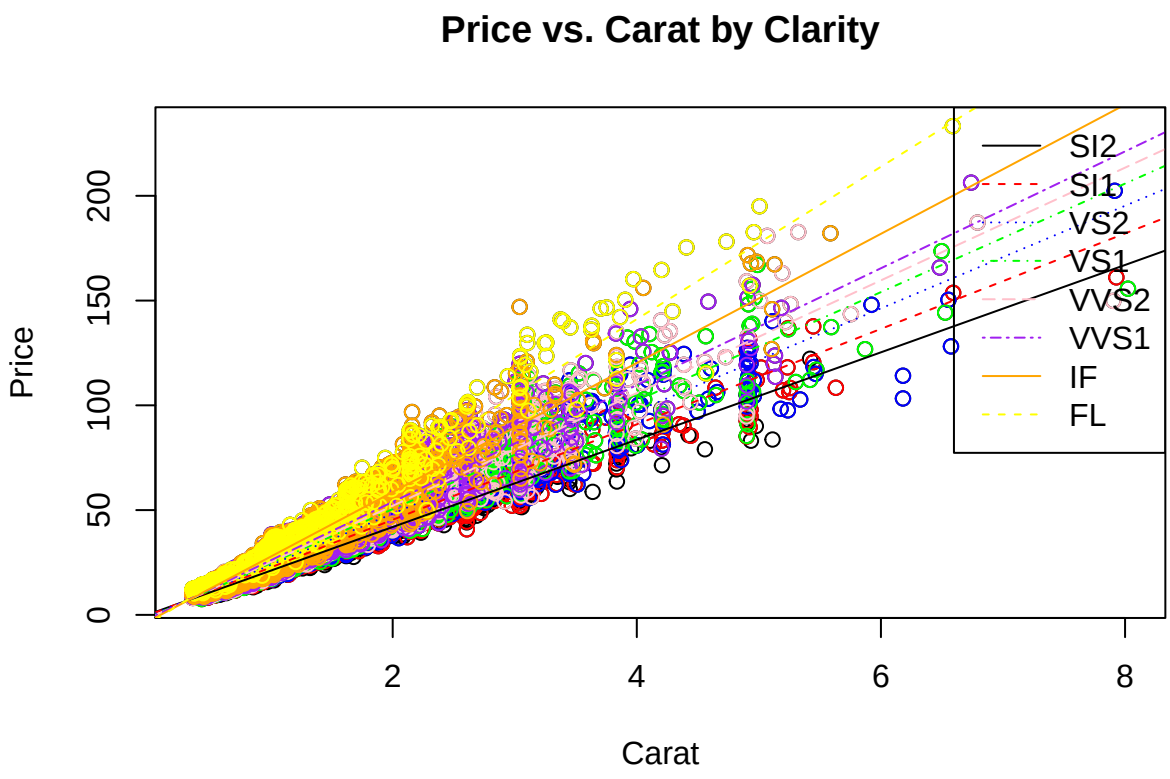
```
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
abline(reg5, lty=5, col='pink')
abline(reg6, lty=6, col='purple')
abline(reg7, lty=7, col='orange')
legend("topright", c("J","I","H","G","F","E","D"), lty=c(1,2,3,4,5,6,7), col=c('black','red','blue','gr
```




```
#the slopes for all of the lines are similar, but there still may be interaction
```

```
#let's plot carat vs price by clarityscore
a1 <- subset(datFormatted_fixed2, clarity=="SI2")
a2 <- subset(datFormatted_fixed2, clarity=="SI1")
a3 <- subset(datFormatted_fixed2, clarity=="VS2")
a4 <- subset(datFormatted_fixed2, clarity=="VS1")
a5 <- subset(datFormatted_fixed2, clarity=="VVS2")
a6 <- subset(datFormatted_fixed2, clarity=="VVS1")
a7 <- subset(datFormatted_fixed2, clarity=="IF")
a8 <- subset(datFormatted_fixed2, clarity=="FL")
reg1 <- lm(price~carat, data=a1)
reg2 <- lm(price~carat, data=a2)
reg3 <- lm(price~carat, data=a3)
reg4 <- lm(price~carat, data=a4)
reg5 <- lm(price~carat, data=a5)
reg6 <- lm(price~carat, data=a6)
reg7 <- lm(price~carat, data=a7)
```

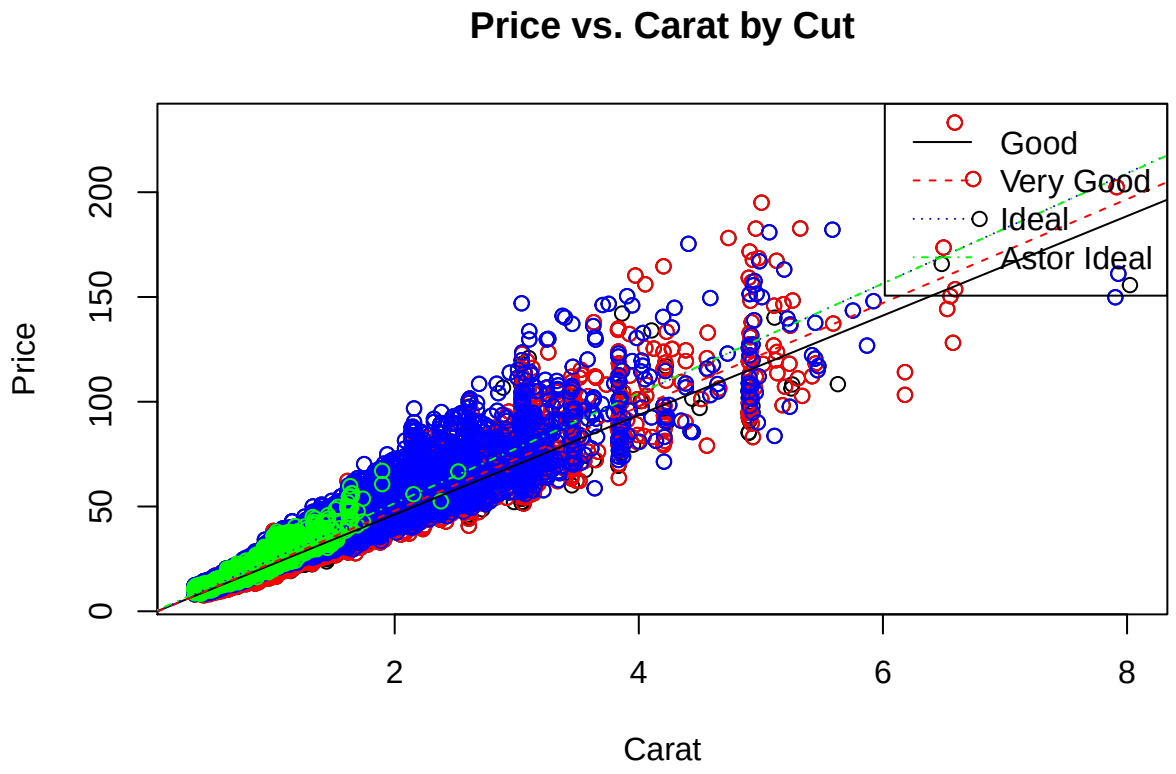
```
reg8 <- lm(price~carat, data=a8)
plot(carat, price, main="Price vs. Carat by Clarity", xlab="Carat", ylab="Price")
points(a2$carat, a2$price, col='red')
points(a3$carat, a3$price, col='blue')
points(a4$carat, a4$price, col='green')
points(a5$carat, a5$price, col='pink')
points(a6$carat, a6$price, col='purple')
points(a7$carat, a7$price, col='orange')
points(a8$carat, a8$price, col='yellow')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
abline(reg5, lty=5, col='pink')
abline(reg6, lty=6, col='purple')
abline(reg7, lty=7, col='orange')
abline(reg8, lty=8, col='yellow')
legend("topright", c("SI2","SI1","VS2","VS1","VVS2","VVS1","IF", "FL"), lty=c(1,2,3,4,5,6,7,8), col=c('
```




```
#the slopes for all of the lines are similar, but there still may be interaction
```

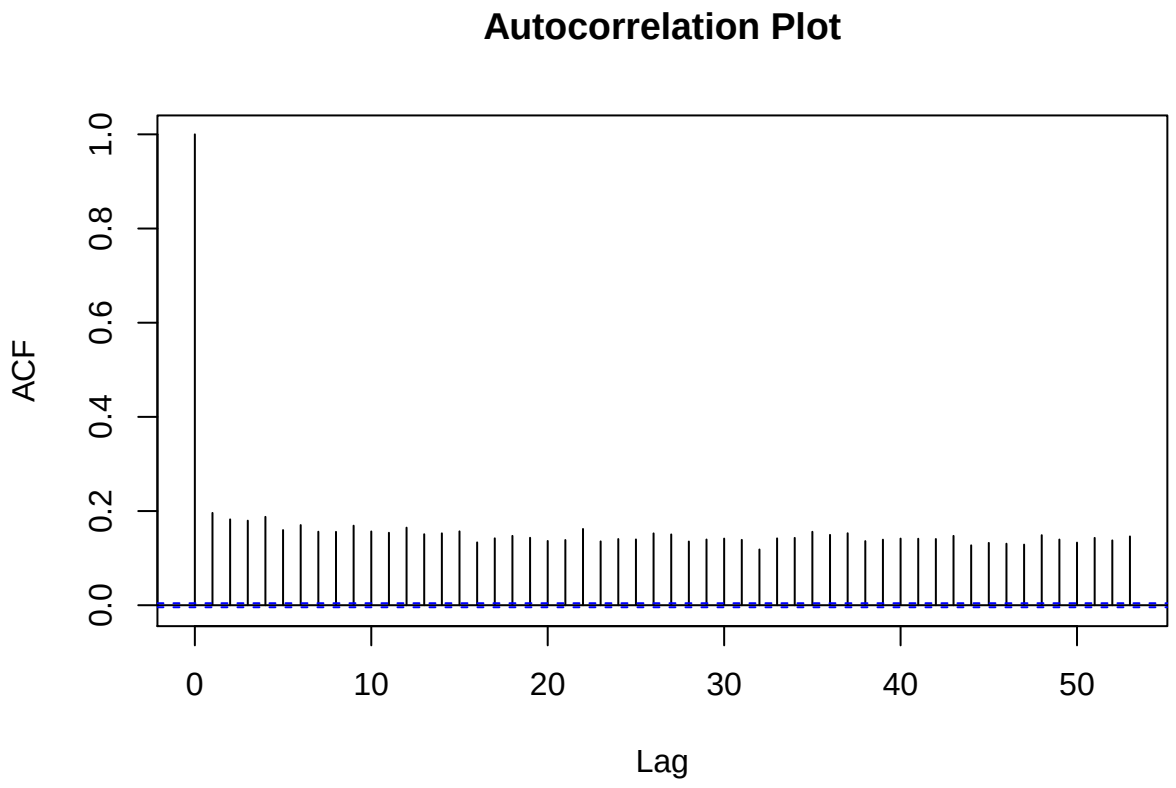
```
#let's plot carat vs price by cutscore
a1 <- subset(datFormatted_fixed2, cut=="Good")
a2 <- subset(datFormatted_fixed2, cut=="Very Good")
a3 <- subset(datFormatted_fixed2, cut=="Ideal")
```

```
a4 <- subset(datFormatted_fixed2, cut=="Astor Ideal")
reg1 <- lm(price~carat, data=a1)
reg2 <- lm(price~carat, data=a2)
reg3 <- lm(price~carat, data=a3)
reg4 <- lm(price~carat, data=a4)
plot(carat, price, main="Price vs. Carat by Cut", xlab="Carat", ylab="Price")
points(a2$carat, a2$price, col='red')
points(a3$carat, a3$price, col='blue')
points(a4$carat, a4$price, col='green')
abline(reg1, lty=1)
abline(reg2, lty=2, col='red')
abline(reg3, lty=3, col='blue')
abline(reg4, lty=4, col='green')
legend("topright", c("Good","Very Good","Ideal","Astor Ideal"), lty=c(1,2,3,4), col=c('black','red','blu
```

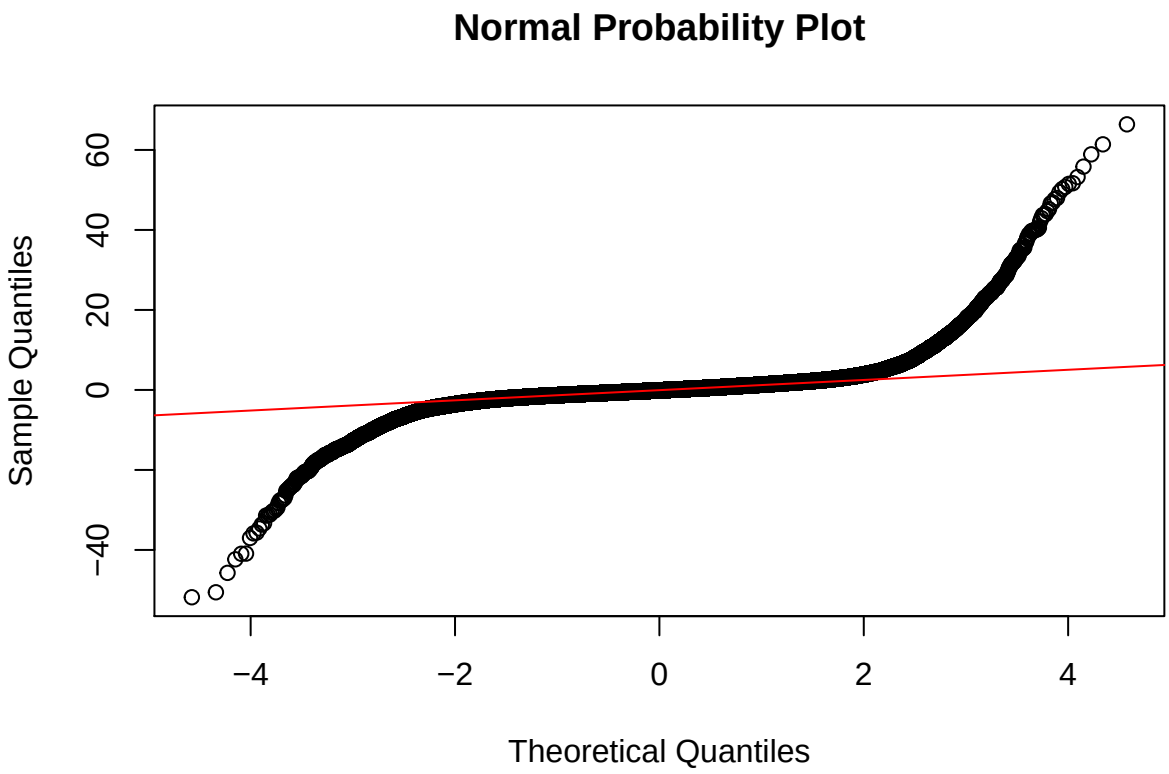



```
#the slopes for all of the lines are similar, but there still may be interaction
```

```
##acf plot of residuals
acf(lmodel_fixed2$residuals,main="Autocorrelation Plot")
```




```
##QQ plot of residuals
qqnorm(lmodel_fixed2$residuals, main="Normal Probability Plot")
qqline(lmodel_fixed2$residuals, col="red")
```



Both the response and numerical predictor are transformed now and the model is more compliant with the linear model assumptions.

