Statistical Analysis Report

Author: Aurora

Background

Diamond is very precious and expensive, and the price of diamond is related to many factors. So it is necessary to find out which kind of factor could impact the diamond price. This analysis will seek to discover some variables to and build the model to explain the price of the diamond. It is helpful to the market to predict the price of diamond.

Data Source

Data is about the price of diamond. There are 7 variables, price (price the diamond sold for), carat (size of diamond in carats), clarity (a numerical measure of clarity associated with standard measures in diamonds), color (a numerical measure of colour, also using standard diamond evaluations), cut (a numeric measure of quality of cut), source (the diamond manufacturing who mined, graded and cut the diamond), year (the year the diamond was first cut)

Data Transformation and Cleaning (Description)

Price

Price was transformed from integer to numeric.

Clarity

Clarity was transformed from integer to numeric.

Color

Color was transformed from integer to numeric.

Cut

Cut was transformed from integer to numeric.

Source

The data identifying the diamond manufacturing who mined, graded and cut the diamond was transformed to four dummy variables.

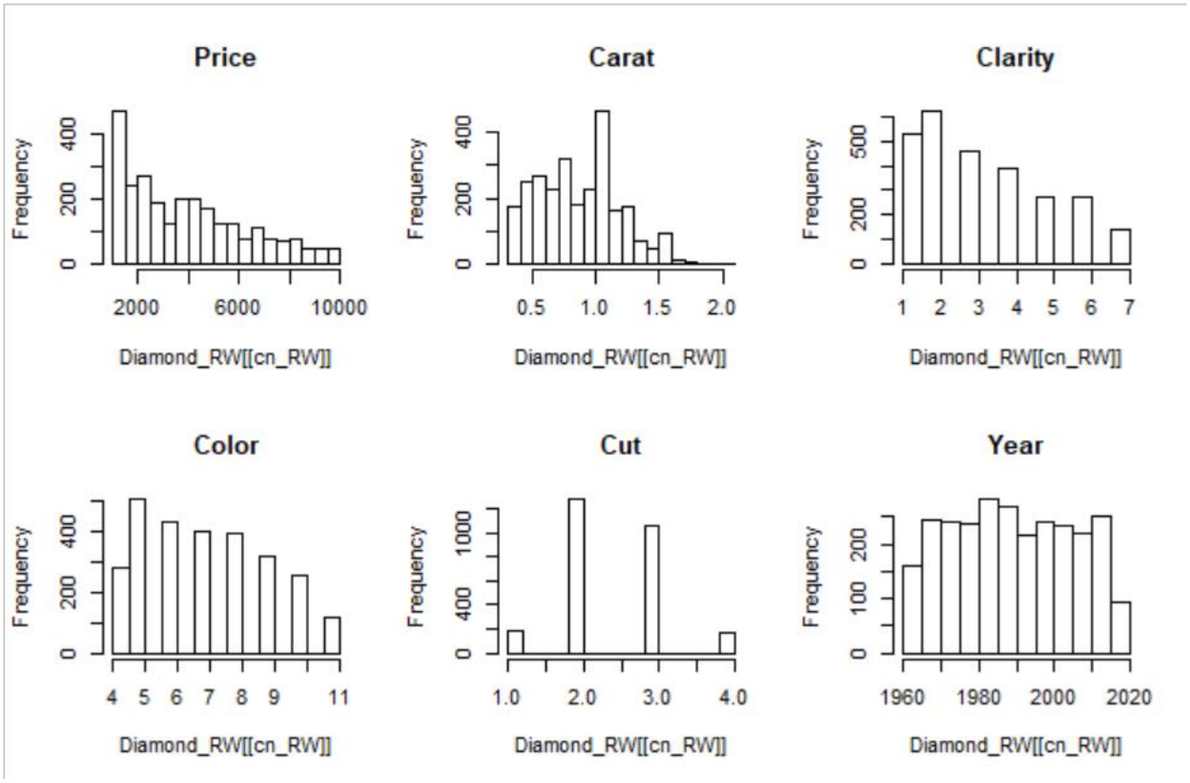
Year

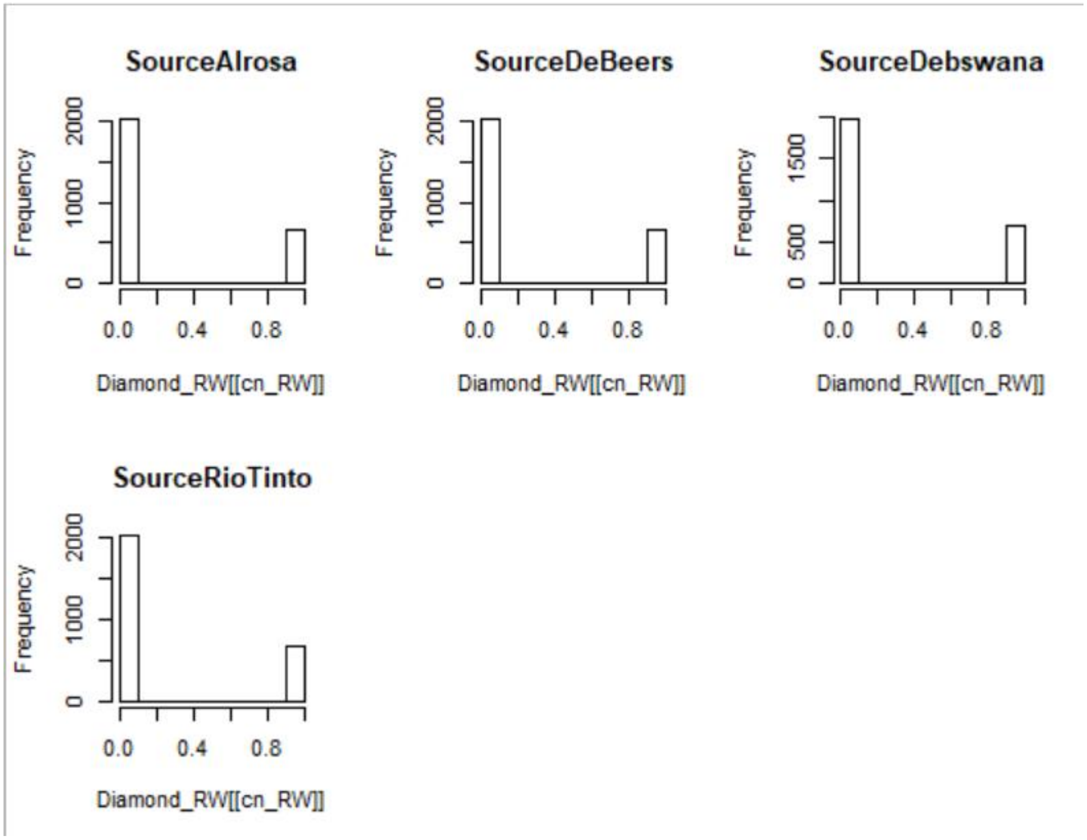
Year was transformed from integer to numeric.

