House price prediction using regression analysis

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All About Dataset

Name of Dataset :- Real Estate data Source :- https://www.kaggle.com/dcw8161/real-estate-price-prediction/data Variables :- 1) X1 transaction date (Date at which home is bought) 2) X2 house age (age of house from when it was built) 3) X3 distance to the nearest MRT station 4) X4 number of convenient stores 5) X5 latitude (represents the geographical position of property) 6) X6 longitude (represents geographical position of property) 7) Y house price of unit area

Dimensions :- 414 × 8

#Problem statement :

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.3.6     v purrr   0.3.4
## v tibble  3.1.8     v dplyr   1.0.9
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
setwd("C:/Users/HP/Desktop/Real estate data")
```

Reading the data as Real_df

```
Real_df=read.csv('Real estate.csv' , header=TRUE)
head(Real_df)
```

```
##   No X1.transaction.date X2.house.age X3.distance.to.the.nearest.MRT.station
## 1  1            2012.917         32.0                               84.87882
## 2  2            2012.917         19.5                              306.59470
## 3  3            2013.583         13.3                              561.98450
## 4  4            2013.500         13.3                              561.98450
## 5  5            2012.833          5.0                              390.56840
```

```
## 6  6           2012.667          7.1                             2175.03000
##   X4.number.of.convenience.stores X5.latitude X6.longitude
## 1                              10    24.98298     121.5402
## 2                               9    24.98034     121.5395
## 3                               5    24.98746     121.5439
## 4                               5    24.98746     121.5439
## 5                               5    24.97937     121.5425
## 6                               3    24.96305     121.5125
##   Y.house.price.of.unit.area
## 1                       37.9
## 2                       42.2
## 3                       47.3
## 4                       54.8
## 5                       43.1
## 6                       32.1
```

```
str(Real_df)
```

```
## 'data.frame':    414 obs. of  8 variables:
##  $ No                                    : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ X1.transaction.date                   : num  2013 2013 2014 2014 2013 ...
##  $ X2.house.age                          : num  32 19.5 13.3 13.3 5 7.1 34.5 20.3 31.7 17.9 ...
##  $ X3.distance.to.the.nearest.MRT.station: num  84.9 306.6 562 562 390.6 ...
##  $ X4.number.of.convenience.stores       : int  10 9 5 5 5 3 7 6 1 3 ...
##  $ X5.latitude                           : num  25 25 25 25 25 ...
##  $ X6.longitude                          : num  122 122 122 122 122 ...
##  $ Y.house.price.of.unit.area            : num  37.9 42.2 47.3 54.8 43.1 32.1 40.3 46.7 18.8 22.1 ..
```

```
dim(Real_df)
```

```
## [1] 414   8
```

```
summary(Real_df)
```

```
##        No        X1.transaction.date  X2.house.age
##  Min.   :  1.0   Min.   :2013        Min.   : 0.000
##  1st Qu.:104.2   1st Qu.:2013        1st Qu.: 9.025
##  Median :207.5   Median :2013        Median :16.100
##  Mean   :207.5   Mean   :2013        Mean   :17.713
##  3rd Qu.:310.8   3rd Qu.:2013        3rd Qu.:28.150
##  Max.   :414.0   Max.   :2014        Max.   :43.800
##  X3.distance.to.the.nearest.MRT.station X4.number.of.convenience.stores
##  Min.   :  23.38                         Min.   : 0.000
##  1st Qu.: 289.32                         1st Qu.: 1.000
##  Median : 492.23                         Median : 4.000
##  Mean   :1083.89                         Mean   : 4.094
##  3rd Qu.:1454.28                         3rd Qu.: 6.000
##  Max.   :6488.02                         Max.   :10.000
##   X5.latitude     X6.longitude   Y.house.price.of.unit.area
##  Min.   :24.93   Min.   :121.5   Min.   :  7.60
##  1st Qu.:24.96   1st Qu.:121.5   1st Qu.: 27.70
##  Median :24.97   Median :121.5   Median : 38.45
```

```
##  Mean   :24.97   Mean   :121.5   Mean   : 37.98
##  3rd Qu.:24.98   3rd Qu.:121.5   3rd Qu.: 46.60
##  Max.   :25.01   Max.   :121.6   Max.   :117.50
```

```
sum(is.na(Real_df))
```

```
## [1] 0
```

our data doesn't contain any N.A. values hence it is good to define a linear regression model

model fitting

```
model1=lm(Y.house.price.of.unit.area~. , Real_df)
summary(model1)
```

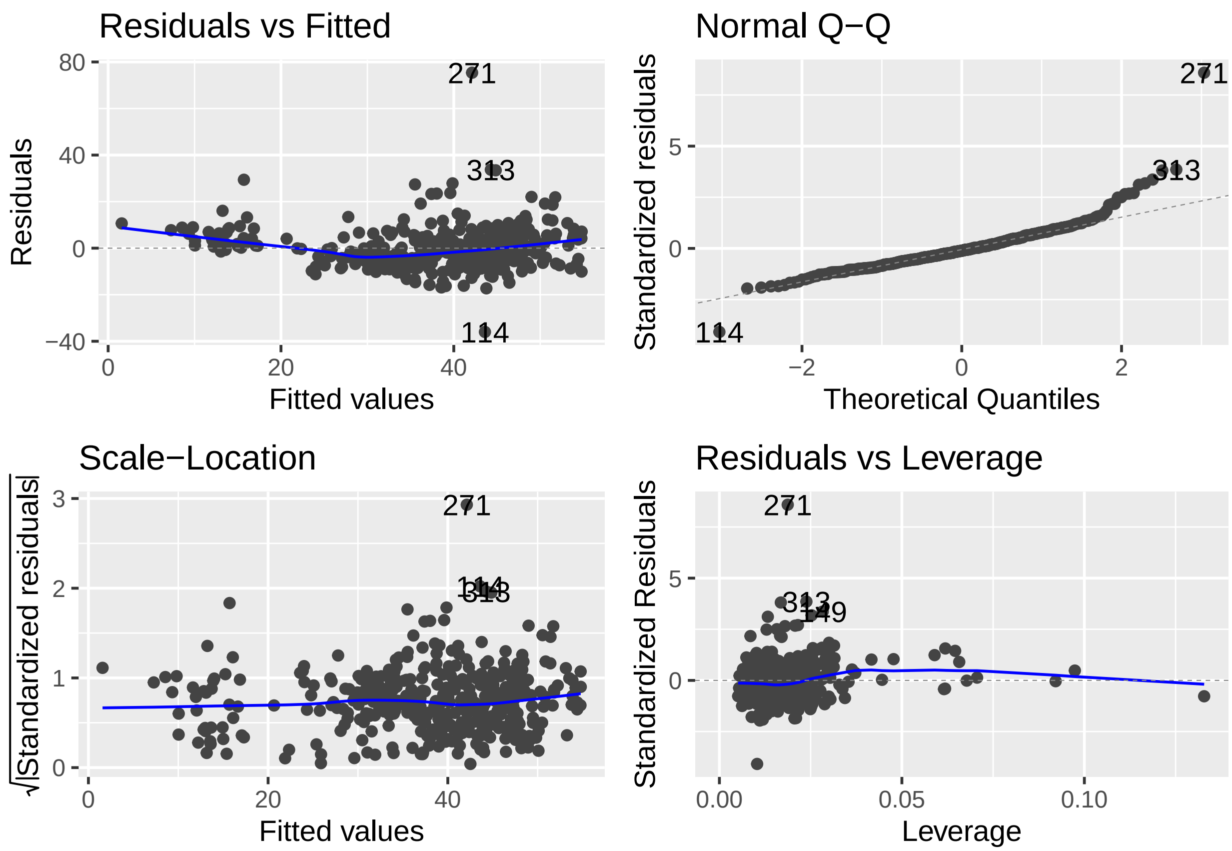
baseline model