Next, check for multicollinearity with VIF analysis. It will show by what factor the variance is multiplied by for this situation compared to a perfectly uncorrelated situation.

VIF > 10 is commonly used to check for multicolinearity.

```
# perform vif analysis
vif(lmodel_fixed2)
```

```
##          carat     claritySI1     clarityVS2     clarityVS1    clarityVVS2
##       1.041999       2.173198       2.058518       2.083541       1.893912
##    clarityVVS1      clarityIF      clarityFL         colorI         colorH
##       1.870169       1.337111       1.055010       2.314738       2.372706
##         colorG         colorF         colorE         colorD   cutVery Good
##       2.653447       2.755009       2.728393       2.660621       3.797541
##       cutIdeal cutAstor Ideal
##       3.913422       1.220150
```

```
# none of the scores are over 10 ( all of them are actually less than 4)
```

None of the scores are over 10.

Let's perform ANOVA test.

```r
# perform anova test
anova(lmodel_fixed2)
```

```
## Analysis of Variance Table
##
## Response: price
##               Df   Sum Sq  Mean Sq   F value    Pr(>F)
## carat          1 24766501 24766501 5026365.8 < 2.2e-16 ***
## clarity        7   312449    44636    9058.8 < 2.2e-16 ***
## color          6   238103    39684    8053.9 < 2.2e-16 ***
## cut            3    99364    33121    6722.0 < 2.2e-16 ***
## Residuals 210620  1037792        5
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

All of the predictors are considered significant.

Perform pairwise test to see if all categorical variables are significantly different in their means for price for each value.

```r
pairwise_clarity<-glht(lmodel_fixed2, linfct = mcp(clarity= "Tukey"))
summary(pairwise_clarity)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = price ~ ., data = datFormatted_fixed2)
##
## Linear Hypotheses:
##                   Estimate Std. Error t value Pr(>|t|)
## SI1 - SI2 == 0    0.89425    0.01777   50.31   <2e-16 ***
## VS2 - SI2 == 0    1.69676    0.01829   92.78   <2e-16 ***
## VS1 - SI2 == 0    2.21034    0.01819  121.50   <2e-16 ***
## VVS2 - SI2 == 0   2.60361    0.01915  135.93   <2e-16 ***
## VVS1 - SI2 == 0   3.11588    0.01933  161.16   <2e-16 ***
## IF - SI2 == 0     3.95267    0.02663  148.41   <2e-16 ***
## FL - SI2 == 0     7.77057    0.07263  106.98   <2e-16 ***
## VS2 - SI1 == 0    0.80250    0.01583   50.70   <2e-16 ***
## VS1 - SI1 == 0    1.31609    0.01571   83.77   <2e-16 ***
## VVS2 - SI1 == 0   1.70935    0.01684  101.49   <2e-16 ***
## VVS1 - SI1 == 0   2.22162    0.01705  130.33   <2e-16 ***
## IF - SI1 == 0     3.05842    0.02500  122.35   <2e-16 ***
## FL - SI1 == 0     6.87632    0.07198   95.53   <2e-16 ***
## VS1 - VS2 == 0    0.51359    0.01627   31.57   <2e-16 ***
## VVS2 - VS2 == 0   0.90685    0.01737   52.20   <2e-16 ***
## VVS1 - VS2 == 0   1.41912    0.01758   80.73   <2e-16 ***
## IF - VS2 == 0     2.25592    0.02537   88.94   <2e-16 ***
## FL - VS2 == 0     6.07381    0.07210   84.24   <2e-16 ***
## VVS2 - VS1 == 0   0.39327    0.01725   22.80   <2e-16 ***
## VVS1 - VS1 == 0   0.90553    0.01745   51.88   <2e-16 ***
```

```
## IF - VS1 == 0     1.74233    0.02527   68.94   <2e-16 ***
## FL - VS1 == 0     5.56023    0.07204   77.18   <2e-16 ***
## VVS1 - VVS2 == 0  0.51227    0.01843   27.80   <2e-16 ***
## IF - VVS2 == 0    1.34907    0.02596   51.97   <2e-16 ***
## FL - VVS2 == 0    5.16696    0.07231   71.46   <2e-16 ***
## IF - VVS1 == 0    0.83680    0.02608   32.09   <2e-16 ***
## FL - VVS1 == 0    4.65469    0.07237   64.32   <2e-16 ***
## FL - IF == 0      3.81790    0.07452   51.23   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
pairwise_color<-glht(lmodel_fixed2, linfct = mcp(color= "Tukey"))
summary(pairwise_color)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = price ~ ., data = datFormatted_fixed2)
##
## Linear Hypotheses:
##            Estimate Std. Error t value Pr(>|t|)
## I - J == 0  1.21381    0.02236   54.27   <2e-16 ***
## H - J == 0  1.98527    0.02214   89.68   <2e-16 ***
## G - J == 0  2.61038    0.02132  122.42   <2e-16 ***
## F - J == 0  3.10530    0.02110  147.15   <2e-16 ***
## E - J == 0  3.35230    0.02123  157.94   <2e-16 ***
## D - J == 0  3.88496    0.02145  181.08   <2e-16 ***
## H - I == 0  0.77146    0.01922   40.15   <2e-16 ***
## G - I == 0  1.39657    0.01825   76.51   <2e-16 ***
## F - I == 0  1.89149    0.01798  105.20   <2e-16 ***
## E - I == 0  2.13849    0.01811  118.06   <2e-16 ***
## D - I == 0  2.67115    0.01842  145.04   <2e-16 ***
## G - H == 0  0.62511    0.01798   34.76   <2e-16 ***
## F - H == 0  1.12004    0.01771   63.23   <2e-16 ***
## E - H == 0  1.36703    0.01784   76.61   <2e-16 ***
## D - H == 0  1.89970    0.01814  104.75   <2e-16 ***
## F - G == 0  0.49493    0.01664   29.74   <2e-16 ***
## E - G == 0  0.74193    0.01677   44.24   <2e-16 ***
## D - G == 0  1.27459    0.01710   74.55   <2e-16 ***
## E - F == 0  0.24700    0.01645   15.01   <2e-16 ***
## D - F == 0  0.77966    0.01679   46.43   <2e-16 ***
## D - E == 0  0.53266    0.01688   31.56   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
pairwise_cut<-glht(lmodel_fixed2, linfct = mcp(cut= "Tukey"))
summary(pairwise_cut)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = price ~ ., data = datFormatted_fixed2)
##
## Linear Hypotheses:
##                               Estimate Std. Error t value Pr(>|t|)
## Very Good - Good == 0          0.39212    0.02048   19.14   <2e-16 ***
## Ideal - Good == 0              1.73664    0.01963   88.48   <2e-16 ***
## Astor Ideal - Good == 0        2.20014    0.04257   51.69   <2e-16 ***
## Ideal - Very Good == 0         1.34452    0.01090  123.39   <2e-16 ***
## Astor Ideal - Very Good == 0   1.80802    0.03932   45.99   <2e-16 ***
## Astor Ideal - Ideal == 0       0.46349    0.03880   11.95   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

They are all significantly different for all pairs.

Let's do partial F test for each categorical variable.

First, make the reduced linear regression model

```
lmodel_noClarity <- lm(price~carat+color+cut)
lmodel_noColor <- lm(price~carat+clarity+cut)
lmodel_noCut <- lm(price~carat+clarity+color)
```

Perform the partial F test.

For clarity :

```
anova(lmodel_noClarity, lmodel_fixed2)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + color + cut
## Model 2: price ~ carat + clarity + color + cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210627 1303009
## 2 210620 1037792  7    265218 7689.4 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

For color :

```
anova(lmodel_noColor, lmodel_fixed2)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + cut
```

```
## Model 2: price ~ carat + clarity + color + cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210626 1287326
## 2 210620 1037792  6    249534 8440.5 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

For cut :

```
anova(lmodel_noCut, lmodel_fixed2)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color
## Model 2: price ~ carat + clarity + color + cut
##   Res.Df     RSS Df Sum of Sq    F    Pr(>F)
## 1 210623 1137155
## 2 210620 1037792  3     99364 6722 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Partial F tests were significant for all of the categorical variables.

We can not drop any of the categorical variables.

Partial F tests on one interaction :

```
lmodel_interactioncocl <- lm(price~carat+cut+clarity*color)
anova(lmodel_fixed2, lmodel_interactioncocl)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + cut + clarity * color
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210578 1013966 42     23826 117.81 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(lmodel_interactioncocl)
```

```
##
## Call:
## lm(formula = price ~ carat + cut + clarity * color)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -51.458  -0.872  -0.065   0.802  64.690
##
## Coefficients:
##                    Estimate Std. Error  t value Pr(>|t|)
```

```
## (Intercept)        -6.65863    0.05235 -127.197  < 2e-16 ***
## carat              25.69112    0.01139 2255.516  < 2e-16 ***
## cutVery Good        0.39086    0.02026   19.297  < 2e-16 ***
## cutIdeal            1.74206    0.01942   89.726  < 2e-16 ***
## cutAstor Ideal      2.23133    0.04209   53.009  < 2e-16 ***
## claritySI1          0.42438    0.06443    6.586 4.52e-11 ***
## clarityVS2          0.83108    0.06624   12.547  < 2e-16 ***
## clarityVS1          1.49383    0.06354   23.510  < 2e-16 ***
## clarityVVS2         2.18080    0.06417   33.985  < 2e-16 ***
## clarityVVS1         2.74070    0.06377   42.978  < 2e-16 ***
## clarityIF           2.82366    0.09247   30.536  < 2e-16 ***
## clarityFL           0.81734    1.55239    0.527 0.598539
## colorI              1.17284    0.05972   19.640  < 2e-16 ***
## colorH              1.58392    0.06106   25.941  < 2e-16 ***
## colorG              2.06695    0.05876   35.173  < 2e-16 ***
## colorF              2.44315    0.05718   42.726  < 2e-16 ***
## colorE              2.61721    0.06039   43.342  < 2e-16 ***
## colorD              2.76977    0.06322   43.813  < 2e-16 ***
## claritySI1:colorI   0.35253    0.08006    4.403 1.07e-05 ***
## clarityVS2:colorI   0.43331    0.08214    5.275 1.33e-07 ***
## clarityVS1:colorI   0.08239    0.07999    1.030 0.303019
## clarityVVS2:colorI -0.19508    0.08151   -2.393 0.016701 *
## clarityVVS1:colorI -0.52012    0.08148   -6.383 1.74e-10 ***
## clarityIF:colorI   -0.30570    0.12028   -2.542 0.011037 *
## clarityFL:colorI   -0.35015    1.90131   -0.184 0.853888
## claritySI1:colorH   0.71403    0.08066    8.853  < 2e-16 ***
## clarityVS2:colorH   1.00376    0.08275   12.130  < 2e-16 ***
## clarityVS1:colorH   0.65122    0.08045    8.095 5.77e-16 ***
## clarityVVS2:colorH  0.14165    0.08162    1.736 0.082638 .
## clarityVVS1:colorH -0.17625    0.08236   -2.140 0.032360 *
## clarityIF:colorH   -0.03191    0.11716   -0.272 0.785352
## clarityFL:colorH    2.94899    1.65992    1.777 0.075637 .
## claritySI1:colorG   0.69592    0.07707    9.030  < 2e-16 ***
## clarityVS2:colorG   1.06737    0.07962   13.406  < 2e-16 ***
## clarityVS1:colorG   0.88345    0.07737   11.419  < 2e-16 ***
## clarityVVS2:colorG  0.30727    0.07950    3.865 0.000111 ***
## clarityVVS1:colorG  0.11320    0.07941    1.426 0.154005
## clarityIF:colorG    0.19761    0.11466    1.723 0.084813 .
## clarityFL:colorG    3.87454    1.59645    2.427 0.015226 *
## claritySI1:colorF   0.50751    0.07576    6.699 2.11e-11 ***
## clarityVS2:colorF   1.00952    0.07787   12.964  < 2e-16 ***
## clarityVS1:colorF   1.02298    0.07587   13.484  < 2e-16 ***
## clarityVVS2:colorF  0.62496    0.07815    7.997 1.28e-15 ***
## clarityVVS1:colorF  0.61254    0.07776    7.877 3.36e-15 ***
## clarityIF:colorF    1.12205    0.11309    9.922  < 2e-16 ***
## clarityFL:colorF    5.94005    1.58755    3.742 0.000183 ***
## claritySI1:colorE   0.51635    0.07816    6.606 3.96e-11 ***
## clarityVS2:colorE   1.00941    0.08019   12.588  < 2e-16 ***
## clarityVS1:colorE   0.91658    0.07802   11.749  < 2e-16 ***
## clarityVVS2:colorE  0.81569    0.08079   10.096  < 2e-16 ***
## clarityVVS1:colorE  0.93279    0.08037   11.606  < 2e-16 ***
## clarityIF:colorE    1.61754    0.11371   14.226  < 2e-16 ***
## clarityFL:colorE    5.73998    1.56874    3.659 0.000253 ***
## claritySI1:colorD   0.58235    0.08117    7.175 7.26e-13 ***
```