Descriptive Data Analysis

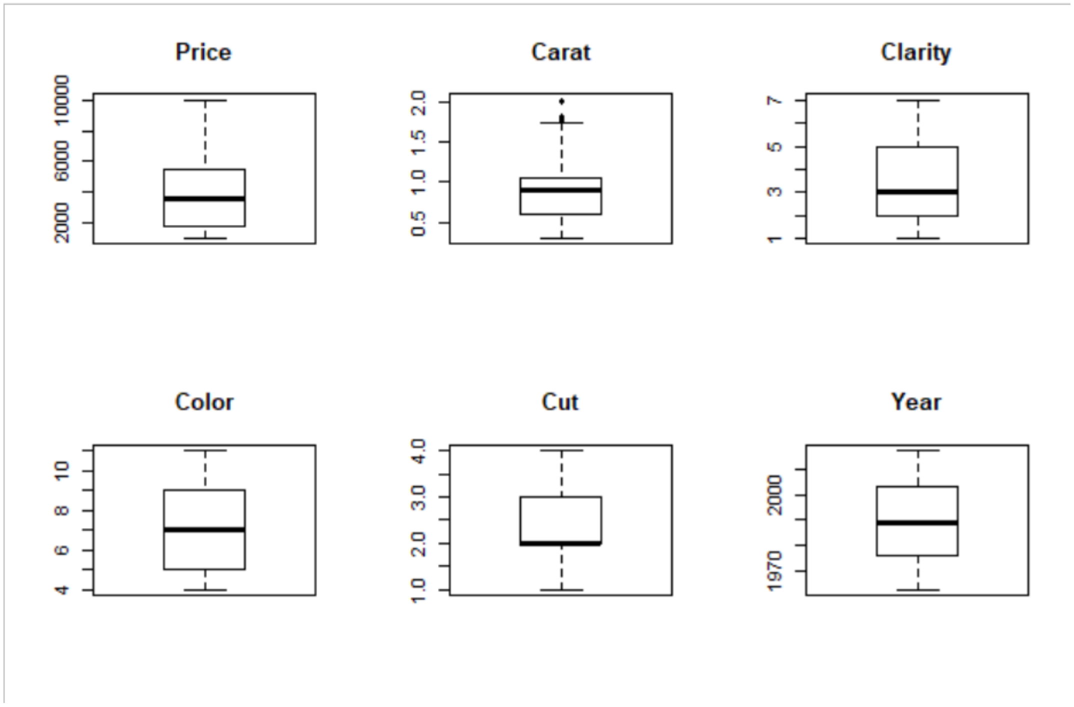
```
     Price            Carat           Clarity           Color       
 Min.   : 1000   Min.   :0.3000   Min.   :1.000   Min.   : 4.000  
 1st Qu.: 1801   1st Qu.:0.6000   1st Qu.:2.000   1st Qu.: 5.000  
 Median : 3604   Median :0.9000   Median :3.000   Median : 7.000  
 Mean   : 3971   Mean   :0.8701   Mean   :3.235   Mean   : 6.997  
 3rd Qu.: 5544   3rd Qu.:1.0600   3rd Qu.:5.000   3rd Qu.: 9.000  
 Max.   :10000   Max.   :2.0200   Max.   :7.000   Max.   :11.000  
      Cut             Source           Year       SourceAlrosa     SourceDeBeers  
 Min.   :1.000   Alrosa  :657   Min.   :1963   Min.   :0.0000   Min.   :0.000  
 1st Qu.:2.000   DeBeers :651   1st Qu.:1976   1st Qu.:0.0000   1st Qu.:0.000  
 Median :2.000   Debswana:706   Median :1989   Median :0.0000   Median :0.000  