```
##
## Call:
## lm(formula = Y.house.price.of.unit.area ~ ., data = Real_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -36.003  -5.196  -0.990   4.181  75.384
##
## Coefficients:
##                                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)                            -1.404e+04  6.788e+03  -2.068  0.03927
## No                                     -3.593e-03  3.653e-03  -0.984  0.32590
## X1.transaction.date                     5.079e+00  1.559e+00   3.259  0.00121
## X2.house.age                           -2.708e-01  3.855e-02  -7.026 9.04e-12
## X3.distance.to.the.nearest.MRT.station -4.521e-03  7.189e-04  -6.289 8.28e-10
## X4.number.of.convenience.stores         1.129e+00  1.882e-01   6.000 4.37e-09
## X5.latitude                             2.247e+02  4.458e+01   5.040 7.02e-07
## X6.longitude                           -1.442e+01  4.863e+01  -0.297  0.76691
##
## (Intercept)                            *
## No
## X1.transaction.date                    **
## X2.house.age                           ***
## X3.distance.to.the.nearest.MRT.station ***
## X4.number.of.convenience.stores        ***
## X5.latitude                            ***
## X6.longitude
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.858 on 406 degrees of freedom
## Multiple R-squared:  0.5834, Adjusted R-squared:  0.5762
## F-statistic: 81.21 on 7 and 406 DF,  p-value: < 2.2e-16
```

considering a level of significance to be 1% It is found that No is just a observation number and also found to be insignificant for prediction of house price of unit area so we define new model after removing **No**.

Asumptions testing

```
library(ggplot2)
library(ggfortify)
autoplot(model1)
```



testing normality

```
shapiro.test(Real_df$Y.house.price.of.unit.area)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  Real_df$Y.house.price.of.unit.area
## W = 0.97275, p-value = 5.411e-07
```

our response is not normally distributed

```
y=Real_df$Y.house.price.of.unit.area
z=sqrt(y)
shapiro.test(z)
```

```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  z
## W = 0.9881, p-value = 0.001858
```

at 1% l.o.s. our z=sqrt(y) satisfies normality so we will take z as response variable

```
library(lmtest)
```

testing homscedasticity

```
## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
bptest(model1)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model1
## BP = 8.6853, df = 7, p-value = 0.276
```

since p value is larger than tha 0.05 so we fail to reject the null hypothesis that data is homoscedastic. So data is homoscedastic.

```
library(mctest)
mctest(model1)
```

testing multicolinearity

```
##
## Call:
## omcdiag(mod = mod, Inter = TRUE, detr = detr, red = red, conf = conf,
##     theil = theil, cn = cn)
##
##
## Overall Multicollinearity Diagnostics
##
##                        MC Results detection
## Determinant |X'X|:         0.1345         0
```

```
## Farrar Chi-Square:       822.1918         1
## Red Indicator:             0.3048         0
## Sum of Lambda Inverse:    13.5303         0
## Theil's Method:           -1.2739         0
## Condition Number:      51881.4595         1
##
## 1 --> COLLINEARITY is detected by the test
## 0 --> COLLINEARITY is not detected by the test
```

by determinant test we can say that multicolinearity is not detected in the model still for further diagnosis we can check VIF

```
library(carData)
library(car)
```

```
##
## Attaching package: 'car'

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

## The following object is masked from 'package:purrr':
##
##     some
```

```
vif(model1)
```

```
##                                   No                    X1.transaction.date
##                             1.005872                               1.016623
##                         X2.house.age X3.distance.to.the.nearest.MRT.station
##                             1.015215                               4.332646
##        X4.number.of.convenience.stores                            X5.latitude
##                             1.617793                               1.610771
##                         X6.longitude
##                             2.931428
```

since VIF for all the predictors is less than 5 so we can conclude that multicolinearity is not present in our current model

Model 2

```
y=Real_df$Y.house.price.of.unit.area
x1=Real_df$X1.transaction.date
x2=Real_df$X2.house.age
x3=Real_df$X3.distance.to.the.nearest.MRT.station
x4=Real_df$X4.number.of.convenience.stores
x5=Real_df$X5.latitude
x6=Real_df$X6.longitude
z=sqrt(y)
df=data.frame(z,x1,x2,x3,x4,x5,x6)
head(df)
```

```
##          z       x1   x2          x3 x4       x5       x6
## 1 6.156298 2012.917 32.0   84.87882 10 24.98298 121.5402
## 2 6.496153 2012.917 19.5  306.59470  9 24.98034 121.5395
## 3 6.877500 2013.583 13.3  561.98450  5 24.98746 121.5439
## 4 7.402702 2013.500 13.3  561.98450  5 24.98746 121.5439
## 5 6.565059 2012.833  5.0  390.56840  5 24.97937 121.5425
## 6 5.665686 2012.667  7.1 2175.03000  3 24.96305 121.5125
```