```
## clarityVS2:colorD   1.25620    0.08335   15.072  < 2e-16 ***
## clarityVS1:colorD   1.18917    0.08048   14.776  < 2e-16 ***
## clarityVVS2:colorD  1.12383    0.08236   13.645  < 2e-16 ***
## clarityVVS1:colorD  1.39554    0.08253   16.910  < 2e-16 ***
## clarityIF:colorD    3.50609    0.11156   31.428  < 2e-16 ***
## clarityFL:colorD    8.04949    1.55491    5.177 2.26e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.194 on 210578 degrees of freedom
## Multiple R-squared:  0.9617, Adjusted R-squared:  0.9617
## F-statistic: 8.955e+04 on 59 and 210578 DF,  p-value: < 2.2e-16
```

```
lmodel_interactioncocu <- lm(price~carat+clarity+cut*color)
anova(lmodel_fixed2, lmodel_interactioncocu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + clarity + cut * color
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210602 1036593 18    1198.5 13.527 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(lmodel_interactioncocu)
```

```
##
## Call:
## lm(formula = price ~ carat + clarity + cut * color)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -51.883  -0.906  -0.111   0.799  66.476
##
## Coefficients:
##                      Estimate Std. Error  t value Pr(>|t|)
## (Intercept)          -7.16058    0.06371 -112.401  < 2e-16 ***
## carat                25.72532    0.01148 2240.851  < 2e-16 ***
## claritySI1            0.89614    0.01777   50.436  < 2e-16 ***
## clarityVS2            1.69806    0.01828   92.870  < 2e-16 ***
## clarityVS1            2.21217    0.01819  121.630  < 2e-16 ***
## clarityVVS2           2.60373    0.01915  135.965  < 2e-16 ***
## clarityVVS1           3.11412    0.01933  161.088  < 2e-16 ***
## clarityIF             3.95170    0.02663  148.403  < 2e-16 ***
## clarityFL             7.81689    0.07279  107.392  < 2e-16 ***
## cutVery Good          0.09481    0.06947    1.365  0.17235
## cutIdeal              1.81583    0.06545   27.743  < 2e-16 ***
## cutAstor Ideal        2.06125    0.14857   13.874  < 2e-16 ***
## colorI                1.15363    0.08162   14.134  < 2e-16 ***
## colorH                2.03625    0.08021   25.386  < 2e-16 ***
## colorG                2.63216    0.07699   34.187  < 2e-16 ***
```

```
## colorF                 2.95479    0.07560   39.086  < 2e-16 ***
## colorE                 3.19027    0.07596   42.001  < 2e-16 ***
## colorD                 3.94585    0.07703   51.226  < 2e-16 ***
## cutVery Good:colorI    0.23663    0.09168    2.581  0.00985 **
## cutIdeal:colorI       -0.01652    0.08641   -0.191  0.84840
## cutAstor Ideal:colorI -0.08087    0.18544   -0.436  0.66276
## cutVery Good:colorH    0.19410    0.09016    2.153  0.03133 *
## cutIdeal:colorH       -0.17866    0.08501   -2.102  0.03559 *
## cutAstor Ideal:colorH  0.11780    0.18407    0.640  0.52219
## cutVery Good:colorG    0.27217    0.08635    3.152  0.00162 **
## cutIdeal:colorG       -0.16237    0.08167   -1.988  0.04681 *
## cutAstor Ideal:colorG -0.11826    0.17935   -0.659  0.50964
## cutVery Good:colorF    0.39907    0.08485    4.703 2.56e-06 ***
## cutIdeal:colorF        0.04767    0.08027    0.594  0.55257
## cutAstor Ideal:colorF  0.18065    0.18364    0.984  0.32525
## cutVery Good:colorE    0.46077    0.08514    5.412 6.25e-08 ***
## cutIdeal:colorE        0.03371    0.08069    0.418  0.67612
## cutAstor Ideal:colorE  0.18985    0.18384    1.033  0.30176
## cutVery Good:colorD    0.28801    0.08625    3.339  0.00084 ***
## cutIdeal:colorD       -0.25977    0.08180   -3.176  0.00150 **
## cutAstor Ideal:colorD  0.77312    0.19038    4.061 4.89e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.219 on 210602 degrees of freedom
## Multiple R-squared:  0.9608, Adjusted R-squared:  0.9608
## F-statistic: 1.475e+05 on 35 and 210602 DF,  p-value: < 2.2e-16
```

```
lmodel_interactioncaco <- lm(price~clarity+cut+carat*color)
anova(lmodel_fixed2, lmodel_interactioncaco)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ clarity + cut + carat * color
##   Res.Df     RSS Df Sum of Sq     F    Pr(>F)
## 1 210620 1037792
## 2 210614  671360  6    366431 19159 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(lmodel_interactioncaco)
```

```
##
## Call:
## lm(formula = price ~ clarity + cut + carat * color)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -43.260  -0.783  -0.035   0.775  56.156
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)    -2.74304    0.03178  -86.32   <2e-16 ***
## claritySI1      0.84847    0.01430   59.34   <2e-16 ***
## clarityVS2      1.66656    0.01471  113.27   <2e-16 ***
## clarityVS1      2.15491    0.01464  147.22   <2e-16 ***
## clarityVVS2     2.45922    0.01542  159.52   <2e-16 ***
## clarityVVS1     2.89578    0.01557  186.01   <2e-16 ***
## clarityIF       3.63054    0.02145  169.27   <2e-16 ***
## clarityFL       7.01608    0.05848  119.97   <2e-16 ***
## cutVery Good    0.45130    0.01648   27.39   <2e-16 ***
## cutIdeal        1.86323    0.01579  117.98   <2e-16 ***
## cutAstor Ideal  2.29616    0.03424   67.06   <2e-16 ***
## carat          20.53807    0.02578  796.57   <2e-16 ***
## colorI         -0.57035    0.03425  -16.65   <2e-16 ***
## colorH         -1.47541    0.03469  -42.53   <2e-16 ***
## colorG         -2.11296    0.03354  -62.99   <2e-16 ***
## colorF         -2.65050    0.03297  -80.39   <2e-16 ***
## colorE         -2.99405    0.03337  -89.72   <2e-16 ***
## colorD         -4.04075    0.03349 -120.67   <2e-16 ***
## carat:colorI    1.81696    0.03508   51.79   <2e-16 ***
## carat:colorH    3.96225    0.03540  111.92   <2e-16 ***
## carat:colorG    5.50436    0.03451  159.52   <2e-16 ***
## carat:colorF    6.86491    0.03448  199.12   <2e-16 ***
## carat:colorE    7.74259    0.03574  216.66   <2e-16 ***
## carat:colorD    9.76064    0.03527  276.73   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.785 on 210614 degrees of freedom
## Multiple R-squared:  0.9746, Adjusted R-squared:  0.9746
## F-statistic: 3.517e+05 on 23 and 210614 DF,  p-value: < 2.2e-16
```

```
lmodel_interactionclcu <- lm(price~carat+color+clarity*cut)
anova(lmodel_fixed2, lmodel_interactionclcu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + color + clarity * cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210599 1033638 21    4154.1 40.304 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(lmodel_interactionclcu)
```

```
##
## Call:
## lm(formula = price ~ carat + color + clarity * cut)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -51.740  -0.914  -0.109   0.807  66.504
```

```
##
## Coefficients:
##                              Estimate Std. Error  t value Pr(>|t|)
## (Intercept)                 -7.38966    0.05247 -140.840  < 2e-16 ***
## carat                       25.71051    0.01147 2240.770  < 2e-16 ***
## colorI                       1.21277    0.02232   54.328  < 2e-16 ***
## colorH                       1.98709    0.02210   89.925  < 2e-16 ***
## colorG                       2.60996    0.02129  122.602  < 2e-16 ***
## colorF                       3.10465    0.02107  147.344  < 2e-16 ***
## colorE                       3.35443    0.02120  158.242  < 2e-16 ***
## colorD                       3.89149    0.02143  181.601  < 2e-16 ***
## claritySI1                   1.13429    0.06138   18.479  < 2e-16 ***
## clarityVS2                   2.04154    0.06433   31.735  < 2e-16 ***
## clarityVS1                   2.36325    0.06426   36.776  < 2e-16 ***
## clarityVVS2                  2.74698    0.07159   38.372  < 2e-16 ***
## clarityVVS1                  3.08539    0.07829   39.411  < 2e-16 ***
## clarityIF                    5.16851    0.12762   40.498  < 2e-16 ***
## clarityFL                   17.85043    0.90588   19.705  < 2e-16 ***
## cutVery Good                 0.60823    0.05410   11.243  < 2e-16 ***
## cutIdeal                     1.95519    0.05180   37.743  < 2e-16 ***
## cutAstor Ideal               2.42815    0.34130    7.114 1.13e-12 ***
## claritySI1:cutVery Good     -0.26417    0.06876   -3.842 0.000122 ***
## clarityVS2:cutVery Good     -0.34129    0.07175   -4.757 1.97e-06 ***
## clarityVS1:cutVery Good     -0.14961    0.07170   -2.087 0.036917 *
## clarityVVS2:cutVery Good    -0.16663    0.07927   -2.102 0.035541 *
## clarityVVS1:cutVery Good    -0.13820    0.08570   -1.613 0.106813
## clarityIF:cutVery Good      -1.15712    0.13723   -8.432  < 2e-16 ***
## clarityFL:cutVery Good      -6.55647    0.92245   -7.108 1.18e-12 ***
## claritySI1:cutIdeal         -0.25912    0.06561   -3.949 7.85e-05 ***
## clarityVS2:cutIdeal         -0.39161    0.06864   -5.705 1.16e-08 ***
## clarityVS1:cutIdeal         -0.17828    0.06849   -2.603 0.009243 **
## clarityVVS2:cutIdeal        -0.15502    0.07570   -2.048 0.040574 *
## clarityVVS1:cutIdeal         0.08177    0.08203    0.997 0.318872
## clarityIF:cutIdeal          -1.31567    0.13171   -9.989  < 2e-16 ***
## clarityFL:cutIdeal         -10.87788    0.90932  -11.963  < 2e-16 ***
## claritySI1:cutAstor Ideal   -0.39581    0.35689   -1.109 0.267414
## clarityVS2:cutAstor Ideal   -0.43020    0.35247   -1.221 0.222265
## clarityVS1:cutAstor Ideal   -0.15944    0.35207   -0.453 0.650648
## clarityVVS2:cutAstor Ideal  -0.19433    0.35761   -0.543 0.586833
## clarityVVS1:cutAstor Ideal   0.25532    0.36134    0.707 0.479816
## clarityIF:cutAstor Ideal    -1.41456    0.44461   -3.182 0.001465 **
## clarityFL:cutAstor Ideal   -14.56746    2.41723   -6.027 1.68e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.215 on 210599 degrees of freedom
## Multiple R-squared:  0.9609, Adjusted R-squared:  0.9609
## F-statistic: 1.363e+05 on 38 and 210599 DF,  p-value: < 2.2e-16
```

```
lmodel_interactionclca <- lm(price~cut+color+clarity*carat)
anova(lmodel_fixed2, lmodel_interactionclca)
```

```
## Analysis of Variance Table
##
```

```
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ cut + color + clarity * carat
##   Res.Df     RSS Df Sum of Sq     F    Pr(>F)
## 1 210620 1037792
## 2 210613  773495  7    264297 10281 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(lmodel_interactionclca)
```