 Mean   :2.449   RioTinto:676   Mean   :1990   Mean   :0.2442   Mean   :0.242  
 3rd Qu.:3.000                  3rd Qu.:2003   3rd Qu.:0.0000   3rd Qu.:0.000  
 Max.   :4.000                  Max.   :2017   Max.   :1.0000   Max.   :1.000  
 SourceDebswana   SourceRioTinto  
 Min.   :0.0000   Min.   :0.0000  
 1st Qu.:0.0000   1st Qu.:0.0000  
 Median :0.0000   Median :0.0000  
 Mean   :0.2625   Mean   :0.2513  
 3rd Qu.:1.0000   3rd Qu.:1.0000  
 Max.   :1.0000   Max.   :1.0000  
```

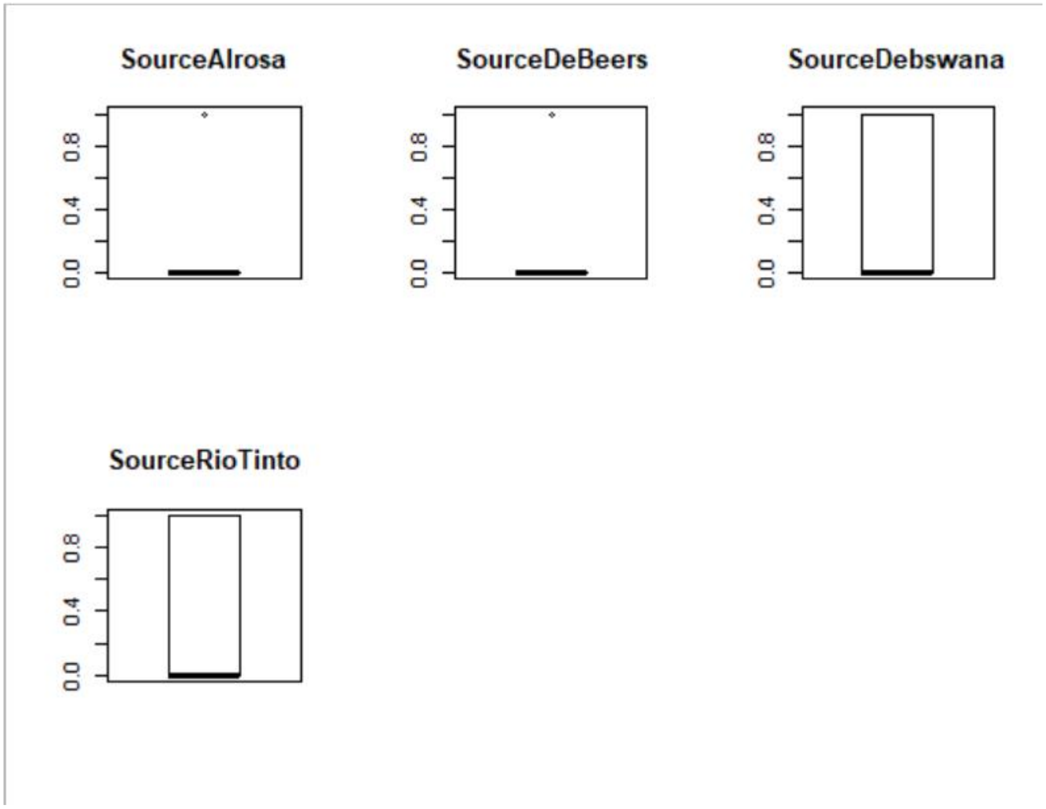
From the summary statistics we conclude that the transformation of data worked properly. And all of the data looks reasonable. There are no values that seems to be necessarily wrong. About the carat, the maximum seems to be a little higher. Maybe there are some extreme values.