```
model2=lm(z~. , df)
summary(model2)
```

```
##
## Call:
## lm(formula = z ~ ., data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.7308 -0.3774 -0.0559  0.3459  4.3869
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.330e+03  5.128e+02  -2.592 0.009872 **
## x1           4.061e-01  1.179e-01   3.446 0.000628 ***
## x2          -2.138e-02  2.916e-03  -7.333 1.23e-12 ***
## x3          -3.962e-04  5.435e-05  -7.291 1.62e-12 ***
## x4           8.898e-02  1.424e-02   6.247 1.05e-09 ***
## x5           2.086e+01  3.373e+00   6.184 1.53e-09 ***
## x6          -1.982e-02  3.677e+00  -0.005 0.995701
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6704 on 407 degrees of freedom
## Multiple R-squared:  0.6484, Adjusted R-squared:  0.6432
## F-statistic: 125.1 on 6 and 407 DF,  p-value: < 2.2e-16
```

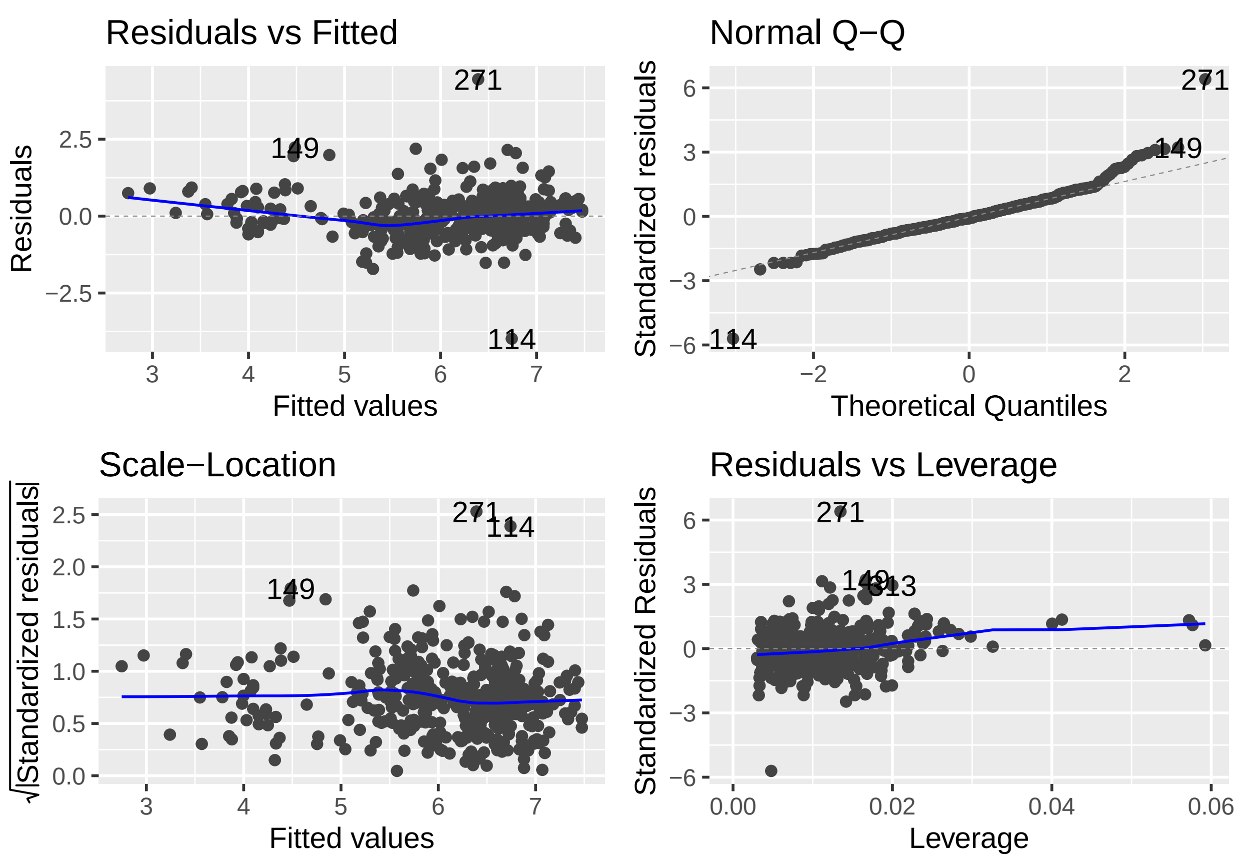
```
model3=lm(z~.-x5-x6,df)
summary(model3)
```

latitude(x6) found to be insignificant using p value criteria and threshold to be 5% but longitude (x5) was found significant but both together show location and single variable doesnt have a meaning so we will discard both the variables.

```
##
## Call:
## lm(formula = z ~ . - x5 - x6, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.9851 -0.4112 -0.0601  0.3679  4.4479
##
```

```
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -9.301e+02  2.468e+02  -3.769 0.000188 ***
## x1           4.653e-01  1.226e-01   3.795 0.000170 ***
## x2          -2.001e-02  3.035e-03  -6.595 1.32e-10 ***
## x3          -5.026e-04  3.439e-05 -14.614  < 2e-16 ***
## x4           1.002e-01  1.472e-02   6.803 3.65e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7 on 409 degrees of freedom
## Multiple R-squared:  0.6149, Adjusted R-squared:  0.6111
## F-statistic: 163.2 on 4 and 409 DF,  p-value: < 2.2e-16
```

```
library(ggplot2)
library(ggfortify)
autoplot(model3)
```



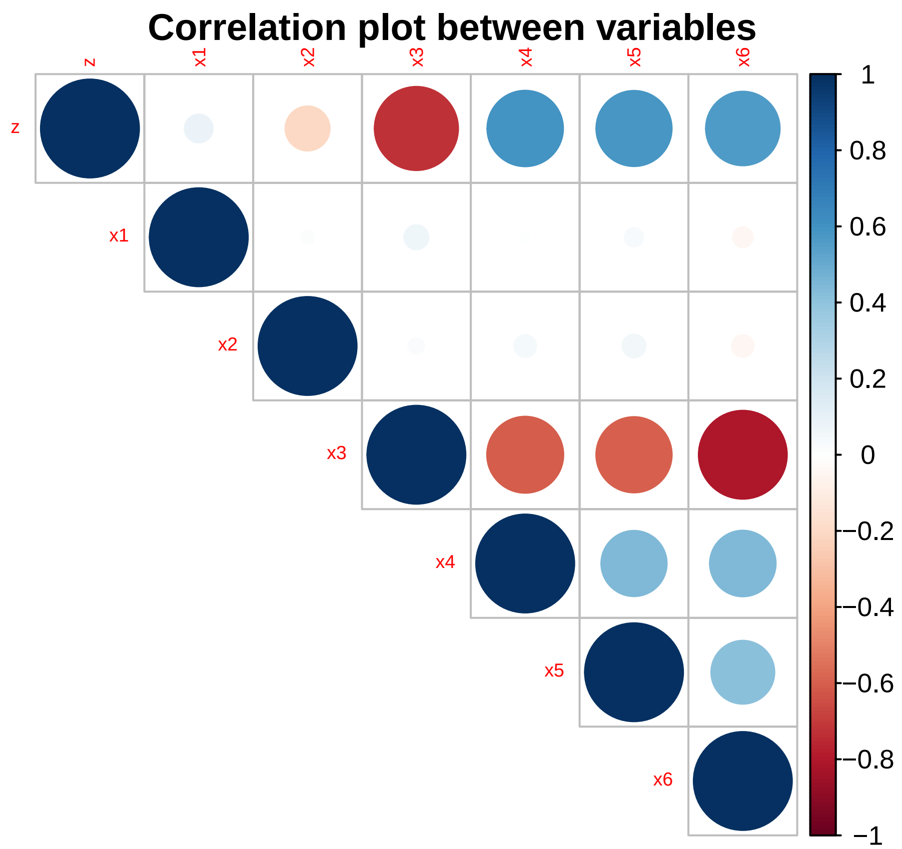