```
##
## Call:
## lm(formula = price ~ cut + color + clarity * carat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -62.129  -0.849  -0.096   0.801  54.691
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       -3.66749    0.03495 -104.94   <2e-16 ***
## cutVery Good       0.32565    0.01769   18.41   <2e-16 ***
## cutIdeal           1.66206    0.01695   98.05   <2e-16 ***
## cutAstor Ideal     2.11606    0.03675   57.58   <2e-16 ***
## colorI             1.12040    0.01931   58.01   <2e-16 ***
## colorH             1.87791    0.01912   98.22   <2e-16 ***
## colorG             2.42390    0.01843  131.53   <2e-16 ***
## colorF             2.87245    0.01825  157.42   <2e-16 ***
## colorE             3.11455    0.01835  169.69   <2e-16 ***
## colorD             3.66660    0.01855  197.63   <2e-16 ***
## claritySI1        -0.52455    0.03380  -15.52   <2e-16 ***
## clarityVS2        -1.01154    0.03377  -29.95   <2e-16 ***
## clarityVS1        -1.58420    0.03352  -47.26   <2e-16 ***
## clarityVVS2       -1.78758    0.03547  -50.40   <2e-16 ***
## clarityVVS1       -1.85125    0.03639  -50.88   <2e-16 ***
## clarityIF         -3.14940    0.04710  -66.87   <2e-16 ***
## clarityFL         -5.88751    0.10146  -58.03   <2e-16 ***
## carat             21.54418    0.03058  704.62   <2e-16 ***
## claritySI1:carat   1.80647    0.03816   47.34   <2e-16 ***
## clarityVS2:carat   3.46636    0.03741   92.66   <2e-16 ***
## clarityVS1:carat   4.80129    0.03719  129.11   <2e-16 ***
## clarityVVS2:carat  5.61259    0.04031  139.24   <2e-16 ***
## clarityVVS1:carat  6.46355    0.04244  152.30   <2e-16 ***
## clarityIF:carat    9.30135    0.05419  171.63   <2e-16 ***
## clarityFL:carat   15.14299    0.08565  176.79   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.916 on 210613 degrees of freedom
## Multiple R-squared:  0.9708, Adjusted R-squared:  0.9708
## F-statistic: 2.914e+05 on 24 and 210613 DF,  p-value: < 2.2e-16
```

```r
lmodel_interactioncacu <- lm(price~clarity+color+carat*cut)
anova(lmodel_fixed2, lmodel_interactioncacu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ clarity + color + carat * cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210617 1004782  3     33009 2306.4 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
summary(lmodel_interactioncacu)
```

```
##
## Call:
## lm(formula = price ~ clarity + color + carat * cut)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -57.893  -0.873  -0.088   0.789  64.562
##
## Coefficients:
##                       Estimate Std. Error  t value Pr(>|t|)
## (Intercept)          -5.60986    0.04513 -124.308   <2e-16 ***
## claritySI1            0.89340    0.01749   51.083   <2e-16 ***
## clarityVS2            1.69793    0.01800   94.348   <2e-16 ***
## clarityVS1            2.20834    0.01790  123.358   <2e-16 ***
## clarityVVS2           2.59609    0.01885  137.737   <2e-16 ***
## clarityVVS1           3.12367    0.01903  164.184   <2e-16 ***
## clarityIF             3.98752    0.02621  152.133   <2e-16 ***
## clarityFL             7.81770    0.07148  109.371   <2e-16 ***
## colorI                1.22992    0.02201   55.889   <2e-16 ***
## colorH                1.98774    0.02178   91.252   <2e-16 ***
## colorG                2.61765    0.02098  124.750   <2e-16 ***
## colorF                3.12562    0.02077  150.503   <2e-16 ***
## colorE                3.37138    0.02089  161.414   <2e-16 ***
## colorD                3.88964    0.02111  184.243   <2e-16 ***
## carat                23.90965    0.04026  593.923   <2e-16 ***
## cutVery Good         -0.53069    0.04376  -12.128   <2e-16 ***
## cutIdeal             -0.48145    0.04196  -11.473   <2e-16 ***
## cutAstor Ideal       -0.23558    0.12030   -1.958   0.0502 .
## carat:cutVery Good    1.03921    0.04405   23.592   <2e-16 ***
## carat:cutIdeal        2.65979    0.04316   61.628   <2e-16 ***
## carat:cutAstor Ideal  2.88011    0.14251   20.211   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.184 on 210617 degrees of freedom
## Multiple R-squared:  0.962,  Adjusted R-squared:  0.962
## F-statistic: 2.667e+05 on 20 and 210617 DF,  p-value: < 2.2e-16
```

All of the test results were significant.

Partial f test on all interactions then between all and one.

```
lmodel_fullInteraction <- lm(price~carat*clarity*cut*color)
summary(lmodel_fullInteraction)
```

```
##
## Call:
## lm(formula = price ~ carat * clarity * cut * color)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -34.079  -0.599  -0.015   0.585  39.726
##
## Coefficients: (25 not defined because of singularities)
##                                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)                               0.759695   0.222826   3.409 0.000651
## carat                                    18.359837   0.168658 108.858  < 2e-16
## claritySI1                                0.465661   0.277188   1.680 0.092970
## clarityVS2                               -0.844013   0.277508  -3.041 0.002355
## clarityVS1                                0.262366   0.260187   1.008 0.313276
## clarityVVS2                              -0.111901   0.331843  -0.337 0.735958
## clarityVVS1                               0.447035   0.330246   1.354 0.175853
## clarityIF                                 0.374778   0.553808   0.677 0.498579
## clarityFL                                -8.227554   7.755804  -1.061 0.288770
## cutVery Good                              0.167817   0.243390   0.689 0.490510
## cutIdeal                                  0.026638   0.235162   0.113 0.909812
## cutAstor Ideal                           -0.669798   1.707210  -0.392 0.694811
## colorI                                   -0.221532   0.289332  -0.766 0.443875
## colorH                                   -0.958744   0.301155  -3.184 0.001455
## colorG                                   -1.110678   0.319397  -3.477 0.000506
## colorF                                   -0.706716   0.294625  -2.399 0.016455
## colorE                                   -0.633783   0.288794  -2.195 0.028194
## colorD                                   -0.971682   0.313373  -3.101 0.001931
## carat:claritySI1                         -0.156786   0.221509  -0.708 0.479066
## carat:clarityVS2                          1.754452   0.230380   7.615 2.64e-14
## carat:clarityVS1                          0.855887   0.203994   4.196 2.72e-05
## carat:clarityVVS2                         1.205017   0.324995   3.708 0.000209
## carat:clarityVVS1                         0.723817   0.329028   2.200 0.027818
## carat:clarityIF                           1.226222   0.422571   2.902 0.003710
## carat:clarityFL                           7.276068   7.066312   1.030 0.303160
## carat:cutVery Good                        0.045857   0.189531   0.242 0.808820
## carat:cutIdeal                            0.965786   0.183411   5.266 1.40e-07
## carat:cutAstor Ideal                      2.589587   1.918625   1.350 0.177111
## claritySI1:cutVery Good                  -0.909667   0.307168  -2.961 0.003062
## clarityVS2:cutVery Good                   0.606205   0.307441   1.972 0.048636
## clarityVS1:cutVery Good                  -1.094983   0.291294  -3.759 0.000171
## clarityVVS2:cutVery Good                 -0.272586   0.359188  -0.759 0.447917
## clarityVVS1:cutVery Good                 -0.864462   0.362368  -2.386 0.017053
## clarityIF:cutVery Good                   -1.210705   0.603576  -2.006 0.044870
## clarityFL:cutVery Good                    3.858004   1.698215   2.272 0.023100
## claritySI1:cutIdeal                      -0.635969   0.294799  -2.157 0.030984
## clarityVS2:cutIdeal                       0.451465   0.295542   1.528 0.126617
```

```
## clarityVS1:cutIdeal                -0.834913   0.278446  -2.998 0.002714
## clarityVVS2:cutIdeal               -0.629127   0.346637  -1.815 0.069533
## clarityVVS1:cutIdeal               -1.217296   0.346546  -3.513 0.000444
## clarityIF:cutIdeal                 -0.938590   0.570937  -1.644 0.100188
## clarityFL:cutIdeal                  9.941429   1.676725   5.929 3.05e-09
## claritySI1:cutAstor Ideal           0.490352   1.921059   0.255 0.798530
## clarityVS2:cutAstor Ideal          -0.061500   1.847822  -0.033 0.973449
## clarityVS1:cutAstor Ideal          -0.091731   1.856279  -0.049 0.960587
## clarityVVS2:cutAstor Ideal         -0.273867   1.850330  -0.148 0.882335
## clarityVVS1:cutAstor Ideal          0.753764   1.829058   0.412 0.680263
## clarityIF:cutAstor Ideal            1.170040   2.122753   0.551 0.581504
## clarityFL:cutAstor Ideal            7.307900   2.077340   3.518 0.000435
## carat:colorI                        0.775938   0.239747   3.236 0.001210
## carat:colorH                        2.060634   0.258811   7.962 1.70e-15
## carat:colorG                        2.526890   0.294372   8.584  < 2e-16
## carat:colorF                        2.298876   0.270289   8.505  < 2e-16
## carat:colorE                        2.354156   0.258501   9.107  < 2e-16
## carat:colorD                        3.039803   0.296234  10.262  < 2e-16
## claritySI1:colorI                  -0.854158   0.369081  -2.314 0.020653
## clarityVS2:colorI                  -0.071694   0.361475  -0.198 0.842781
## clarityVS1:colorI                  -1.090127   0.361734  -3.014 0.002582
## clarityVVS2:colorI                 -1.459756   0.422421  -3.456 0.000549
## clarityVVS1:colorI                 -0.999417   0.432401  -2.311 0.020816
## clarityIF:colorI                   -0.201229   0.986598  -0.204 0.838383
## clarityFL:colorI                   -3.001007  15.183217  -0.198 0.843317
## claritySI1:colorH                   0.272330   0.369716   0.737 0.461371
## clarityVS2:colorH                  -0.617186   0.377243  -1.636 0.101832
## clarityVS1:colorH                  -1.156002   0.360032  -3.211 0.001324
## clarityVVS2:colorH                 -0.333062   0.440509  -0.756 0.449599
## clarityVVS1:colorH                 -1.911350   0.469023  -4.075 4.60e-05
## clarityIF:colorH                   -1.148921   1.138771  -1.009 0.313017
## clarityFL:colorH                   -1.704769   7.652822  -0.223 0.823720
## claritySI1:colorG                  -0.608181   0.385064  -1.579 0.114239
## clarityVS2:colorG                  -0.861087   0.387798  -2.220 0.026389
## clarityVS1:colorG                  -2.004740   0.378761  -5.293 1.21e-07
## clarityVVS2:colorG                 -2.592132   0.431390  -6.009 1.87e-09
## clarityVVS1:colorG                 -2.706858   0.474907  -5.700 1.20e-08
## clarityIF:colorG                   -1.290898   0.738699  -1.748 0.080547
## clarityFL:colorG                   -6.017177   7.639482  -0.788 0.430907
## claritySI1:colorF                  -1.704428   0.362530  -4.701 2.58e-06
## clarityVS2:colorF                  -2.127864   0.363106  -5.860 4.63e-09
## clarityVS1:colorF                  -3.264917   0.354337  -9.214  < 2e-16
## clarityVVS2:colorF                 -2.199802   0.427153  -5.150 2.61e-07
## clarityVVS1:colorF                 -3.530786   0.433821  -8.139 4.01e-16
## clarityIF:colorF                   -3.361779   0.736321  -4.566 4.98e-06
## clarityFL:colorF                   -2.087083   7.801069  -0.268 0.789055
## claritySI1:colorE                  -1.397351   0.363095  -3.848 0.000119
## clarityVS2:colorE                  -1.941519   0.360983  -5.378 7.52e-08
## clarityVS1:colorE                  -2.840245   0.356997  -7.956 1.79e-15
## clarityVVS2:colorE                 -3.663502   0.415152  -8.824  < 2e-16
## clarityVVS1:colorE                 -4.329805   0.431972 -10.023  < 2e-16
## clarityIF:colorE                   -5.675970   0.695786  -8.158 3.43e-16
## clarityFL:colorE                   -3.233250   7.767809  -0.416 0.677237
## claritySI1:colorD                  -0.879128   0.385629  -2.280 0.022625
```