SourceAlrosa
SourceDeBeers
SourceDebswana
SourceRioTinto
Frequency
0
1000
2000
500
1500
0.0
0.4
0.8
Diamond_RW[[cn_RW]]

Outlier

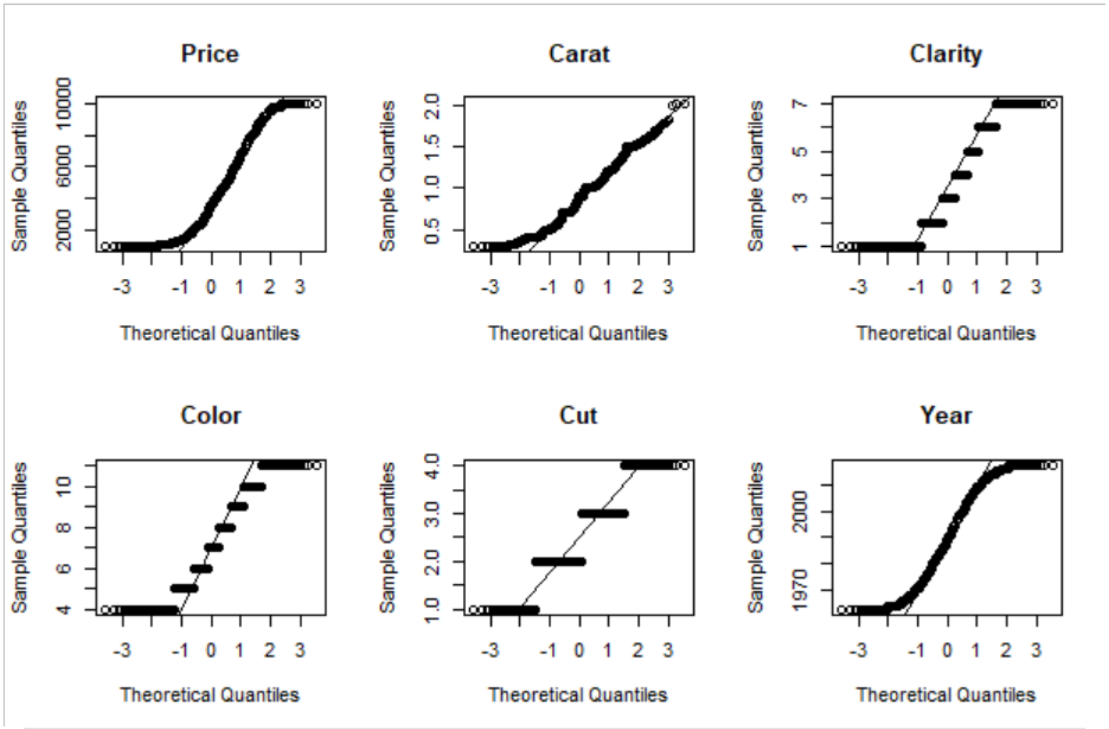

Price
2000
6000
10000
Carat
0.5
1.0
1.5
2.0
Clarity
1
3
5
7
Color
4
6
8
10
Cut
1.0
2.0
3.0
4.0
Year
1970
2000