```
library(corrplot)
```

Interaction terms

```
## Warning: package 'corrplot' was built under R version 4.2.2
```

```
## corrplot 0.92 loaded
```

```
corrplot(cor(df),type="upper",method="circle",title="Correlation plot between variables",
         mar=c(0.7,0.7,0.7,0.7),tl.cex = 0.6)
```




```
print(paste("from corrplot we can see that among the variables present in the model x3(distance to neare
```

```
## [1] "from corrplot we can see that among the variables present in the model x3(distance to nearest M
```

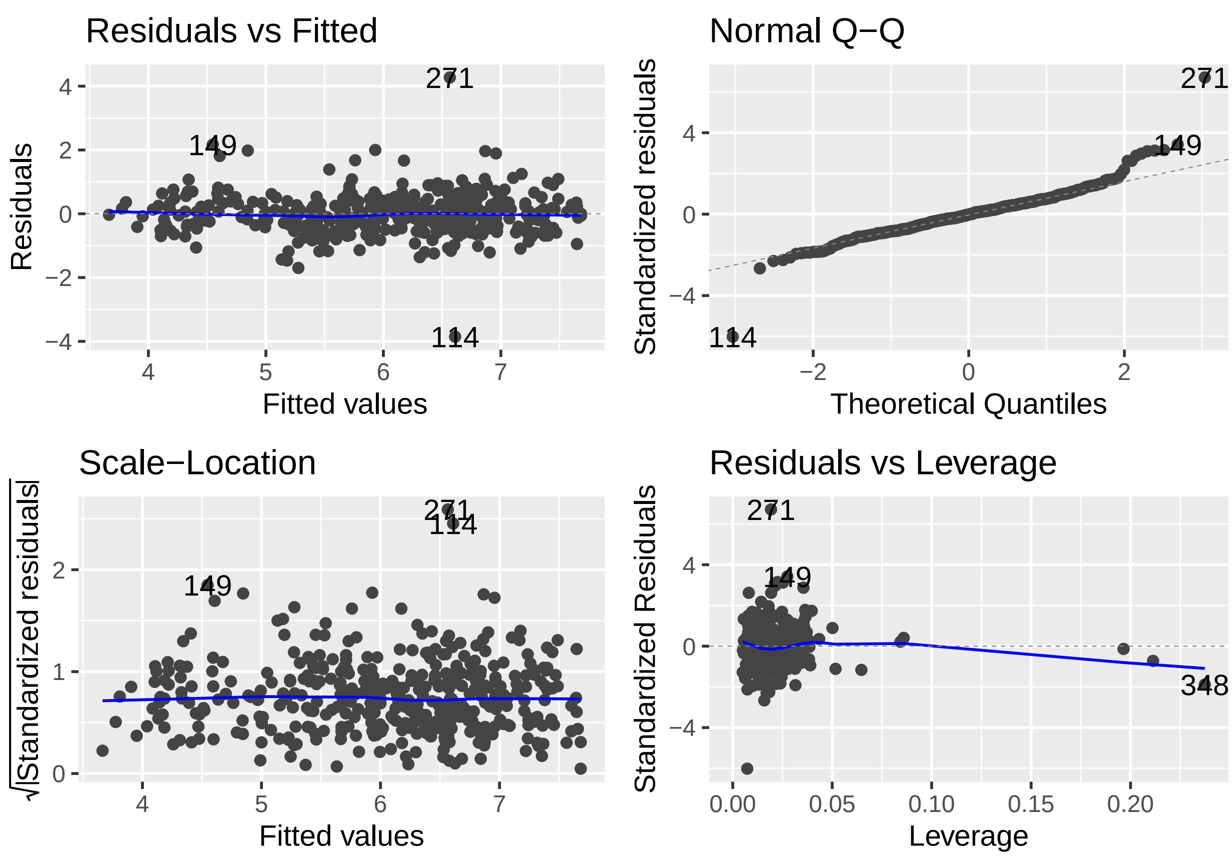
since the correlation between x3 and x4 is high we will add the interaction term of x3 and x4 in the model and also we will add higher powers of x2 and x3 so as to obtain more efficient model

```
model4=lm(z~.-x5-x6+x3:x4+I(x3^2)+I(x2^3),df)
summary(model4)
```

```
##
## Call:
## lm(formula = z ~ . - x5 - x6 + x3:x4 + I(x3^2) + I(x2^3), data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.8539 -0.3741 -0.0121  0.3298  4.2739
##
## Coefficients:
```

```
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.070e+03  2.271e+02  -4.711 3.39e-06 ***
## x1           5.351e-01  1.128e-01   4.742 2.93e-06 ***
## x2          -5.431e-02  7.066e-03  -7.686 1.15e-13 ***
## x3          -8.513e-04  1.104e-04  -7.709 9.86e-14 ***
## x4           8.348e-02  1.733e-02   4.816 2.07e-06 ***
## I(x3^2)      8.432e-08  1.936e-08   4.356 1.68e-05 ***
## I(x2^3)      2.319e-05  4.491e-06   5.164 3.79e-07 ***
## x3:x4       -4.230e-05  2.013e-05  -2.101   0.0363 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6426 on 406 degrees of freedom
## Multiple R-squared:  0.6777, Adjusted R-squared:  0.6722
## F-statistic:   122 on 7 and 406 DF,  p-value: < 2.2e-16
```