```
## clarityVS2:colorD                    -1.642488   0.389212  -4.220 2.44e-05
## clarityVS1:colorD                    -4.210398   0.377111 -11.165  < 2e-16
## clarityVVS2:colorD                   -3.699361   0.432795  -8.548  < 2e-16
## clarityVVS1:colorD                   -1.884903   0.432511  -4.358 1.31e-05
## clarityIF:colorD                     -8.017651   0.654705 -12.246  < 2e-16
## clarityFL:colorD                     -6.325196   7.573261  -0.835 0.403605
## cutVery Good:colorI                  -0.570009   0.317905  -1.793 0.072971
## cutIdeal:colorI                      -0.537059   0.304121  -1.766 0.077408
## cutAstor Ideal:colorI                -1.927156   2.807038  -0.687 0.492371
## cutVery Good:colorH                  -0.110255   0.332125  -0.332 0.739913
## cutIdeal:colorH                      -0.065988   0.318959  -0.207 0.836099
## cutAstor Ideal:colorH                 1.306665   2.948435   0.443 0.657641
## cutVery Good:colorG                  -0.333492   0.345549  -0.965 0.334492
## cutIdeal:colorG                      -0.377055   0.335004  -1.126 0.260368
## cutAstor Ideal:colorG                 1.993938   2.300352   0.867 0.386054
## cutVery Good:colorF                  -0.508735   0.321748  -1.581 0.113843
## cutIdeal:colorF                      -1.064030   0.310328  -3.429 0.000607
## cutAstor Ideal:colorF                 1.637639   2.911663   0.562 0.573816
## cutVery Good:colorE                  -0.713037   0.319974  -2.228 0.025853
## cutIdeal:colorE                      -1.464298   0.308673  -4.744 2.10e-06
## cutAstor Ideal:colorE                 2.260606   2.774297   0.815 0.415165
## cutVery Good:colorD                  -0.433893   0.345286  -1.257 0.208892
## cutIdeal:colorD                      -0.515784   0.331282  -1.557 0.119488
## cutAstor Ideal:colorD                 1.975176   2.571917   0.768 0.442501
## carat:claritySI1:cutVery Good         0.976888   0.249386   3.917 8.96e-05
## carat:clarityVS2:cutVery Good        -0.666545   0.255991  -2.604 0.009221
## carat:clarityVS1:cutVery Good         1.194401   0.233347   5.119 3.08e-07
## carat:clarityVVS2:cutVery Good        0.592874   0.348803   1.700 0.089181
## carat:clarityVVS1:cutVery Good        1.197316   0.359526   3.330 0.000868
## carat:clarityIF:cutVery Good          1.608812   0.477737   3.368 0.000758
## carat:clarityFL:cutVery Good         -1.872322   0.695624  -2.692 0.007112
## carat:claritySI1:cutIdeal             0.939680   0.241093   3.898 9.72e-05
## carat:clarityVS2:cutIdeal             0.026849   0.248423   0.108 0.913935
## carat:clarityVS1:cutIdeal             1.431896   0.225748   6.343 2.26e-10
## carat:clarityVVS2:cutIdeal            1.535284   0.341631   4.494 6.99e-06
## carat:clarityVVS1:cutIdeal            2.371377   0.353521   6.708 1.98e-11
## carat:clarityIF:cutIdeal              1.748425   0.457542   3.821 0.000133
## carat:clarityFL:cutIdeal             -2.962418   0.684318  -4.329 1.50e-05
## carat:claritySI1:cutAstor Ideal      -0.242450   2.160855  -0.112 0.910664
## carat:clarityVS2:cutAstor Ideal       0.060232   2.042849   0.029 0.976478
## carat:clarityVS1:cutAstor Ideal       0.494121   2.076208   0.238 0.811888
## carat:clarityVVS2:cutAstor Ideal      1.182519   2.067348   0.572 0.567324
## carat:clarityVVS1:cutAstor Ideal     -0.627061   2.067581  -0.303 0.761675
## carat:clarityIF:cutAstor Ideal       -0.073896   2.413403  -0.031 0.975574
## carat:clarityFL:cutAstor Ideal              NA         NA      NA       NA
## carat:claritySI1:colorI               1.269860   0.319409   3.976 7.02e-05
## carat:clarityVS2:colorI               0.627530   0.316373   1.984 0.047312
## carat:clarityVS1:colorI               1.633047   0.316111   5.166 2.39e-07
## carat:clarityVVS2:colorI              2.464256   0.413084   5.966 2.44e-09
## carat:clarityVVS1:colorI              1.526772   0.427420   3.572 0.000354
## carat:clarityIF:colorI                0.368185   1.150870   0.320 0.749030
## carat:clarityFL:colorI                0.093435  12.345020   0.008 0.993961
## carat:claritySI1:colorH               0.489927   0.324204   1.511 0.130747
## carat:clarityVS2:colorH               1.828960   0.338889   5.397 6.79e-08
```

```
## carat:clarityVS1:colorH                2.350727   0.315625   7.448 9.52e-14
## carat:clarityVVS2:colorH               1.746916   0.435028   4.016 5.93e-05
## carat:clarityVVS1:colorH               3.741175   0.490783   7.623 2.49e-14
## carat:clarityIF:colorH                 2.777702   1.297860   2.140 0.032338
## carat:clarityFL:colorH                 0.167656   7.074850   0.024 0.981094
## carat:claritySI1:colorG                1.743930   0.359401   4.852 1.22e-06
## carat:clarityVS2:colorG                2.552373   0.363559   7.021 2.22e-12
## carat:clarityVS1:colorG                3.631206   0.348733  10.413  < 2e-16
## carat:clarityVVS2:colorG               4.580653   0.427795  10.708  < 2e-16
## carat:clarityVVS1:colorG               4.757068   0.491562   9.677  < 2e-16
## carat:clarityIF:colorG                 2.727960   0.655597   4.161 3.17e-05
## carat:clarityFL:colorG                 5.350890   7.082287   0.756 0.449931
## carat:claritySI1:colorF                2.807118   0.334419   8.394  < 2e-16
## carat:clarityVS2:colorF                3.934157   0.336010  11.708  < 2e-16
## carat:clarityVS1:colorF                5.477777   0.328004  16.700  < 2e-16
## carat:clarityVVS2:colorF               4.611457   0.441989  10.433  < 2e-16
## carat:clarityVVS1:colorF               6.302758   0.449519  14.021  < 2e-16
## carat:clarityIF:colorF                 6.173151   0.644888   9.572  < 2e-16
## carat:clarityFL:colorF                 6.839692   7.054245   0.970 0.332254
## carat:claritySI1:colorE                2.544756   0.335355   7.588 3.26e-14
## carat:clarityVS2:colorE                3.810490   0.333463  11.427  < 2e-16
## carat:clarityVS1:colorE                4.917001   0.335281  14.665  < 2e-16
## carat:clarityVVS2:colorE               6.510696   0.421192  15.458  < 2e-16
## carat:clarityVVS1:colorE               8.096091   0.451657  17.925  < 2e-16
## carat:clarityIF:colorE                10.370602   0.615392  16.852  < 2e-16
## carat:clarityFL:colorE                 3.982816   7.039461   0.566 0.571541
## carat:claritySI1:colorD                1.878181   0.368225   5.101 3.39e-07
## carat:clarityVS2:colorD                3.700341   0.375566   9.853  < 2e-16
## carat:clarityVS1:colorD                7.053911   0.358865  19.656  < 2e-16
## carat:clarityVVS2:colorD               7.178204   0.443636  16.180  < 2e-16
## carat:clarityVVS1:colorD               5.494150   0.448219  12.258  < 2e-16
## carat:clarityIF:colorD                13.951068   0.526206  26.513  < 2e-16
## carat:clarityFL:colorD                11.832222   7.034299   1.682 0.092556
## carat:cutVery Good:colorI              0.762025   0.268538   2.838 0.004545
## carat:cutIdeal:colorI                  0.751152   0.258272   2.908 0.003634
## carat:cutAstor Ideal:colorI            1.090103   3.408889   0.320 0.749134
## carat:cutVery Good:colorH              0.289323   0.290624   0.996 0.319483
## carat:cutIdeal:colorH                  0.610504   0.280190   2.179 0.029340
## carat:cutAstor Ideal:colorH           -1.807405   4.040331  -0.447 0.654629
## carat:cutVery Good:colorG              0.498226   0.320579   1.554 0.120152
## carat:cutIdeal:colorG                  0.938483   0.314371   2.985 0.002834
## carat:cutAstor Ideal:colorG           -3.039909   2.942030  -1.033 0.301479
## carat:cutVery Good:colorF              0.611047   0.299051   2.043 0.041025
## carat:cutIdeal:colorF                  1.778167   0.293367   6.061 1.35e-09
## carat:cutAstor Ideal:colorF           -1.342987   3.210270  -0.418 0.675698
## carat:cutVery Good:colorE              1.007399   0.294853   3.417 0.000634
## carat:cutIdeal:colorE                  2.389044   0.290907   8.212  < 2e-16
## carat:cutAstor Ideal:colorE           -2.231735   3.341062  -0.668 0.504152
## carat:cutVery Good:colorD              0.687025   0.332211   2.068 0.038638
## carat:cutIdeal:colorD                  1.063689   0.319959   3.324 0.000886
## carat:cutAstor Ideal:colorD           -2.180361   3.255175  -0.670 0.502977
## claritySI1:cutVery Good:colorI         1.263609   0.408285   3.095 0.001969
## clarityVS2:cutVery Good:colorI         0.220158   0.401035   0.549 0.583023
## clarityVS1:cutVery Good:colorI         1.364980   0.401607   3.399 0.000677
```

```
## clarityVVS2:cutVery Good:colorI          1.179965   0.461206   2.558 0.010515
## clarityVVS1:cutVery Good:colorI          1.311995   0.476379   2.754 0.005886
## clarityIF:cutVery Good:colorI            0.687727   1.035678   0.664 0.506668
## clarityFL:cutVery Good:colorI            7.615797  13.436147   0.567 0.570841
## claritySI1:cutIdeal:colorI               0.935520   0.390108   2.398 0.016481
## clarityVS2:cutIdeal:colorI               0.297545   0.383374   0.776 0.437677
## clarityVS1:cutIdeal:colorI               1.250408   0.382499   3.269 0.001079
## clarityVVS2:cutIdeal:colorI              2.064467   0.441109   4.680 2.87e-06
## clarityVVS1:cutIdeal:colorI              1.164929   0.452822   2.573 0.010094
## clarityIF:cutIdeal:colorI               -0.011168   1.006494  -0.011 0.991147
## clarityFL:cutIdeal:colorI                      NA         NA      NA       NA
## claritySI1:cutAstor Ideal:colorI         1.260638   3.008155   0.419 0.675163
## clarityVS2:cutAstor Ideal:colorI         2.497642   2.931836   0.852 0.394269
## clarityVS1:cutAstor Ideal:colorI         2.720893   2.940630   0.925 0.354824
## clarityVVS2:cutAstor Ideal:colorI        3.054068   2.927342   1.043 0.296815
## clarityVVS1:cutAstor Ideal:colorI        2.166715   2.943394   0.736 0.461654
## clarityIF:cutAstor Ideal:colorI          1.448292   3.307630   0.438 0.661485
## clarityFL:cutAstor Ideal:colorI                NA         NA      NA       NA
## claritySI1:cutVery Good:colorH          -0.218275   0.413449  -0.528 0.597543
## clarityVS2:cutVery Good:colorH           0.024985   0.417588   0.060 0.952291
## clarityVS1:cutVery Good:colorH           0.791887   0.402413   1.968 0.049087
## clarityVVS2:cutVery Good:colorH         -0.497294   0.479184  -1.038 0.299368
## clarityVVS1:cutVery Good:colorH          0.861575   0.509686   1.690 0.090952
## clarityIF:cutVery Good:colorH            0.548104   1.178643   0.465 0.641911
## clarityFL:cutVery Good:colorH            2.087020   3.396026   0.615 0.538854
## claritySI1:cutIdeal:colorH              -0.463402   0.394064  -1.176 0.239614
## clarityVS2:cutIdeal:colorH               0.221386   0.401329   0.552 0.581201
## clarityVS1:cutIdeal:colorH               0.586522   0.384278   1.526 0.126937
## clarityVVS2:cutIdeal:colorH             -0.315400   0.461086  -0.684 0.493953
## clarityVVS1:cutIdeal:colorH              1.606164   0.489983   3.278 0.001046
## clarityIF:cutIdeal:colorH                0.568849   1.153832   0.493 0.622007
## clarityFL:cutIdeal:colorH                      NA         NA      NA       NA
## claritySI1:cutAstor Ideal:colorH        -1.586051   3.118678  -0.509 0.611058
## clarityVS2:cutAstor Ideal:colorH         0.290577   3.067138   0.095 0.924522
## clarityVS1:cutAstor Ideal:colorH         0.030695   3.060665   0.010 0.991998
## clarityVVS2:cutAstor Ideal:colorH        0.562471   3.069350   0.183 0.854599
## clarityVVS1:cutAstor Ideal:colorH        0.393202   3.069232   0.128 0.898061
## clarityIF:cutAstor Ideal:colorH          1.551377   3.629992   0.427 0.669105
## clarityFL:cutAstor Ideal:colorH                NA         NA      NA       NA
## claritySI1:cutVery Good:colorG           0.936979   0.421872   2.221 0.026352
## clarityVS2:cutVery Good:colorG           0.182446   0.424540   0.430 0.667379
## clarityVS1:cutVery Good:colorG           0.973146   0.415322   2.343 0.019124
## clarityVVS2:cutVery Good:colorG          0.576043   0.467156   1.233 0.217546
## clarityVVS1:cutVery Good:colorG          1.280822   0.511509   2.504 0.012280
## clarityIF:cutVery Good:colorG            0.215771   0.795925   0.271 0.786318
## clarityFL:cutVery Good:colorG            6.954129   1.250134   5.563 2.66e-08
## claritySI1:cutIdeal:colorG               0.563917   0.406068   1.389 0.164917
## clarityVS2:cutIdeal:colorG               0.134310   0.409827   0.328 0.743120
## clarityVS1:cutIdeal:colorG               0.899093   0.400503   2.245 0.024775
## clarityVVS2:cutIdeal:colorG              1.842083   0.451386   4.081 4.49e-05
## clarityVVS1:cutIdeal:colorG              1.774881   0.494189   3.592 0.000329
## clarityIF:cutIdeal:colorG                0.422680   0.759916   0.556 0.578061
## clarityFL:cutIdeal:colorG                      NA         NA      NA       NA
## claritySI1:cutAstor Ideal:colorG        -2.743688   2.501628  -1.097 0.272747
```