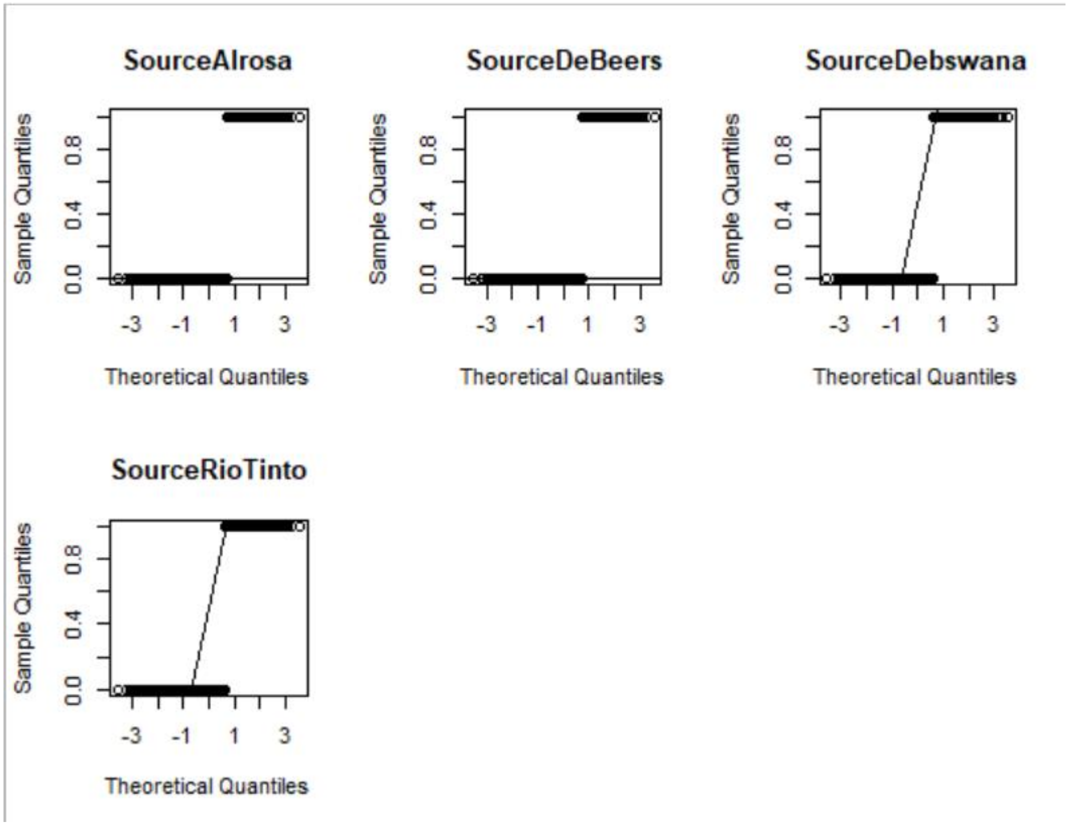


There seem to be outliers in Carat. And just leave it here, to decide what we could do about it later.

Exploratory Data Analysis

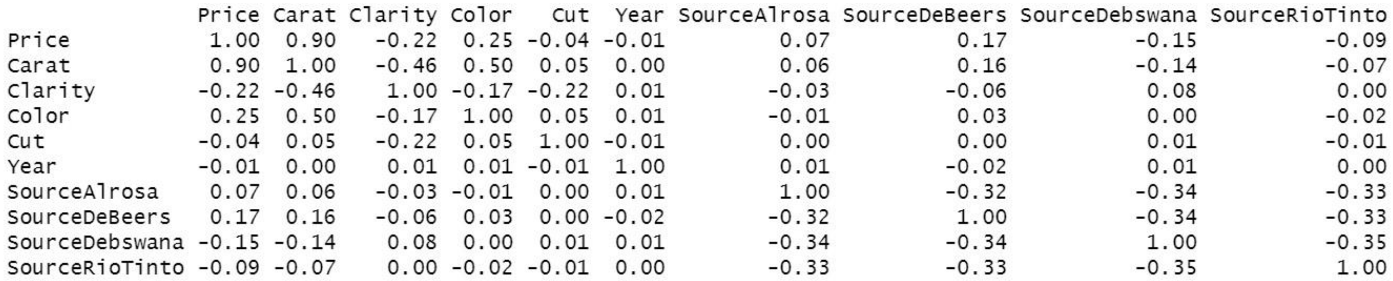
```
                statistic p.value
Price          0.9213888 2.416619e-35
Carat          0.9720116 1.572993e-22
Clarity        0.9075301 1.236322e-37
Color          0.9395519 8.533522e-32
Cut            0.8328177 1.253891e-46
Year           0.9553    5.80826e-28
SourceAlrosa   0.5335691 1.392702e-64
SourceDeBeers  0.531601  1.158704e-64
SourceDebswana 0.5487832 5.905137e-64
SourceRioTinto 0.5396479 2.468368e-64
```