```
autoplot(model4)
```



so our current model has 67% accuracy with interaction terms of predictors and higher powers of predictor

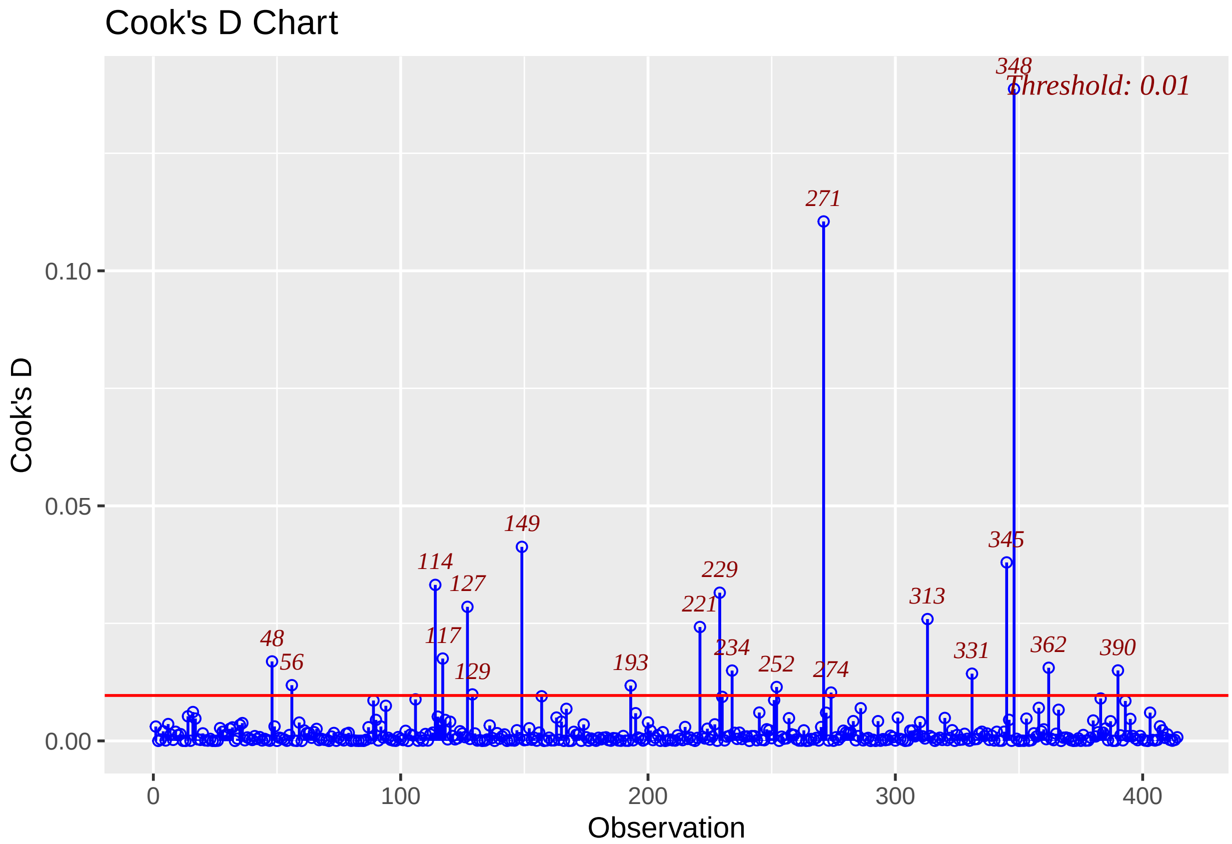
```
library(olsrr)
```

```
##
## Attaching package: 'olsrr'
```

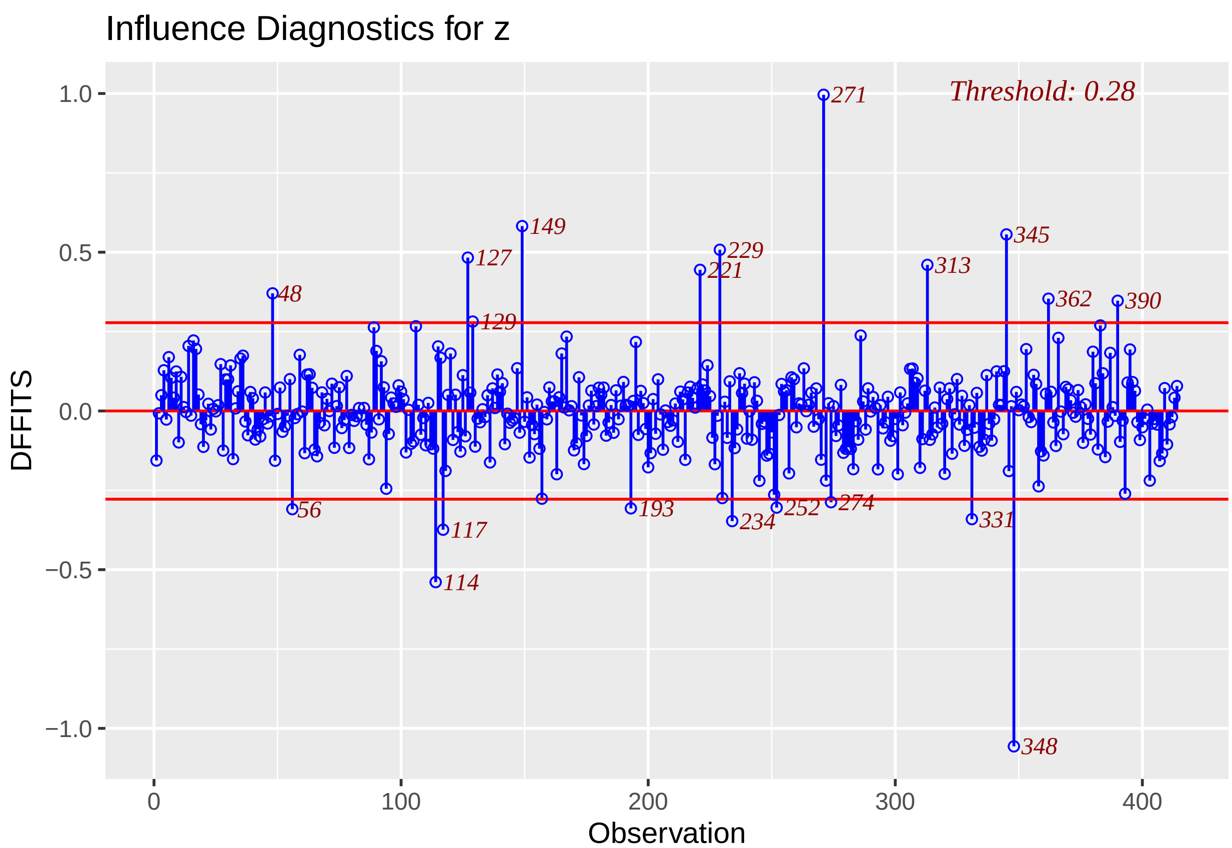
```
## The following object is masked from 'package:datasets':
```

```
##
##     rivers
```

```
ols_plot_cooksd_chart(model4)
```




```
ols_plot_dffits(model4)
```



20 observations are found to be outlier using Cook's D

```r
df1=df[-c(48,56,114,117,127,129,149,193,221,229,234,252,271,274,313,331,345,348,362,390),]
```

```r
df1
```

```
##              z       x1   x2         x3 x4       x5       x6
## 1   6.156298 2012.917 32.0   84.87882 10 24.98298 121.5402
## 2   6.496153 2012.917 19.5  306.59470  9 24.98034 121.5395
## 3   6.877500 2013.583 13.3  561.98450  5 24.98746 121.5439
## 4   7.402702 2013.500 13.3  561.98450  5 24.98746 121.5439
## 5   6.565059 2012.833  5.0  390.56840  5 24.97937 121.5425
## 6   5.665686 2012.667  7.1 2175.03000  3 24.96305 121.5125
## 7   6.348228 2012.667 34.5  623.47310  7 24.97933 121.5364
## 8   6.833740 2013.417 20.3  287.60250  6 24.98042 121.5423
## 9   4.335897 2013.500 31.7 5512.03800  1 24.95095 121.4846
## 10  4.701064 2013.417 17.9 1783.18000  3 24.96731 121.5149
## 11  6.434283 2013.083 34.8  405.21340  1 24.97349 121.5337
## 12  7.622336 2013.333  6.3   90.45606  9 24.97433 121.5431
## 13  6.268971 2012.917 13.0  492.23130  5 24.96515 121.5374
## 14  4.878524 2012.667 20.4 2469.64500  4 24.96108 121.5105
## 15  5.856620 2013.500 13.2 1164.83800  4 24.99156 121.5341
## 16  7.106335 2013.583 35.7  579.20830  2 24.98240 121.5462
## 17  8.372574 2013.250  0.0  292.99780  6 24.97744 121.5446
## 18  6.115554 2012.750 17.7  350.85150  1 24.97544 121.5312
## 19  6.503845 2013.417 16.9  368.13630  8 24.96750 121.5445
```