```
## clarityVS2:cutAstor Ideal:colorG       -0.003604   2.434009  -0.001 0.998819
## clarityVS1:cutAstor Ideal:colorG        0.736754   2.440658   0.302 0.762754
## clarityVVS2:cutAstor Ideal:colorG       1.377322   2.462077   0.559 0.575879
## clarityVVS1:cutAstor Ideal:colorG      -1.182214   2.447325  -0.483 0.629051
## clarityIF:cutAstor Ideal:colorG        -1.012843   2.831445  -0.358 0.720559
## clarityFL:cutAstor Ideal:colorG               NA         NA      NA       NA
## claritySI1:cutVery Good:colorF          1.320640   0.400132   3.301 0.000965
## clarityVS2:cutVery Good:colorF          0.581630   0.400626   1.452 0.146557
## clarityVS1:cutVery Good:colorF          1.035832   0.391397   2.647 0.008133
## clarityVVS2:cutVery Good:colorF        -1.109430   0.462748  -2.397 0.016509
## clarityVVS1:cutVery Good:colorF         1.445993   0.473182   3.056 0.002244
## clarityIF:cutVery Good:colorF          -0.253363   0.789023  -0.321 0.748127
## clarityFL:cutVery Good:colorF           0.708159   2.040990   0.347 0.728615
## claritySI1:cutIdeal:colorF              1.288615   0.384484   3.352 0.000804
## clarityVS2:cutIdeal:colorF              1.291875   0.384912   3.356 0.000790
## clarityVS1:cutIdeal:colorF              2.204199   0.376102   5.861 4.62e-09
## clarityVVS2:cutIdeal:colorF             1.102438   0.446027   2.472 0.013449
## clarityVVS1:cutIdeal:colorF             2.686992   0.453998   5.919 3.25e-09
## clarityIF:cutIdeal:colorF               1.747024   0.756878   2.308 0.020989
## clarityFL:cutIdeal:colorF              -3.237112   1.845597  -1.754 0.079438
## claritySI1:cutAstor Ideal:colorF       -1.229464   3.077635  -0.399 0.689538
## clarityVS2:cutAstor Ideal:colorF        1.276852   3.023122   0.422 0.672761
## clarityVS1:cutAstor Ideal:colorF        0.765137   3.027562   0.253 0.800482
## clarityVVS2:cutAstor Ideal:colorF       0.255870   3.034530   0.084 0.932802
## clarityVVS1:cutAstor Ideal:colorF       0.605334   3.025298   0.200 0.841410
## clarityIF:cutAstor Ideal:colorF        -1.722187   3.796293  -0.454 0.650081
## clarityFL:cutAstor Ideal:colorF               NA         NA      NA       NA
## claritySI1:cutVery Good:colorE          1.183755   0.404287   2.928 0.003412
## clarityVS2:cutVery Good:colorE         -0.141168   0.401258  -0.352 0.724979
## clarityVS1:cutVery Good:colorE          0.404244   0.397321   1.017 0.308953
## clarityVVS2:cutVery Good:colorE         0.913315   0.454266   2.011 0.044376
## clarityVVS1:cutVery Good:colorE         1.316045   0.474406   2.774 0.005536
## clarityIF:cutVery Good:colorE           2.420354   0.752267   3.217 0.001294
## clarityFL:cutVery Good:colorE           5.704023   1.812802   3.147 0.001652
## claritySI1:cutIdeal:colorE              1.323806   0.387620   3.415 0.000637
## clarityVS2:cutIdeal:colorE              1.166221   0.386069   3.021 0.002522
## clarityVS1:cutIdeal:colorE              1.704505   0.381606   4.467 7.95e-06
## clarityVVS2:cutIdeal:colorE             2.842058   0.437999   6.489 8.68e-11
## clarityVVS1:cutIdeal:colorE             3.322962   0.454978   7.304 2.81e-13
## clarityIF:cutIdeal:colorE               4.174039   0.718992   5.805 6.43e-09
## clarityFL:cutIdeal:colorE               1.066102   1.669543   0.639 0.523111
## claritySI1:cutAstor Ideal:colorE       -3.074889   2.953690  -1.041 0.297861
## clarityVS2:cutAstor Ideal:colorE        0.666763   2.885913   0.231 0.817283
## clarityVS1:cutAstor Ideal:colorE       -0.466560   2.892425  -0.161 0.871854
## clarityVVS2:cutAstor Ideal:colorE       0.698095   2.900493   0.241 0.809802
## clarityVVS1:cutAstor Ideal:colorE      -1.770632   2.923143  -0.606 0.544696
## clarityIF:cutAstor Ideal:colorE        -3.522837   3.866232  -0.911 0.362201
## clarityFL:cutAstor Ideal:colorE               NA         NA      NA       NA
## claritySI1:cutVery Good:colorD          0.485993   0.426862   1.139 0.254902
## clarityVS2:cutVery Good:colorD         -0.387780   0.430526  -0.901 0.367743
## clarityVS1:cutVery Good:colorD          1.759007   0.418469   4.203 2.63e-05
## clarityVVS2:cutVery Good:colorD         1.133316   0.473513   2.393 0.016693
## clarityVVS1:cutVery Good:colorD        -1.484432   0.476266  -3.117 0.001828
## clarityIF:cutVery Good:colorD           4.260782   0.714846   5.960 2.52e-09
```

```
## clarityFL:cutVery Good:colorD                 NA         NA      NA       NA
## claritySI1:cutIdeal:colorD                 0.027161   0.408937   0.066 0.947045
## clarityVS2:cutIdeal:colorD                 0.296938   0.413219   0.719 0.472390
## clarityVS1:cutIdeal:colorD                 2.199149   0.400174   5.495 3.90e-08
## clarityVVS2:cutIdeal:colorD                1.421839   0.453849   3.133 0.001731
## clarityVVS1:cutIdeal:colorD               -0.055003   0.455073  -0.121 0.903797
## clarityIF:cutIdeal:colorD                  4.916130   0.677559   7.256 4.01e-13
## clarityFL:cutIdeal:colorD                        NA         NA      NA       NA
## claritySI1:cutAstor Ideal:colorD          -2.022536   2.766467  -0.731 0.464725
## clarityVS2:cutAstor Ideal:colorD          -0.880687   2.694361  -0.327 0.743772
## clarityVS1:cutAstor Ideal:colorD          -2.175765   2.704629  -0.804 0.421132
## clarityVVS2:cutAstor Ideal:colorD         -0.745807   2.716602  -0.275 0.783672
## clarityVVS1:cutAstor Ideal:colorD         -5.062966   2.734902  -1.851 0.064136
## clarityIF:cutAstor Ideal:colorD           -0.292514   4.701490  -0.062 0.950390
## clarityFL:cutAstor Ideal:colorD                  NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorI      -1.224392   0.356046  -3.439 0.000584
## carat:clarityVS2:cutVery Good:colorI      -0.181822   0.351573  -0.517 0.605039
## carat:clarityVS1:cutVery Good:colorI      -1.373802   0.352533  -3.897 9.74e-05
## carat:clarityVVS2:cutVery Good:colorI     -1.470683   0.449241  -3.274 0.001062
## carat:clarityVVS1:cutVery Good:colorI     -1.350564   0.470783  -2.869 0.004121
## carat:clarityIF:cutVery Good:colorI       -0.534169   1.192042  -0.448 0.654073
## carat:clarityFL:cutVery Good:colorI       -3.678202  10.261170  -0.358 0.720001
## carat:claritySI1:cutIdeal:colorI          -0.882704   0.344642  -2.561 0.010431
## carat:clarityVS2:cutIdeal:colorI          -0.408132   0.340644  -1.198 0.230872
## carat:clarityVS1:cutIdeal:colorI          -1.263297   0.341052  -3.704 0.000212
## carat:clarityVVS2:cutIdeal:colorI         -2.773492   0.436333  -6.356 2.07e-10
## carat:clarityVVS1:cutIdeal:colorI         -1.169462   0.459590  -2.545 0.010942
## carat:clarityIF:cutIdeal:colorI            0.729419   1.183199   0.616 0.537578
## carat:clarityFL:cutIdeal:colorI                  NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorI    -0.372356   3.620006  -0.103 0.918074
## carat:clarityVS2:cutAstor Ideal:colorI    -1.214980   3.527888  -0.344 0.730551
## carat:clarityVS1:cutAstor Ideal:colorI    -2.022666   3.539676  -0.571 0.567711
## carat:clarityVVS2:cutAstor Ideal:colorI   -2.832026   3.525908  -0.803 0.421857
## carat:clarityVVS1:cutAstor Ideal:colorI   -0.334579   3.549305  -0.094 0.924898
## carat:clarityIF:cutAstor Ideal:colorI     -0.387967   4.042322  -0.096 0.923539
## carat:clarityFL:cutAstor Ideal:colorI            NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorH       0.239162   0.367193   0.651 0.514838
## carat:clarityVS2:cutVery Good:colorH      -0.082431   0.375460  -0.220 0.826224
## carat:clarityVS1:cutVery Good:colorH      -0.844104   0.355525  -2.374 0.017586
## carat:clarityVVS2:cutVery Good:colorH      0.338002   0.470430   0.718 0.472452
## carat:clarityVVS1:cutVery Good:colorH     -1.273651   0.528038  -2.412 0.015864
## carat:clarityIF:cutVery Good:colorH       -0.837758   1.330293  -0.630 0.528856
## carat:clarityFL:cutVery Good:colorH        1.524399   3.328640   0.458 0.646978
## carat:claritySI1:cutIdeal:colorH           0.405012   0.353252   1.147 0.251580
## carat:clarityVS2:cutIdeal:colorH          -0.453945   0.365293  -1.243 0.213985
## carat:clarityVS1:cutIdeal:colorH          -0.621145   0.344184  -1.805 0.071125
## carat:clarityVVS2:cutIdeal:colorH          0.015101   0.459717   0.033 0.973796
## carat:clarityVVS1:cutIdeal:colorH         -2.382380   0.519683  -4.584 4.56e-06
## carat:clarityIF:cutIdeal:colorH           -0.827566   1.319521  -0.627 0.530547
## carat:clarityFL:cutIdeal:colorH                  NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorH     2.263131   4.202830   0.538 0.590248
## carat:clarityVS2:cutAstor Ideal:colorH     0.851592   4.137778   0.206 0.836940
## carat:clarityVS1:cutAstor Ideal:colorH     0.642386   4.142471   0.155 0.876764
## carat:clarityVVS2:cutAstor Ideal:colorH   -0.673578   4.149707  -0.162 0.871054
```

```
## carat:clarityVVS1:cutAstor Ideal:colorH -0.094624   4.173108  -0.023 0.981910
## carat:clarityIF:cutAstor Ideal:colorH   -3.792721   5.086705  -0.746 0.455901
## carat:clarityFL:cutAstor Ideal:colorH          NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorG    -1.032930   0.394410  -2.619 0.008821
## carat:clarityVS2:cutVery Good:colorG    -0.299925   0.396581  -0.756 0.449484
## carat:clarityVS1:cutVery Good:colorG    -0.754748   0.382761  -1.972 0.048628
## carat:clarityVVS2:cutVery Good:colorG   -0.569656   0.461599  -1.234 0.217169
## carat:clarityVVS1:cutVery Good:colorG   -1.322229   0.526821  -2.510 0.012080
## carat:clarityIF:cutVery Good:colorG      0.119026   0.713538   0.167 0.867519
## carat:clarityFL:cutVery Good:colorG     -3.587274   0.970229  -3.697 0.000218
## carat:claritySI1:cutIdeal:colorG        -0.812016   0.384936  -2.109 0.034904
## carat:clarityVS2:cutIdeal:colorG        -0.360107   0.388797  -0.926 0.354339
## carat:clarityVS1:cutIdeal:colorG        -0.582886   0.375813  -1.551 0.120903
## carat:clarityVVS2:cutIdeal:colorG       -1.999108   0.453385  -4.409 1.04e-05
## carat:clarityVVS1:cutIdeal:colorG       -1.565851   0.519585  -3.014 0.002581
## carat:clarityIF:cutIdeal:colorG          0.684127   0.693777   0.986 0.324090
## carat:clarityFL:cutIdeal:colorG                NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorG   3.771209   3.143564   1.200 0.230273
## carat:clarityVS2:cutAstor Ideal:colorG   1.076841   3.055131   0.352 0.724487
## carat:clarityVS1:cutAstor Ideal:colorG  -0.108599   3.079761  -0.035 0.971871
## carat:clarityVVS2:cutAstor Ideal:colorG -0.949023   3.113879  -0.305 0.760540
## carat:clarityVVS1:cutAstor Ideal:colorG  3.323128   3.109313   1.069 0.285176
## carat:clarityIF:cutAstor Ideal:colorG    1.672275   3.521904   0.475 0.634915
## carat:clarityFL:cutAstor Ideal:colorG          NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorF    -1.269670   0.371831  -3.415 0.000639
## carat:clarityVS2:cutVery Good:colorF    -0.400340   0.371574  -1.077 0.281295
## carat:clarityVS1:cutVery Good:colorF    -0.796908   0.363688  -2.191 0.028439
## carat:clarityVVS2:cutVery Good:colorF    1.475570   0.475950   3.100 0.001934
## carat:clarityVVS1:cutVery Good:colorF   -1.327762   0.489577  -2.712 0.006687
## carat:clarityIF:cutVery Good:colorF      0.875340   0.699248   1.252 0.210633
## carat:clarityFL:cutVery Good:colorF     -1.382939   0.787084  -1.757 0.078912
## carat:claritySI1:cutIdeal:colorF        -1.276515   0.364413  -3.503 0.000460
## carat:clarityVS2:cutIdeal:colorF        -1.287961   0.364297  -3.535 0.000407
## carat:clarityVS1:cutIdeal:colorF        -1.868101   0.357745  -5.222 1.77e-07
## carat:clarityVVS2:cutIdeal:colorF       -0.683882   0.466816  -1.465 0.142924
## carat:clarityVVS1:cutIdeal:colorF       -1.910780   0.481183  -3.971 7.16e-05
## carat:clarityIF:cutIdeal:colorF         -0.306687   0.682415  -0.449 0.653133
## carat:clarityFL:cutIdeal:colorF                NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorF   1.150670   3.402706   0.338 0.735241
## carat:clarityVS2:cutAstor Ideal:colorF  -1.581233   3.322770  -0.476 0.634162
## carat:clarityVS1:cutAstor Ideal:colorF  -1.006855   3.346137  -0.301 0.763491
## carat:clarityVVS2:cutAstor Ideal:colorF  0.133755   3.380976   0.040 0.968443
## carat:clarityVVS1:cutAstor Ideal:colorF  1.100089   3.365275   0.327 0.743748
## carat:clarityIF:cutAstor Ideal:colorF    2.450740   4.395952   0.557 0.577187
## carat:clarityFL:cutAstor Ideal:colorF          NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorE    -1.357257   0.379754  -3.574 0.000352
## carat:clarityVS2:cutVery Good:colorE     0.340632   0.374528   0.909 0.363088
## carat:clarityVS1:cutVery Good:colorE     0.085539   0.377055   0.227 0.820532
## carat:clarityVVS2:cutVery Good:colorE   -0.879923   0.461421  -1.907 0.056524
## carat:clarityVVS1:cutVery Good:colorE   -1.575890   0.496542  -3.174 0.001505
## carat:clarityIF:cutVery Good:colorE     -3.258229   0.674818  -4.828 1.38e-06
## carat:clarityFL:cutVery Good:colorE     -1.193473   0.419520  -2.845 0.004444
## carat:claritySI1:cutIdeal:colorE        -1.468805   0.371571  -3.953 7.72e-05
## carat:clarityVS2:cutIdeal:colorE        -1.061451   0.369284  -2.874 0.004049
```