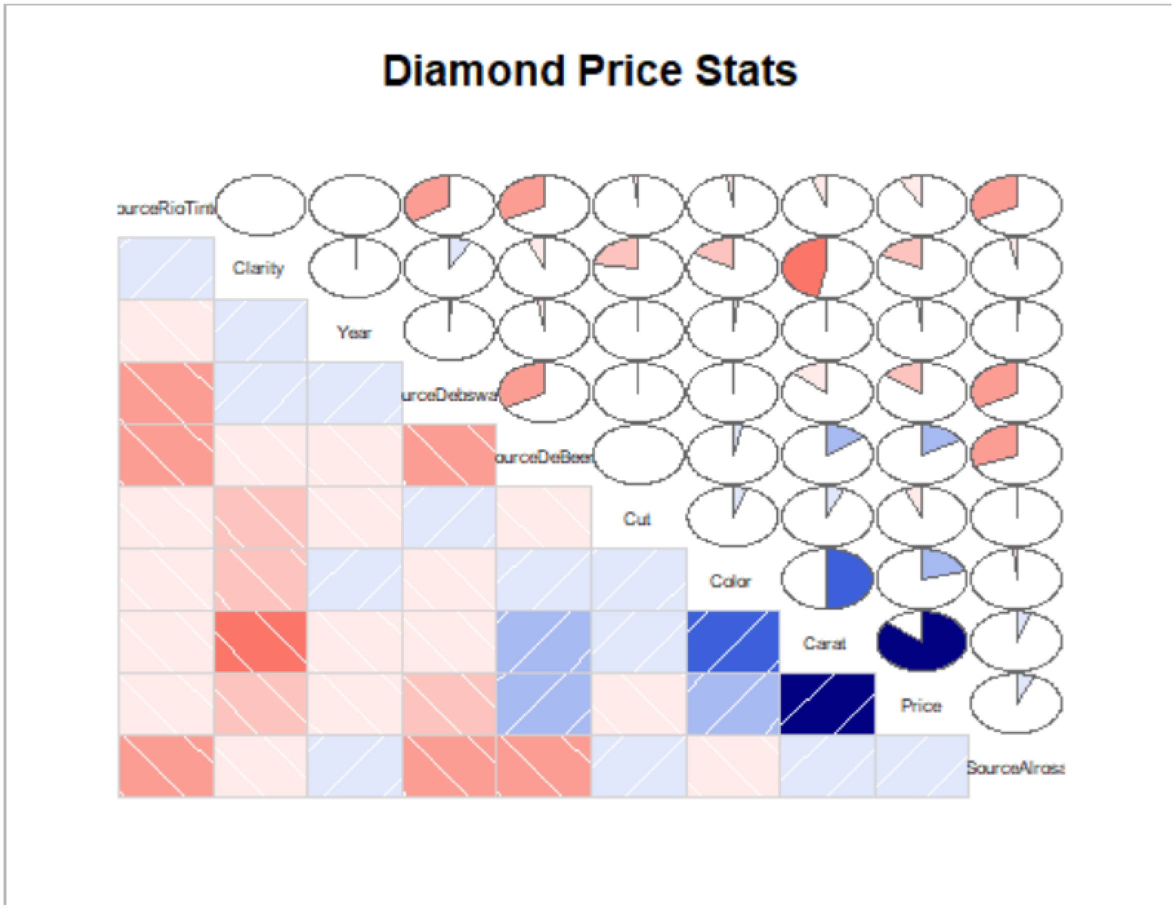


It seems that no variable is normally distributed because of the p value.

Correlations



```
               Price Carat Clarity Color   Cut  Year SourceAlrosa SourceDeBeers SourceDebswana SourceRioTinto
Price           1.00  0.90   -0.22  0.25 -0.04 -0.01         0.07          0.17          -0.15          -0.09
Carat           0.90  1.00   -0.46  0.50  0.05  0.00         0.06          0.16          -0.14          -0.07
Clarity        -0.22 -0.46    1.00 -0.17 -0.22  0.01        -0.03         -0.06           0.08           0.00
Color           0.25  0.50   -0.17  1.00  0.05  0.01        -0.01          0.03           0.00          -0.02
Cut            -0.04  0.05   -0.22  0.05  1.00 -0.01         0.00          0.00           0.01          -0.01
Year           -0.01  0.00    0.01  0.01 -0.01  1.00         0.01         -0.02           0.01           0.00
SourceAlrosa    0.07  0.06   -0.03 -0.01  0.00  0.01         1.00         -0.32          -0.34          -0.33
SourceDeBeers   0.17  0.16   -0.06  0.03  0.00 -0.02        -0.32          1.00          -0.34          -0.33
SourceDebswana -0.15 -0.14    0.08  0.00  0.01  0.01        -0.34         -0.34           1.00          -0.35
SourceRioTinto -0.09 -0.07    0.00 -0.02 -0.01  0.00        -0.33         -0.33          -0.35           1.00
```



Price seems to be very strongly positively correlated with Carat. And the positive correlation between Color and Carat is also strong. And there are also positive correlation between:

1 Color and Price.

2 SourceDebeers and Carat.

3 SourceDebeers and Price.

Also, clarity and carat has strongly negative correlation. There are also positive correlation between:

1 Clarity and Cut.

2 Clarity and Color.

3 Clarity and Price.

4 SourceDebswana and Price.

5 SourceDebswana and Carat.

Models

Model 1: All Variables included

1. Overall, the model is significant (p-value of F-Stat < 0.05)
2. 89.5% of variation is explained by the model.
3. The residuals look approximately symmetrical.
4. Six variables look significant (p-values of t-test <0.05). Carat, Clarity, Color, Cut, SourceAlrosa, SourceDeBeers
5. Variable Clarity is positively correlated with price instead of negatively.

```
Call:
lm(formula = Price ~ Carat + Clarity + Color + Cut + Year + SourceAlrosa +
    SourceDeBeers + SourceDebswana, data = Diamond_RW, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max
-2907.8  -474.9   -82.1   333.2  3536.8

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      28.2840  1895.1384   0.015 0.988094
Carat          8783.3676    62.0966 141.447  < 2e-16 ***
Clarity         403.4900     9.7556  41.360  < 2e-16 ***
Color          -403.0785     8.8292 -45.653  < 2e-16 ***
Cut            -176.5198    21.8572  -8.076    1e-15 ***
Year             -0.9194     0.9517  -0.966 0.334078
SourceAlrosa    139.9556    43.1149   3.246 0.001184 **
SourceDeBeers   151.2230    43.5422   3.473 0.000523 ***
SourceDebswana   23.9222    42.3178   0.565 0.571917
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 784.4 on 2681 degrees of freedom
Multiple R-squared:  0.8953,   Adjusted R-squared:  0.895
F-statistic:  2865 on 8 and 2681 DF,  p-value: < 2.2e-16
```

Model 2: Backward Selection

1. Overall, the model is significant (p-value of F-Stat < 0.05)
2. 89.5% of variation is explained by the model.
3. The residuals look approximately symmetrical.
4. All six variables (and the intercept) look significant (p-values of t-test <0.001).
5. Variable Clarity is still positively correlated with price instead of negatively.

```
Call:
lm(formula = Price ~ Carat + Clarity + Color + Cut + SourceAlrosa + 
    SourceDeBeers, data = Diamond_RW, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max 
-2923.0  -471.6   -86.2   333.0  3524.4 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)    
(Intercept)   -1789.396     97.894 -18.279  < 2e-16 ***
Carat          8782.467     62.040 141.562  < 2e-16 ***
Clarity         403.637      9.749  41.405  < 2e-16 ***
Color          -403.073      8.821 -45.695  < 2e-16 ***
Cut            -176.183     21.848  -8.064  1.1e-15 ***
SourceAlrosa    127.666     37.447   3.409 0.000661 ***
SourceDeBeers   139.850     38.014   3.679 0.000239 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 784.3 on 2683 degrees of freedom
Multiple R-squared:  0.8952,	Adjusted R-squared:  0.895 
F-statistic:  3820 on 6 and 2683 DF,  p-value: < 2.2e-16
```

Model 3: Forward Selection

1. Overall, the model is significant (p-value of F-Stat < 0.05)
2. 89.5% of variation is explained by the model.
3. The residuals look approximately symmetrical.
4. Six variables (and the intercept) look significant (p-values of t-test <0.01).
5. Variable Clarity is still positively correlated with price instead of negatively.

```
Call:
lm(formula = Price ~ Carat + Color + Clarity + Cut + SourceDeBeers + 
    SourceAlrosa, data = Diamond_RW, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max 
-2923.0  -471.6   -86.2   333.0  3524.4 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)    
(Intercept)   -1789.396     97.894 -18.279  < 2e-16 ***
Carat          8782.467     62.040 141.562  < 2e-16 ***
Color          -403.073      8.821 -45.695  < 2e-16 ***
Clarity         403.637      9.749  41.405  < 2e-16 ***
Cut            -176.183     21.848  -8.064  1.1e-15 ***
SourceDeBeers   139.850     38.014   3.679 0.000239 ***
SourceAlrosa    127.666     37.447   3.409 0.000661 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 784.3 on 2683 degrees of freedom
Multiple R-squared:  0.8952,	Adjusted R-squared:  0.895 
F-statistic:  3820 on 6 and 2683 DF,  p-value: < 2.2e-16
```