```
## 20  6.906519 2012.667  1.5   23.38284  7 24.96772 121.5410
## 21  5.412947 2013.417  4.5 2275.87700  3 24.96314 121.5115
## 22  7.183314 2013.417 10.5  279.17260  7 24.97528 121.5454
## 23  4.959839 2012.917 14.7 1360.13900  1 24.95204 121.5484
## 24  6.920983 2013.083 10.1  279.17260  7 24.97528 121.5454
## 25  6.228965 2013.000 39.6  480.69770  4 24.97353 121.5388
## 26  5.196152 2013.083 29.3 1487.86800  2 24.97542 121.5173
## 27  7.496666 2012.667  3.1  383.86240  5 24.98085 121.5439
## 28  5.796551 2013.250 10.4  276.44900  5 24.95593 121.5391
## 29  6.855655 2013.500 19.2  557.47800  4 24.97419 121.5380
## 30  7.556454 2013.083  7.1  451.24380  5 24.97563 121.5469
## 31  4.701064 2013.500 25.9 4519.69000  0 24.94826 121.4959
## 32  5.000000 2012.750 29.6  769.40340  7 24.98281 121.5341
## 33  5.848077 2012.750 37.9  488.57270  1 24.97349 121.5345
## 34  7.021396 2013.250 16.5  323.65500  6 24.97841 121.5428
## 35  7.422937 2012.750 15.4  205.36700  7 24.98419 121.5424
## 36  5.224940 2013.500 13.9 4079.41800  0 25.01459 121.5182
## 37  4.785394 2012.917 14.7 1935.00900  2 24.96386 121.5146
## 38  5.029911 2013.167 12.0 1360.13900  1 24.95204 121.5484
## 39  6.906519 2012.667  3.1  577.96150  6 24.97201 121.5472
## 40  6.797058 2013.167 16.2  289.32480  5 24.98203 121.5435
## 41  3.987480 2013.000 13.6 4082.01500  0 24.94155 121.5038
## 42  4.266146 2013.500 16.8 4066.58700  0 24.94297 121.5034
## 43  5.890671 2013.417 36.1  519.46170  5 24.96305 121.5376
## 44  5.839521 2012.750 34.4  512.78710  6 24.98748 121.5430
## 45  7.341662 2013.583  2.7  533.47620  4 24.97445 121.5477
## 46  6.188699 2013.083 36.6  488.81930  8 24.97015 121.5449
## 47  6.480741 2013.417 21.7  463.96230  9 24.97030 121.5446
## 49  3.660601 2013.417 24.2 4605.74900  0 24.94684 121.4958
## 50  3.633180 2012.667 29.4 4510.35900  1 24.94925 121.4954
## 51  6.648308 2013.417 21.7  512.54870  4 24.97400 121.5384
## 52  4.549725 2013.083 31.3 1758.40600  1 24.95402 121.5528
## 53  5.196152 2013.583 32.1 1438.57900  3 24.97419 121.5175
## 54  6.236986 2013.083 13.3  492.23130  5 24.96515 121.5374
## 55  7.190271 2013.083 16.1  289.32480  5 24.98203 121.5435
## 57  6.473021 2013.417 33.6  371.24950  8 24.97254 121.5406
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## 59  4.753946 2013.500 30.3 4510.35900  1 24.94925 121.4954
## 60  6.511528 2013.083 13.3  336.05320  5 24.95776 121.5344
## 61  4.615192 2013.417 11.0 1931.20700  2 24.96365 121.5147
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## 63  5.263079 2012.917 17.2 2175.87700  3 24.96303 121.5125
## 64  7.416198 2013.583  2.6  533.47620  4 24.97445 121.5477
## 65  5.029911 2013.333 17.5  995.75540  0 24.96305 121.5491
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## 68  7.536577 2013.500  8.5  104.81010  5 24.96674 121.5407
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## 70  6.480741 2012.833 12.5  561.98450  5 24.98746 121.5439
## 71  7.681146 2013.583  6.6   90.45606  9 24.97433 121.5431
## 72  6.387488 2013.083 35.5  640.73910  3 24.97563 121.5371
## 73  6.024948 2013.583 32.5  424.54420  8 24.97587 121.5391
## 74  4.472136 2013.167 13.8 4082.01500  0 24.94155 121.5038
## 75  7.375636 2012.917  6.8  379.55750 10 24.98343 121.5376
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## 76  5.431390 2013.500 12.3 1360.13900  1 24.95204 121.5484
## 77  6.066300 2013.583 35.9  616.40040  3 24.97723 121.5377
## 78  5.059644 2012.833 20.5 2185.12800  3 24.96322 121.5124
## 79  5.458938 2012.917 38.2  552.43710  2 24.97598 121.5338
## 80  5.147815 2013.000 18.0 1414.83700  1 24.95182 121.5489
## 81  6.348228 2013.500 11.8  533.47620  4 24.97445 121.5477
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## 83  6.935416 2013.083 13.2  150.93470  7 24.96725 121.5425
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## 85  6.610598 2013.083 15.1  383.28050  7 24.96735 121.5446
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## 109 5.839521 2013.417 31.4  592.50060  2 24.97260 121.5356
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## 130 6.403124 2013.417 38.5  216.83290  7 24.98086 121.5416
## 131 6.123724 2013.250 29.6  535.52700  8 24.98092 121.5365
## 132 5.540758 2013.500  4.0 2147.37600  3 24.96299 121.5128
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## 137 6.841053 2012.750 11.4  390.56840  5 24.97937 121.5425
## 138 6.884766 2013.500 13.6  319.07080  6 24.96495 121.5428
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## 140 6.519202 2012.667 12.9  492.23130  5 24.96515 121.5374
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## 145 5.329165 2013.083 11.9 1360.13900  1 24.95204 121.5484
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## 184 4.335897 2013.500 17.0 4082.01500  0 24.94155 121.5038
## 185 4.669047 2012.750 14.1 2615.46500  0 24.95495 121.5617
## 186 4.636809 2012.750 31.4 1447.28600  3 24.97285 121.5173
## 187 5.069517 2013.167 20.9 2185.12800  3 24.96322 121.5124
## 188 4.690416 2013.000  8.9 3078.17600  0 24.95464 121.5663
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## 246 6.387488 2013.417  7.5  639.61980  5 24.97258 121.5481
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## 334 6.196773 2012.750  7.8  104.81010  5 24.96674 121.5407
## 335 4.774935 2012.917 30.0 1013.34100  5 24.99006 121.5346
## 336 6.041523 2013.583 27.3  337.60160  6 24.96431 121.5406
## 337 5.966574 2012.833  5.1 1867.23300  2 24.98407 121.5175
## 338 5.558777 2012.833 31.3  600.86040  5 24.96871 121.5465
## 339 6.024948 2012.917 31.5  258.18600  9 24.96867 121.5433
## 340 7.099296 2013.333  1.7  329.97470  5 24.98254 121.5439
## 341 6.549809 2013.333 33.6  270.88950  0 24.97281 121.5327
## 342 6.082763 2013.000 13.0  750.07040  2 24.97371 121.5495
## 343 7.314369 2012.667  5.7   90.45606  9 24.97433 121.5431
## 344 6.826419 2013.000 33.5  563.28540  8 24.98223 121.5360
## 346 6.156298 2012.667  0.0  185.42960  0 24.97110 121.5317
## 347 5.549775 2013.417 13.2 1712.63200  2 24.96412 121.5167
## 349 7.328028 2012.833  4.6  259.66070  6 24.97585 121.5452
## 350 6.855655 2012.750  7.8  104.81010  5 24.96674 121.5407
## 351 6.503845 2013.000 13.2  492.23130  5 24.96515 121.5374
## 352 5.347897 2012.833  4.0 2180.24500  3 24.96324 121.5124
## 353 5.069517 2012.833 18.4 2674.96100  3 24.96143 121.5083
## 354 5.594640 2013.500  4.1 2147.37600  3 24.96299 121.5128
## 355 5.486347 2013.417 12.2 1360.13900  1 24.95204 121.5484
## 356 7.791020 2013.250  3.8  383.86240  5 24.98085 121.5439
## 357 6.730527 2012.833 10.3  211.44730  1 24.97417 121.5300
## 358 6.700746 2013.417  0.0  338.96790  9 24.96853 121.5441
## 359 6.715653 2013.167  1.1  193.58450  6 24.96571 121.5409
## 360 4.969909 2013.500  5.6 2408.99300  0 24.95505 121.5596
## 361 6.862944 2012.667 32.9   87.30222 10 24.98300 121.5402
```
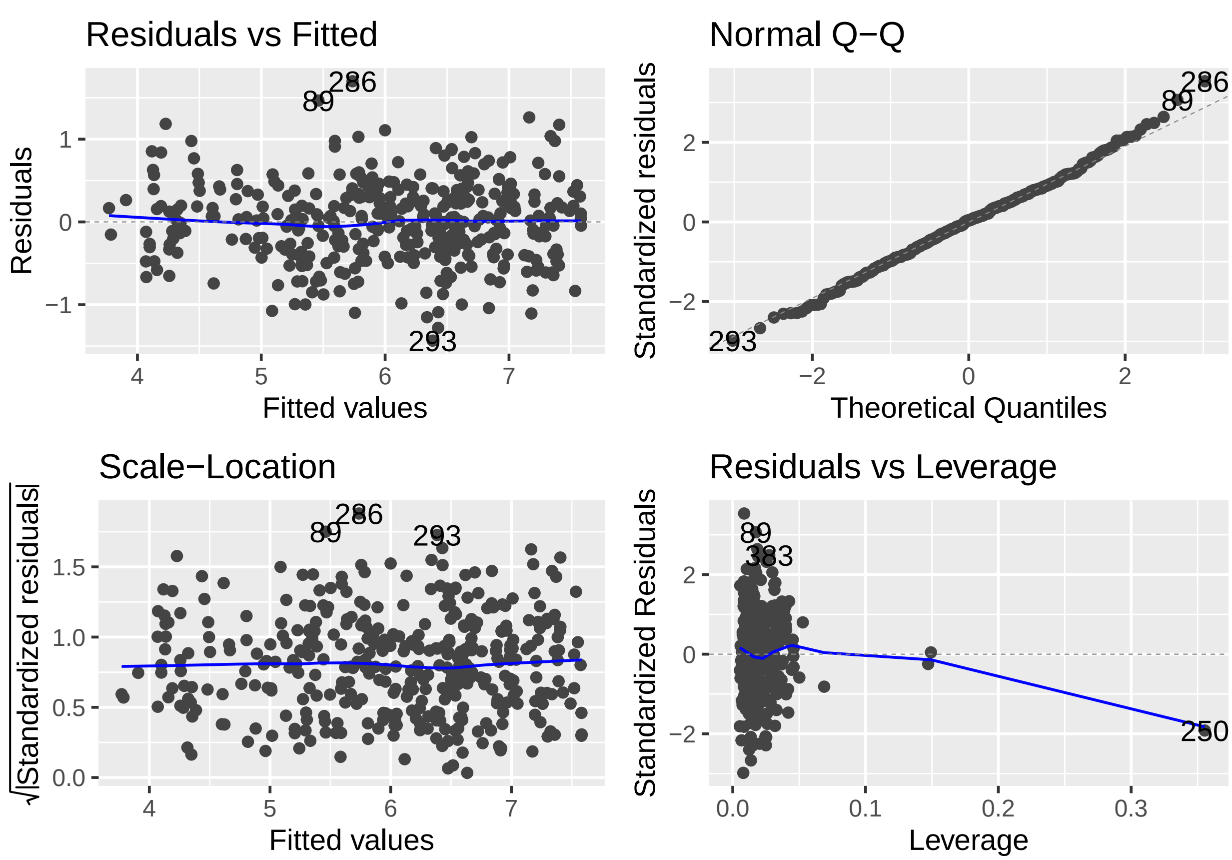