```
## carat:clarityVS1:cutIdeal:colorE        -1.085015   0.371428  -2.921 0.003487
## carat:clarityVVS2:cutIdeal:colorE       -2.502076   0.453904  -5.512 3.54e-08
## carat:clarityVVS1:cutIdeal:colorE       -2.841932   0.488438  -5.818 5.95e-09
## carat:clarityIF:cutIdeal:colorE         -3.747186   0.658484  -5.691 1.27e-08
## carat:clarityFL:cutIdeal:colorE                NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorE   2.948013   3.533285   0.834 0.404082
## carat:clarityVS2:cutAstor Ideal:colorE  -1.001606   3.442299  -0.291 0.771075
## carat:clarityVS1:cutAstor Ideal:colorE   1.090556   3.462464   0.315 0.752788
## carat:clarityVVS2:cutAstor Ideal:colorE -0.255548   3.481134  -0.073 0.941480
## carat:clarityVVS1:cutAstor Ideal:colorE  3.979565   3.503207   1.136 0.255967
## carat:clarityIF:cutAstor Ideal:colorE    6.945137   4.563771   1.522 0.128061
## carat:clarityFL:cutAstor Ideal:colorE          NA         NA      NA       NA
## carat:claritySI1:cutVery Good:colorD    -0.418404   0.411381  -1.017 0.309121
## carat:clarityVS2:cutVery Good:colorD     0.555414   0.417347   1.331 0.183250
## carat:clarityVS1:cutVery Good:colorD    -1.783322   0.402247  -4.433 9.28e-06
## carat:clarityVVS2:cutVery Good:colorD   -1.372548   0.486734  -2.820 0.004804
## carat:clarityVVS1:cutVery Good:colorD    1.979689   0.494101   4.007 6.16e-05
## carat:clarityIF:cutVery Good:colorD     -4.856686   0.595175  -8.160 3.37e-16
## carat:clarityFL:cutVery Good:colorD            NA         NA      NA       NA
## carat:claritySI1:cutIdeal:colorD         0.320011   0.397684   0.805 0.421001
## carat:clarityVS2:cutIdeal:colorD        -0.002044   0.405032  -0.005 0.995973
## carat:clarityVS1:cutIdeal:colorD        -1.803032   0.388673  -4.639 3.50e-06
## carat:clarityVVS2:cutIdeal:colorD       -0.717930   0.470694  -1.525 0.127196
## carat:clarityVVS1:cutIdeal:colorD        1.400102   0.481646   2.907 0.003651
## carat:clarityIF:cutIdeal:colorD         -3.639868   0.569104  -6.396 1.60e-10
## carat:clarityFL:cutIdeal:colorD                NA         NA      NA       NA
## carat:claritySI1:cutAstor Ideal:colorD   2.343429   3.460108   0.677 0.498235
## carat:clarityVS2:cutAstor Ideal:colorD   2.171530   3.360899   0.646 0.518205
## carat:clarityVS1:cutAstor Ideal:colorD   4.104940   3.380968   1.214 0.224699
## carat:clarityVVS2:cutAstor Ideal:colorD  2.430934   3.397897   0.715 0.474348
## carat:clarityVVS1:cutAstor Ideal:colorD  9.709782   3.406081   2.851 0.004362
## carat:clarityIF:cutAstor Ideal:colorD    4.508020   5.314429   0.848 0.396294
## carat:clarityFL:cutAstor Ideal:colorD          NA         NA      NA       NA
##
## (Intercept)                             ***
## carat                                   ***
## claritySI1                              .
## clarityVS2                              **
## clarityVS1
## clarityVVS2
## clarityVVS1
## clarityIF
## clarityFL
## cutVery Good
## cutIdeal
## cutAstor Ideal
## colorI
## colorH                                  **
## colorG                                  ***
## colorF                                  *
## colorE                                  *
## colorD                                  **
## carat:claritySI1
## carat:clarityVS2                        ***
```

```
## carat:clarityVS1                        ***
## carat:clarityVVS2                       ***
## carat:clarityVVS1                       *
## carat:clarityIF                         **
## carat:clarityFL
## carat:cutVery Good
## carat:cutIdeal                          ***
## carat:cutAstor Ideal
## claritySI1:cutVery Good                 **
## clarityVS2:cutVery Good                 *
## clarityVS1:cutVery Good                 ***
## clarityVVS2:cutVery Good
## clarityVVS1:cutVery Good                *
## clarityIF:cutVery Good                  *
## clarityFL:cutVery Good                  *
## claritySI1:cutIdeal                     *
## clarityVS2:cutIdeal
## clarityVS1:cutIdeal                     **
## clarityVVS2:cutIdeal                    .
## clarityVVS1:cutIdeal                    ***
## clarityIF:cutIdeal
## clarityFL:cutIdeal                      ***
## claritySI1:cutAstor Ideal
## clarityVS2:cutAstor Ideal
## clarityVS1:cutAstor Ideal
## clarityVVS2:cutAstor Ideal
## clarityVVS1:cutAstor Ideal
## clarityIF:cutAstor Ideal
## clarityFL:cutAstor Ideal                ***
## carat:colorI                            **
## carat:colorH                            ***
## carat:colorG                            ***
## carat:colorF                            ***
## carat:colorE                            ***
## carat:colorD                            ***
## claritySI1:colorI                       *
## clarityVS2:colorI
## clarityVS1:colorI                       **
## clarityVVS2:colorI                      ***
## clarityVVS1:colorI                      *
## clarityIF:colorI
## clarityFL:colorI
## claritySI1:colorH
## clarityVS2:colorH
## clarityVS1:colorH                       **
## clarityVVS2:colorH
## clarityVVS1:colorH                      ***
## clarityIF:colorH
## clarityFL:colorH
## claritySI1:colorG
## clarityVS2:colorG                       *
## clarityVS1:colorG                       ***
## clarityVVS2:colorG                      ***
## clarityVVS1:colorG                      ***
```

```
## clarityIF:colorG                        .
## clarityFL:colorG
## claritySI1:colorF                       ***
## clarityVS2:colorF                       ***
## clarityVS1:colorF                       ***
## clarityVVS2:colorF                      ***
## clarityVVS1:colorF                      ***
## clarityIF:colorF                        ***
## clarityFL:colorF
## claritySI1:colorE                       ***
## clarityVS2:colorE                       ***
## clarityVS1:colorE                       ***
## clarityVVS2:colorE                      ***
## clarityVVS1:colorE                      ***
## clarityIF:colorE                        ***
## clarityFL:colorE
## claritySI1:colorD                       *
## clarityVS2:colorD                       ***
## clarityVS1:colorD                       ***
## clarityVVS2:colorD                      ***
## clarityVVS1:colorD                      ***
## clarityIF:colorD                        ***
## clarityFL:colorD
## cutVery Good:colorI                     .
## cutIdeal:colorI                         .
## cutAstor Ideal:colorI
## cutVery Good:colorH
## cutIdeal:colorH
## cutAstor Ideal:colorH
## cutVery Good:colorG
## cutIdeal:colorG
## cutAstor Ideal:colorG
## cutVery Good:colorF
## cutIdeal:colorF                         ***
## cutAstor Ideal:colorF
## cutVery Good:colorE                     *
## cutIdeal:colorE                         ***
## cutAstor Ideal:colorE
## cutVery Good:colorD
## cutIdeal:colorD
## cutAstor Ideal:colorD
## carat:claritySI1:cutVery Good           ***
## carat:clarityVS2:cutVery Good           **
## carat:clarityVS1:cutVery Good           ***
## carat:clarityVVS2:cutVery Good          .
## carat:clarityVVS1:cutVery Good          ***
## carat:clarityIF:cutVery Good            ***
## carat:clarityFL:cutVery Good            **
## carat:claritySI1:cutIdeal               ***
## carat:clarityVS2:cutIdeal
## carat:clarityVS1:cutIdeal               ***
## carat:clarityVVS2:cutIdeal              ***
## carat:clarityVVS1:cutIdeal              ***
## carat:clarityIF:cutIdeal                ***
```

```
## carat:clarityFL:cutIdeal               ***
## carat:claritySI1:cutAstor Ideal
## carat:clarityVS2:cutAstor Ideal
## carat:clarityVS1:cutAstor Ideal
## carat:clarityVVS2:cutAstor Ideal
## carat:clarityVVS1:cutAstor Ideal
## carat:clarityIF:cutAstor Ideal
## carat:clarityFL:cutAstor Ideal
## carat:claritySI1:colorI                ***
## carat:clarityVS2:colorI                *
## carat:clarityVS1:colorI                ***
## carat:clarityVVS2:colorI               ***
## carat:clarityVVS1:colorI               ***
## carat:clarityIF:colorI
## carat:clarityFL:colorI
## carat:claritySI1:colorH
## carat:clarityVS2:colorH                ***
## carat:clarityVS1:colorH                ***
## carat:clarityVVS2:colorH               ***
## carat:clarityVVS1:colorH               ***
## carat:clarityIF:colorH                 *
## carat:clarityFL:colorH
## carat:claritySI1:colorG                ***
## carat:clarityVS2:colorG                ***
## carat:clarityVS1:colorG                ***
## carat:clarityVVS2:colorG               ***
## carat:clarityVVS1:colorG               ***
## carat:clarityIF:colorG                 ***
## carat:clarityFL:colorG
## carat:claritySI1:colorF                ***
## carat:clarityVS2:colorF                ***
## carat:clarityVS1:colorF                ***
## carat:clarityVVS2:colorF               ***
## carat:clarityVVS1:colorF               ***
## carat:clarityIF:colorF                 ***
## carat:clarityFL:colorF
## carat:claritySI1:colorE                ***
## carat:clarityVS2:colorE                ***
## carat:clarityVS1:colorE                ***
## carat:clarityVVS2:colorE               ***
## carat:clarityVVS1:colorE               ***
## carat:clarityIF:colorE                 ***
## carat:clarityFL:colorE
## carat:claritySI1:colorD                ***
## carat:clarityVS2:colorD                ***
## carat:clarityVS1:colorD                ***
## carat:clarityVVS2:colorD               ***
## carat:clarityVVS1:colorD               ***
## carat:clarityIF:colorD                 ***
## carat:clarityFL:colorD                 .
## carat:cutVery Good:colorI              **
## carat:cutIdeal:colorI                  **
## carat:cutAstor Ideal:colorI
## carat:cutVery Good:colorH
```

```
## carat:cutIdeal:colorH                  *
## carat:cutAstor Ideal:colorH
## carat:cutVery Good:colorG
## carat:cutIdeal:colorG                  **
## carat:cutAstor Ideal:colorG
## carat:cutVery Good:colorF              *
## carat:cutIdeal:colorF                  ***
## carat:cutAstor Ideal:colorF
## carat:cutVery Good:colorE              ***
## carat:cutIdeal:colorE                  ***
## carat:cutAstor Ideal:colorE
## carat:cutVery Good:colorD              *
## carat:cutIdeal:colorD                  ***
## carat:cutAstor Ideal:colorD
## claritySI1:cutVery Good:colorI         **
## clarityVS2:cutVery Good:colorI
## clarityVS1:cutVery Good:colorI         ***
## clarityVVS2:cutVery Good:colorI        *
## clarityVVS1:cutVery Good:colorI        **
## clarityIF:cutVery Good:colorI
## clarityFL:cutVery Good:colorI
## claritySI1:cutIdeal:colorI             *
## clarityVS2:cutIdeal:colorI
## clarityVS1:cutIdeal:colorI             **
## clarityVVS2:cutIdeal:colorI            ***
## clarityVVS1:cutIdeal:colorI            *
## clarityIF:cutIdeal:colorI
## clarityFL:cutIdeal:colorI
## claritySI1:cutAstor Ideal:colorI
## clarityVS2:cutAstor Ideal:colorI
## clarityVS1:cutAstor Ideal:colorI
## clarityVVS2:cutAstor Ideal:colorI
## clarityVVS1:cutAstor Ideal:colorI
## clarityIF:cutAstor Ideal:colorI
## clarityFL:cutAstor Ideal:colorI
## claritySI1:cutVery Good:colorH
## clarityVS2:cutVery Good:colorH
## clarityVS1:cutVery Good:colorH         *
## clarityVVS2:cutVery Good:colorH
## clarityVVS1:cutVery Good:colorH        .
## clarityIF:cutVery Good:colorH
## clarityFL:cutVery Good:colorH
## claritySI1:cutIdeal:colorH
## clarityVS2:cutIdeal:colorH
## clarityVS1:cutIdeal:colorH
## clarityVVS2:cutIdeal:colorH
## clarityVVS1:cutIdeal:colorH            **
## clarityIF:cutIdeal:colorH
## clarityFL:cutIdeal:colorH
## claritySI1:cutAstor Ideal:colorH
## clarityVS2:cutAstor Ideal:colorH
## clarityVS1:cutAstor Ideal:colorH
## clarityVVS2:cutAstor Ideal:colorH
## clarityVVS1:cutAstor Ideal:colorH
```