Model 4: Criteria Selection

1. Overall, the model is significant (p-value of F-Stat < 0.05)
2. 89.5% of variation is explained by the model.
3. The residuals look approximately symmetrical.
4. Six variables (and the intercept) look significant (p-values of t-test <0.01).
5. Variable Clarity is still positively correlated with price instead of negatively.

```
Call:
lm(formula = Price ~ Carat + Clarity + Color + Cut + SourceAlrosa + 
    SourceDeBeers, data = Diamond_RW, na.action = na.omit)

Residuals:
    Min      1Q  Median      3Q     Max 
-2923.0  -471.6   -86.2   333.0  3524.4 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)    
(Intercept)   -1789.396     97.894 -18.279  < 2e-16 ***
Carat          8782.467     62.040 141.562  < 2e-16 ***
Clarity         403.637      9.749  41.405  < 2e-16 ***
Color          -403.073      8.821 -45.695  < 2e-16 ***
Cut            -176.183     21.848  -8.064  1.1e-15 ***
SourceAlrosa    127.666     37.447   3.409 0.000661 ***
SourceDeBeers   139.850     38.014   3.679 0.000239 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 784.3 on 2683 degrees of freedom
Multiple R-squared:  0.8952,	Adjusted R-squared:  0.895 
F-statistic:  3820 on 6 and 2683 DF,  p-value: < 2.2e-16
```

Model Evaluation

Verifying Assumptions

1. **Independence of Predictors**

   The Spearman rho value for Carat, Clarity, Color, Cut, SourceAlrosa, AourceDeBeers are all very low except for Carat and Color which is 0.5. That means there maybe some kind of relation between Carat and Color. The others are independent.

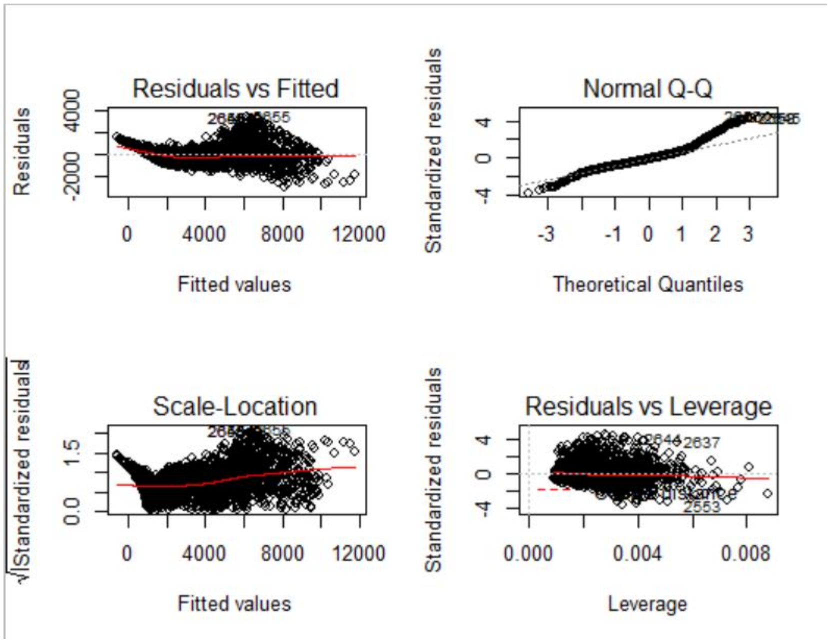
2. **Distribution of Error Terms**

   The p value is all very small. So the error terms seem to be not normally distributed of all models.

```
Shapiro-Wilk normality test

data:  DiaRes_RW
W = 0.93805, p-value < 2.2e-16


Shapiro-Wilk normality test

data:  BckDiaRes_RW
W = 0.9382, p-value < 2.2e-16


Shapiro-Wilk normality test

data:  FwdDiaRes_RW
W = 0.9382, p-value < 2.2e-16

Shapiro-Wilk normality test

data:  StpDiaRes_RW
W = 0.9382, p-value < 2.2e-16
```

3. **Non-AutoCorrelation and Homoscedasticity**

   Based on Residuals vs. Fitted and Scale-Location, the fitted values between 0 and 2000 are all between 0 and 4000. It seems that these data have a pattern. Based on Residuals vs. Leverage and Cook's Distance, there is no data point exerting undue influence or leverage on the model.



Final Model, Recommendation and Interpretation

Based on the above, the results of all four models are similar. But the first model has more variables and the number of variables in other models are the same. So we could pick anyone of these three model. I recommend the following model (developed with Backward selection):

Price =

8782.467*Carat + 403.637*Clarity + (-403.073)*Color + (-176.183)*Cut +

127.666*SourceAlrosa + (139.850)* SourceDeBeers