```
## 363 6.324555 2013.417 17.1  967.40000  4 24.98872 121.5341
## 364 6.928203 2013.500 32.3  109.94550 10 24.98182 121.5409
## 365 5.753260 2013.417 35.3  614.13940  7 24.97913 121.5367
## 366 5.431390 2012.917 17.3 2261.43200  4 24.96182 121.5122
## 367 4.979960 2012.750 14.2 1801.54400  1 24.95153 121.5525
## 368 4.571652 2012.833 15.0 1828.31900  2 24.96464 121.5153
## 369 6.565059 2013.417 18.2  350.85150  1 24.97544 121.5312
## 370 4.774935 2012.667 20.2 2185.12800  3 24.96322 121.5124
## 371 6.488451 2012.750 15.9  289.32480  5 24.98203 121.5435
## 372 7.190271 2013.500  4.1  312.89630  5 24.95591 121.5396
## 373 6.442049 2013.000 33.9  157.60520  7 24.96628 121.5420
## 374 7.224957 2013.083  0.0  274.01440  1 24.97480 121.5306
## 375 7.035624 2013.250  5.4  390.56840  5 24.97937 121.5425
## 376 4.878524 2013.250 21.7 1157.98800  0 24.96165 121.5501
## 377 5.522681 2013.417 14.7 1717.19300  2 24.96447 121.5165
## 378 7.536577 2013.333  3.9   49.66105  8 24.95836 121.5376
## 379 6.115554 2013.333 37.3  587.88770  8 24.97077 121.5463
## 380 8.348653 2013.333  0.0  292.99780  6 24.97744 121.5446
## 381 7.300685 2013.333 14.1  289.32480  5 24.98203 121.5435
## 382 6.877500 2013.417  8.0  132.54690  9 24.98298 121.5398
## 383 5.412947 2013.000 16.3 3529.56400  0 24.93207 121.5160
## 384 6.348228 2012.667 29.1  506.11440  4 24.97845 121.5389
## 385 3.591657 2012.750 16.1 4066.58700  0 24.94297 121.5034
## 386 6.826419 2013.000 18.3   82.88643 10 24.98300 121.5403
## 387 7.436397 2012.833  0.0  185.42960  0 24.97110 121.5317
## 388 5.059644 2013.250 16.2 2103.55500  3 24.96042 121.5146
## 389 5.224940 2013.500 10.4 2251.93800  4 24.95957 121.5135
## 391 6.212890 2013.500 32.8  377.83020  9 24.97151 121.5435
## 392 5.594640 2013.583  6.2 1939.74900  1 24.95155 121.5539
## 393 5.941380 2013.083 42.7  443.80200  6 24.97927 121.5387
## 394 6.348228 2013.000 16.9  967.40000  4 24.98872 121.5341
## 395 4.969909 2013.500 32.6 4136.27100  1 24.95544 121.4963
## 396 6.519202 2012.917 21.2  512.54870  4 24.97400 121.5384
## 397 5.648008 2012.667 37.1  918.63570  1 24.97198 121.5506
## 398 5.674504 2013.417 13.1 1164.83800  4 24.99156 121.5341
## 399 4.795832 2013.417 14.7 1717.19300  2 24.96447 121.5165
## 400 6.107373 2012.917 12.7  170.12890  1 24.97371 121.5298
## 401 5.958188 2013.250 26.8  482.75810  5 24.97433 121.5386
## 402 5.263079 2013.083  7.6 2175.03000  3 24.96305 121.5125
## 403 5.338539 2012.833 12.7  187.48230  1 24.97388 121.5298
## 404 6.300794 2012.667 30.9  161.94200  9 24.98353 121.5397
## 405 6.418723 2013.333 16.4  289.32480  5 24.98203 121.5435
## 406 6.099180 2012.667 23.0  130.99450  6 24.95663 121.5376
## 407 6.363961 2013.167  1.9  372.13860  7 24.97293 121.5403
## 408 4.722288 2013.000  5.2 2408.99300  0 24.95505 121.5596
## 409 5.300943 2013.417 18.5 2175.74400  3 24.96330 121.5124
## 410 3.924283 2013.000 13.7 4082.01500  0 24.94155 121.5038
## 411 7.071068 2012.667  5.6   90.45606  9 24.97433 121.5431
## 412 6.371813 2013.250 18.8  390.96960  7 24.97923 121.5399
## 413 7.245688 2013.000  8.1  104.81010  5 24.96674 121.5407
## 414 7.993748 2013.500  6.5   90.45606  9 24.97433 121.5431
```