```
## clarityIF:cutAstor Ideal:colorH
## clarityFL:cutAstor Ideal:colorH
## claritySI1:cutVery Good:colorG          *
## clarityVS2:cutVery Good:colorG
## clarityVS1:cutVery Good:colorG          *
## clarityVVS2:cutVery Good:colorG
## clarityVVS1:cutVery Good:colorG         *
## clarityIF:cutVery Good:colorG
## clarityFL:cutVery Good:colorG           ***
## claritySI1:cutIdeal:colorG
## clarityVS2:cutIdeal:colorG
## clarityVS1:cutIdeal:colorG              *
## clarityVVS2:cutIdeal:colorG             ***
## clarityVVS1:cutIdeal:colorG             ***
## clarityIF:cutIdeal:colorG
## clarityFL:cutIdeal:colorG
## claritySI1:cutAstor Ideal:colorG
## clarityVS2:cutAstor Ideal:colorG
## clarityVS1:cutAstor Ideal:colorG
## clarityVVS2:cutAstor Ideal:colorG
## clarityVVS1:cutAstor Ideal:colorG
## clarityIF:cutAstor Ideal:colorG
## clarityFL:cutAstor Ideal:colorG
## claritySI1:cutVery Good:colorF          ***
## clarityVS2:cutVery Good:colorF
## clarityVS1:cutVery Good:colorF          **
## clarityVVS2:cutVery Good:colorF         *
## clarityVVS1:cutVery Good:colorF         **
## clarityIF:cutVery Good:colorF
## clarityFL:cutVery Good:colorF
## claritySI1:cutIdeal:colorF              ***
## clarityVS2:cutIdeal:colorF              ***
## clarityVS1:cutIdeal:colorF              ***
## clarityVVS2:cutIdeal:colorF             *
## clarityVVS1:cutIdeal:colorF             ***
## clarityIF:cutIdeal:colorF               *
## clarityFL:cutIdeal:colorF               .
## claritySI1:cutAstor Ideal:colorF
## clarityVS2:cutAstor Ideal:colorF
## clarityVS1:cutAstor Ideal:colorF
## clarityVVS2:cutAstor Ideal:colorF
## clarityVVS1:cutAstor Ideal:colorF
## clarityIF:cutAstor Ideal:colorF
## clarityFL:cutAstor Ideal:colorF
## claritySI1:cutVery Good:colorE          **
## clarityVS2:cutVery Good:colorE
## clarityVS1:cutVery Good:colorE
## clarityVVS2:cutVery Good:colorE         *
## clarityVVS1:cutVery Good:colorE         **
## clarityIF:cutVery Good:colorE           **
## clarityFL:cutVery Good:colorE           **
## claritySI1:cutIdeal:colorE              ***
## clarityVS2:cutIdeal:colorE              **
## clarityVS1:cutIdeal:colorE              ***
```

```
## clarityVVS2:cutIdeal:colorE             ***
## clarityVVS1:cutIdeal:colorE             ***
## clarityIF:cutIdeal:colorE               ***
## clarityFL:cutIdeal:colorE
## claritySI1:cutAstor Ideal:colorE
## clarityVS2:cutAstor Ideal:colorE
## clarityVS1:cutAstor Ideal:colorE
## clarityVVS2:cutAstor Ideal:colorE
## clarityVVS1:cutAstor Ideal:colorE
## clarityIF:cutAstor Ideal:colorE
## clarityFL:cutAstor Ideal:colorE
## claritySI1:cutVery Good:colorD
## clarityVS2:cutVery Good:colorD
## clarityVS1:cutVery Good:colorD          ***
## clarityVVS2:cutVery Good:colorD         *
## clarityVVS1:cutVery Good:colorD         **
## clarityIF:cutVery Good:colorD           ***
## clarityFL:cutVery Good:colorD
## claritySI1:cutIdeal:colorD
## clarityVS2:cutIdeal:colorD
## clarityVS1:cutIdeal:colorD              ***
## clarityVVS2:cutIdeal:colorD             **
## clarityVVS1:cutIdeal:colorD
## clarityIF:cutIdeal:colorD               ***
## clarityFL:cutIdeal:colorD
## claritySI1:cutAstor Ideal:colorD
## clarityVS2:cutAstor Ideal:colorD
## clarityVS1:cutAstor Ideal:colorD
## clarityVVS2:cutAstor Ideal:colorD
## clarityVVS1:cutAstor Ideal:colorD       .
## clarityIF:cutAstor Ideal:colorD
## clarityFL:cutAstor Ideal:colorD
## carat:claritySI1:cutVery Good:colorI    ***
## carat:clarityVS2:cutVery Good:colorI
## carat:clarityVS1:cutVery Good:colorI    ***
## carat:clarityVVS2:cutVery Good:colorI   **
## carat:clarityVVS1:cutVery Good:colorI   **
## carat:clarityIF:cutVery Good:colorI
## carat:clarityFL:cutVery Good:colorI
## carat:claritySI1:cutIdeal:colorI        *
## carat:clarityVS2:cutIdeal:colorI
## carat:clarityVS1:cutIdeal:colorI        ***
## carat:clarityVVS2:cutIdeal:colorI       ***
## carat:clarityVVS1:cutIdeal:colorI       *
## carat:clarityIF:cutIdeal:colorI
## carat:clarityFL:cutIdeal:colorI
## carat:claritySI1:cutAstor Ideal:colorI
## carat:clarityVS2:cutAstor Ideal:colorI
## carat:clarityVS1:cutAstor Ideal:colorI
## carat:clarityVVS2:cutAstor Ideal:colorI
## carat:clarityVVS1:cutAstor Ideal:colorI
## carat:clarityIF:cutAstor Ideal:colorI
## carat:clarityFL:cutAstor Ideal:colorI
## carat:claritySI1:cutVery Good:colorH
```

```
## carat:clarityVS2:cutVery Good:colorH
## carat:clarityVS1:cutVery Good:colorH    *
## carat:clarityVVS2:cutVery Good:colorH
## carat:clarityVVS1:cutVery Good:colorH   *
## carat:clarityIF:cutVery Good:colorH
## carat:clarityFL:cutVery Good:colorH
## carat:claritySI1:cutIdeal:colorH
## carat:clarityVS2:cutIdeal:colorH
## carat:clarityVS1:cutIdeal:colorH        .
## carat:clarityVVS2:cutIdeal:colorH
## carat:clarityVVS1:cutIdeal:colorH       ***
## carat:clarityIF:cutIdeal:colorH
## carat:clarityFL:cutIdeal:colorH
## carat:claritySI1:cutAstor Ideal:colorH
## carat:clarityVS2:cutAstor Ideal:colorH
## carat:clarityVS1:cutAstor Ideal:colorH
## carat:clarityVVS2:cutAstor Ideal:colorH
## carat:clarityVVS1:cutAstor Ideal:colorH
## carat:clarityIF:cutAstor Ideal:colorH
## carat:clarityFL:cutAstor Ideal:colorH
## carat:claritySI1:cutVery Good:colorG    **
## carat:clarityVS2:cutVery Good:colorG
## carat:clarityVS1:cutVery Good:colorG    *
## carat:clarityVVS2:cutVery Good:colorG
## carat:clarityVVS1:cutVery Good:colorG   *
## carat:clarityIF:cutVery Good:colorG
## carat:clarityFL:cutVery Good:colorG     ***
## carat:claritySI1:cutIdeal:colorG        *
## carat:clarityVS2:cutIdeal:colorG
## carat:clarityVS1:cutIdeal:colorG
## carat:clarityVVS2:cutIdeal:colorG       ***
## carat:clarityVVS1:cutIdeal:colorG       **
## carat:clarityIF:cutIdeal:colorG
## carat:clarityFL:cutIdeal:colorG
## carat:claritySI1:cutAstor Ideal:colorG
## carat:clarityVS2:cutAstor Ideal:colorG
## carat:clarityVS1:cutAstor Ideal:colorG
## carat:clarityVVS2:cutAstor Ideal:colorG
## carat:clarityVVS1:cutAstor Ideal:colorG
## carat:clarityIF:cutAstor Ideal:colorG
## carat:clarityFL:cutAstor Ideal:colorG
## carat:claritySI1:cutVery Good:colorF    ***
## carat:clarityVS2:cutVery Good:colorF
## carat:clarityVS1:cutVery Good:colorF    *
## carat:clarityVVS2:cutVery Good:colorF   **
## carat:clarityVVS1:cutVery Good:colorF   **
## carat:clarityIF:cutVery Good:colorF
## carat:clarityFL:cutVery Good:colorF     .
## carat:claritySI1:cutIdeal:colorF        ***
## carat:clarityVS2:cutIdeal:colorF        ***
## carat:clarityVS1:cutIdeal:colorF        ***
## carat:clarityVVS2:cutIdeal:colorF
## carat:clarityVVS1:cutIdeal:colorF       ***
## carat:clarityIF:cutIdeal:colorF
```

```
## carat:clarityFL:cutIdeal:colorF
## carat:claritySI1:cutAstor Ideal:colorF
## carat:clarityVS2:cutAstor Ideal:colorF
## carat:clarityVS1:cutAstor Ideal:colorF
## carat:clarityVVS2:cutAstor Ideal:colorF
## carat:clarityVVS1:cutAstor Ideal:colorF
## carat:clarityIF:cutAstor Ideal:colorF
## carat:clarityFL:cutAstor Ideal:colorF
## carat:claritySI1:cutVery Good:colorE    ***
## carat:clarityVS2:cutVery Good:colorE
## carat:clarityVS1:cutVery Good:colorE
## carat:clarityVVS2:cutVery Good:colorE   .
## carat:clarityVVS1:cutVery Good:colorE   **
## carat:clarityIF:cutVery Good:colorE     ***
## carat:clarityFL:cutVery Good:colorE     **
## carat:claritySI1:cutIdeal:colorE        ***
## carat:clarityVS2:cutIdeal:colorE        **
## carat:clarityVS1:cutIdeal:colorE        **
## carat:clarityVVS2:cutIdeal:colorE       ***
## carat:clarityVVS1:cutIdeal:colorE       ***
## carat:clarityIF:cutIdeal:colorE         ***
## carat:clarityFL:cutIdeal:colorE
## carat:claritySI1:cutAstor Ideal:colorE
## carat:clarityVS2:cutAstor Ideal:colorE
## carat:clarityVS1:cutAstor Ideal:colorE
## carat:clarityVVS2:cutAstor Ideal:colorE
## carat:clarityVVS1:cutAstor Ideal:colorE
## carat:clarityIF:cutAstor Ideal:colorE
## carat:clarityFL:cutAstor Ideal:colorE
## carat:claritySI1:cutVery Good:colorD
## carat:clarityVS2:cutVery Good:colorD
## carat:clarityVS1:cutVery Good:colorD    ***
## carat:clarityVVS2:cutVery Good:colorD   **
## carat:clarityVVS1:cutVery Good:colorD   ***
## carat:clarityIF:cutVery Good:colorD     ***
## carat:clarityFL:cutVery Good:colorD
## carat:claritySI1:cutIdeal:colorD
## carat:clarityVS2:cutIdeal:colorD
## carat:clarityVS1:cutIdeal:colorD        ***
## carat:clarityVVS2:cutIdeal:colorD
## carat:clarityVVS1:cutIdeal:colorD       **
## carat:clarityIF:cutIdeal:colorD         ***
## carat:clarityFL:cutIdeal:colorD
## carat:claritySI1:cutAstor Ideal:colorD
## carat:clarityVS2:cutAstor Ideal:colorD
## carat:clarityVS1:cutAstor Ideal:colorD
## carat:clarityVVS2:cutAstor Ideal:colorD
## carat:clarityVVS1:cutAstor Ideal:colorD **
## carat:clarityIF:cutAstor Ideal:colorD
## carat:clarityFL:cutAstor Ideal:colorD
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.367 on 210215 degrees of freedom
```

```
## Multiple R-squared:  0.9852, Adjusted R-squared:  0.9851
## F-statistic: 3.305e+04 on 422 and 210215 DF,  p-value: < 2.2e-16
```

```
anova(lmodel_fixed2, lmodel_fullInteraction)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat * clarity * cut * color
##   Res.Df     RSS  Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210215  392784 405    645008 852.35 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactioncaco)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ clarity + cut + carat * color
##   Res.Df     RSS Df Sum of Sq     F    Pr(>F)
## 1 210620 1037792
## 2 210614  671360  6    366431 19159 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactioncacu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ clarity + color + carat * cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210617 1004782  3     33009 2306.4 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactionclca)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ cut + color + clarity * carat
##   Res.Df     RSS Df Sum of Sq     F    Pr(>F)
## 1 210620 1037792
## 2 210613  773495  7    264297 10281 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactionclcu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + color + clarity * cut
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210599 1033638 21    4154.1 40.304 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactioncocl)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + cut + clarity * color
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210578 1013966 42     23826 117.81 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lmodel_fixed2, lmodel_interactioncocu)
```

```
## Analysis of Variance Table
##
## Model 1: price ~ carat + clarity + color + cut
## Model 2: price ~ carat + clarity + cut * color
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1 210620 1037792
## 2 210602 1036593 18    1198.5 13.527 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

All of the test results were significant.

For easier interpretation, the model without interaction would work, but interaction terms would aid the prediction significantly.