```
model5=lm(z~.-x5-x6+x3:x4+I(x3^2)+I(x2^3),df1)
summary(model5)
```

```
##
## Call:
## lm(formula = z ~ . - x5 - x6 + x3:x4 + I(x3^2) + I(x2^3), data = df1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.43411 -0.30941  0.01909  0.30615  1.69928
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -8.260e+02  1.743e+02  -4.739 3.02e-06 ***
## x1           4.139e-01  8.659e-02   4.781 2.49e-06 ***
## x2          -4.550e-02  5.519e-03  -8.244 2.63e-15 ***
## x3          -1.106e-03  1.008e-04 -10.978  < 2e-16 ***
## x4           6.104e-02  1.402e-02   4.355 1.71e-05 ***
## I(x3^2)      1.302e-07  1.881e-08   6.922 1.86e-11 ***
## I(x2^3)      1.483e-05  3.686e-06   4.023 6.92e-05 ***
## x3:x4       -5.237e-06  1.686e-05  -0.311    0.756
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4828 on 386 degrees of freedom
## Multiple R-squared:  0.7857, Adjusted R-squared:  0.7819
## F-statistic: 202.2 on 7 and 386 DF,  p-value: < 2.2e-16
```

```
autoplot(model5)
```



since interaction term found to be insignificant in model 5 after removing outliers from the model so we will remove that and define final model

```
final=lm(z~.-x5-x6+I(x3^2)+I(x2^3),df1)
summary(final)
```

```
##
## Call:
## lm(formula = z ~ . - x5 - x6 + I(x3^2) + I(x2^3), data = df1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.43571 -0.30517  0.01962  0.30329  1.69752
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -8.258e+02  1.741e+02  -4.743 2.96e-06 ***
## x1           4.138e-01  8.648e-02   4.785 2.44e-06 ***
## x2          -4.552e-02  5.512e-03  -8.258 2.37e-15 ***
## x3          -1.127e-03  7.609e-05 -14.809  < 2e-16 ***
## x4           5.846e-02  1.128e-02   5.184 3.50e-07 ***
## I(x3^2)      1.337e-07  1.502e-08   8.900  < 2e-16 ***
## I(x2^3)      1.481e-05  3.681e-06   4.024 6.88e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4822 on 387 degrees of freedom
## Multiple R-squared:  0.7857, Adjusted R-squared:  0.7824
## F-statistic: 236.5 on 6 and 387 DF,  p-value: < 2.2e-16
```

since value of $\mathbf{R-Squared}$ is 78.24 % we conclude that Final is our Final model

```
library(formattable)
formattable(final$coefficients)
```

```
## (Intercept)          x1          x2           x3          x4     I(x3^2)
##      -825.8      0.4138    -0.04552    -0.001127     0.05846   1.337e-07
##     I(x2^3)
##   1.481e-05
```

Final model is

$z = -825.8 + 0.4138 \times \mathrm{X}_1 - 0.04552 \times \mathrm{X}_2 - 0.00113 \times \mathrm{X}_3 + 0.0585 \times \mathrm{X}_4 + 1.48e-05 \times \mathrm{I}(\mathrm{X}_2^3) + 1.337e-07 \times \mathrm{I}(\mathrm{X}_3^2)$

Conclusion of the final model:

1)Detected outliers in the model using Cook's D and removed them from dataset 2) From the residual vs fitted graph we can see that the estimated error curve of our final model is almost converge to 0. 3) From the QQ-Plot we can see that the our model behaves like normal except for the tail parts. 4) homoscedasticity is satisfied by the variance of residuals 5) Multi-co-linearity is not present in the final model 6) residuals follow normal distribution with constant variance 7) From value of

$$\mathrm{R}^2$$

we can conclude that final model predicts the house price per unit area ($) with 78.24% accuracy 8)Only following predictors are responsible for predicting house price i) X1 transaction date (Date at which home is bought) ii) X2 house age (age of house from when it was built) iii) X3 distance to the nearest MRT station iv) X4 number of convenient stores from house