In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from statsmodels.graphics.regressionplots import influence_plot
import statsmodels.formula.api as smf
```

In [7]:

```
cars = pd.read_csv('/Users/acer/Sandesh Pal/Data Science Assgn/Multiple REgression/ToyotaCorolla.csv',enc
```

In [8]:

```
cars.head()
```

Out[8]:

	Id	Model	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	Fuel_Type	HP	Met_Color	...	Central_Lock	Powered_Windows	Power_Steer
0	1	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13500	23	10	2002	46986	Diesel	90	1	...	1	1	
1	2	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13750	23	10	2002	72937	Diesel	90	1	...	1	0	
2	3	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13950	24	9	2002	41711	Diesel	90	1	...	0	0	
3	4	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	14950	26	7	2002	48000	Diesel	90	0	...	0	0	
4	5	TOYOTA Corolla 2.0 D4D HATCHB SOL 2/3-Doors	13750	30	3	2002	38500	Diesel	90	0	...	1	1	

5 rows × 38 columns

In [9]:

```
cars_cl = cars.drop(cars.iloc[:,:2], axis=1)
```

In [10]:

```
cars_cl.head()
```

Out[10]:

	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	Fuel_Type	HP	Met_Color	Color	Automatic	...	Central_Lock	Powered_Windows	Power_
0	13500	23	10	2002	46986	Diesel	90	1	Blue	0	...	1	1	
1	13750	23	10	2002	72937	Diesel	90	1	Silver	0	...	1	0	
2	13950	24	9	2002	41711	Diesel	90	1	Blue	0	...	0	0	
3	14950	26	7	2002	48000	Diesel	90	0	Black	0	...	0	0	
4	13750	30	3	2002	38500	Diesel	90	0	Black	0	...	1	1	

5 rows × 36 columns

In [11]:

```
cars_cl.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1436 entries, 0 to 1435
Data columns (total 36 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   Price             1436 non-null   int64
 1   Age_08_04         1436 non-null   int64
 2   Mfg_Month         1436 non-null   int64
 3   Mfg_Year          1436 non-null   int64
 4   KM                1436 non-null   int64
 5   Fuel_Type         1436 non-null   object
 6   HP                1436 non-null   int64
 7   Met_Color         1436 non-null   int64
 8   Color             1436 non-null   object
 9   Automatic         1436 non-null   int64
 10  cc                1436 non-null   int64
 11  Doors             1436 non-null   int64
 12  Cylinders         1436 non-null   int64
 13  Gears             1436 non-null   int64
 14  Quarterly_Tax     1436 non-null   int64
 15  Weight            1436 non-null   int64
 16  Mfr_Guarantee     1436 non-null   int64
 17  BOVAG_Guarantee   1436 non-null   int64
 18  Guarantee_Period  1436 non-null   int64
 19  ABS               1436 non-null   int64
 20  Airbag_1          1436 non-null   int64
 21  Airbag_2          1436 non-null   int64
 22  Airco             1436 non-null   int64
 23  Automatic_airco   1436 non-null   int64
 24  Boardcomputer     1436 non-null   int64
 25  CD_Player         1436 non-null   int64
 26  Central_Lock      1436 non-null   int64
 27  Powered_Windows   1436 non-null   int64
 28  Power_Steering    1436 non-null   int64
 29  Radio             1436 non-null   int64
 30  Mistlamps         1436 non-null   int64
 31  Sport_Model       1436 non-null   int64
 32  Backseat_Divider  1436 non-null   int64
 33  Metallic_Rim      1436 non-null   int64
 34  Radio_cassette    1436 non-null   int64
 35  Tow_Bar           1436 non-null   int64
dtypes: int64(34), object(2)
memory usage: 404.0+ KB
```

In [12]:

```
cars_cl.isnull().sum()
```

Out[12]:

```
Price                0
Age_08_04            0
Mfg_Month            0
Mfg_Year             0
KM                   0
Fuel_Type            0
HP                   0
Met_Color            0
Color                0
Automatic            0
cc                   0
Doors                0
Cylinders            0
Gears                0
Quarterly_Tax        0
Weight               0
Mfr_Guarantee        0
BOVAG_Guarantee      0
Guarantee_Period     0
ABS                  0
Airbag_1             0
Airbag_2             0
Airco                0
Automatic_airco      0
Boardcomputer        0
CD_Player            0
Central_Lock         0
Powered_Windows      0
Power_Steering       0
Radio                0
Mistlamps            0
Sport_Model          0
Backseat_Divider     0
Metallic_Rim         0
Radio_cassette       0
Tow_Bar              0
dtype: int64
```

In [13]:

```
cars_cl.shape
```

Out[13]:

```
(1436, 36)
```

In [14]:

```
cars_cl.dtypes
```

Out[14]:

```
Price                 int64
Age_08_04             int64
Mfg_Month             int64
Mfg_Year              int64
KM                    int64
Fuel_Type            object
HP                    int64
Met_Color             int64
Color                object
Automatic             int64
cc                    int64
Doors                 int64
Cylinders             int64
Gears                 int64
Quarterly_Tax         int64
Weight                int64
Mfr_Guarantee         int64
BOVAG_Guarantee       int64
Guarantee_Period      int64
ABS                   int64
Airbag_1              int64
Airbag_2              int64
Airco                 int64
Automatic_airco       int64
Boardcomputer         int64
CD_Player             int64
Central_Lock          int64
Powered_Windows       int64
Power_Steering        int64
Radio                 int64
Mistlamps             int64
Sport_Model           int64
Backseat_Divider      int64
Metallic_Rim          int64
Radio_cassette        int64
Tow_Bar               int64
dtype: object
```

In [15]:

```
cars_cl.columns
```

Out[15]:

```
Index(['Price', 'Age_08_04', 'Mfg_Month', 'Mfg_Year', 'KM', 'Fuel_Type', 'HP',
       'Met_Color', 'Color', 'Automatic', 'cc', 'Doors', 'Cylinders', 'Gears',
       'Quarterly_Tax', 'Weight', 'Mfr_Guarantee', 'BOVAG_Guarantee',
       'Guarantee_Period', 'ABS', 'Airbag_1', 'Airbag_2', 'Airco',
       'Automatic_airco', 'Boardcomputer', 'CD_Player', 'Central_Lock',
       'Powered_Windows', 'Power_Steering', 'Radio', 'Mistlamps',
       'Sport_Model', 'Backseat_Divider', 'Metallic_Rim', 'Radio_cassette',
       'Tow_Bar'],
      dtype='object')
```

In [16]:

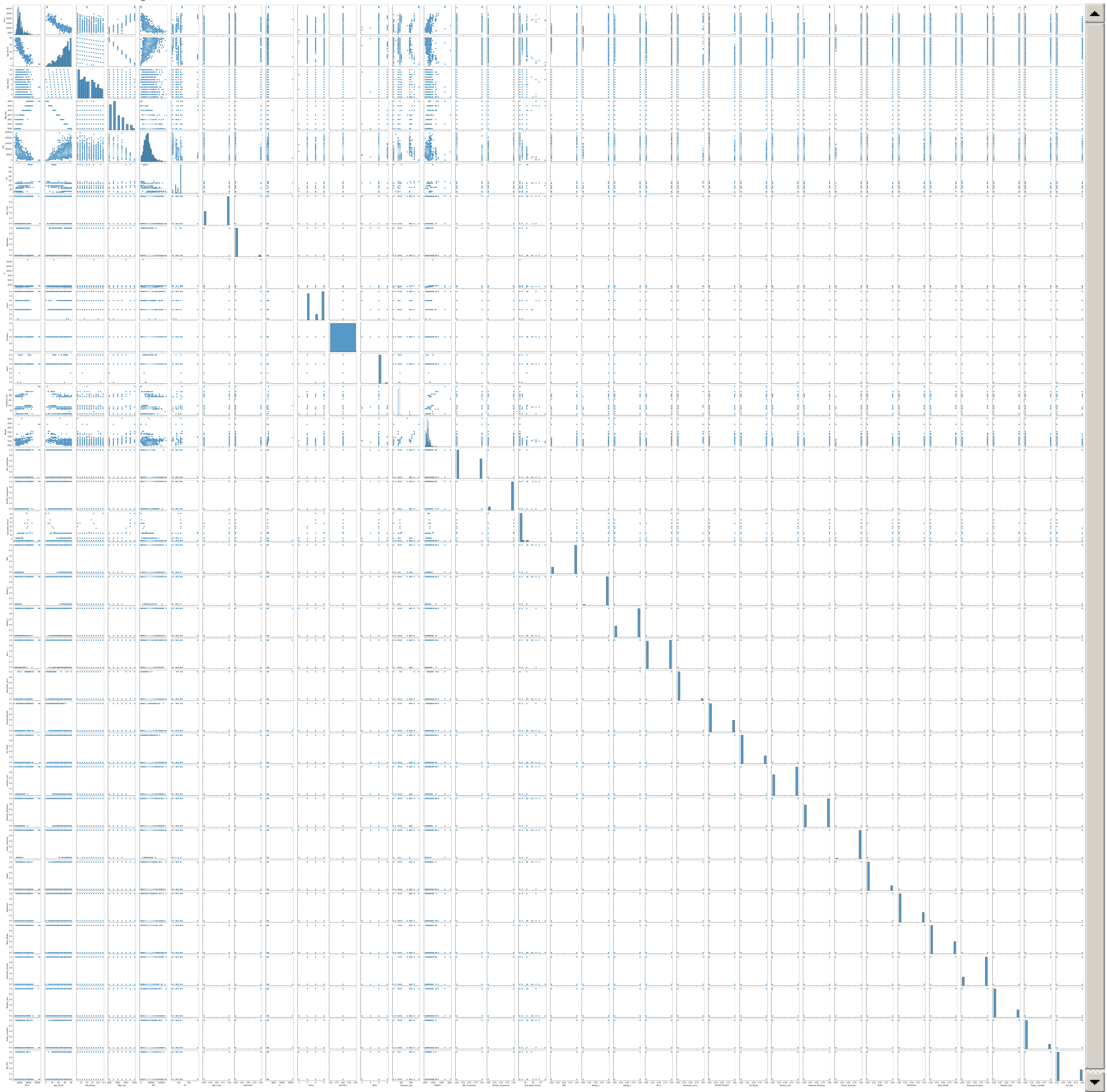
```
model = smf.ols('Price~Age_08_04+KM+HP+Doors+Cylinders+Gears+Weight',data=cars_cl).fit()
```

In [17]:

```
sns.pairplot(cars_cl)
```

Out[17]:

```
<seaborn.axisgrid.PairGrid at 0x22392218190>
```



In [18]:

```
model.params
```

Out[18]:

```
Intercept     -410.845504
Age_08_04     -122.242218
KM              -0.019994
HP              28.350149
Doors           -9.680229
Cylinders    -1643.382016
Gears          622.282925
Weight          18.609651
dtype: float64
```

In [19]:

```
model.pvalues
```

Out[19]:

```
Intercept     1.181900e-07
Age_08_04    4.387432e-290
KM            2.238900e-56
HP            2.231791e-26
Doors         8.087723e-01
Cylinders     1.181900e-07
Gears         1.653931e-03
Weight        7.856458e-96
dtype: float64
```

In [20]:

```
model.tvalues
```

Out[20]:

```
Intercept    -5.323309
Age_08_04   -46.728942
KM          -16.542560
HP           10.842418
Doors        -0.242055
Cylinders    -5.323309
Gears         3.152234
Weight       22.446903
dtype: float64
```

In [21]:

```
model.rsquared
```

Out[21]:

```
0.8628024511073656
```

In [22]:

```
model.rsquared_adj
```

Out[22]:

```
0.8622263942190831
```

In [23]:

```
model.summary()
```

Out[23]:

OLS Regression Results

Dep. Variable:	Price	**R-squared:**	0.863
Model:	OLS	**Adj. R-squared:**	0.862
Method:	Least Squares	**F-statistic:**	1498.
Date:	Wed, 23 Jun 2021	**Prob (F-statistic):**	0.00
Time:	14:07:02	**Log-Likelihood:**	-12381.
No. Observations:	1436	**AIC:**	2.478e+04
Df Residuals:	1429	**BIC:**	2.481e+04
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
Intercept	-410.8455	77.179	-5.323	0.000	-562.241	-259.450
Age_08_04	-122.2422	2.616	-46.729	0.000	-127.374	-117.111
KM	-0.0200	0.001	-16.543	0.000	-0.022	-0.018
HP	28.3501	2.615	10.842	0.000	23.221	33.479
Doors	-9.6802	39.992	-0.242	0.809	-88.129	68.769
Cylinders	-1643.3820	308.714	-5.323	0.000	-2248.964	-1037.800
Gears	622.2829	197.410	3.152	0.002	235.038	1009.528
Weight	18.6097	0.829	22.447	0.000	16.983	20.236

Omnibus:	199.596	**Durbin-Watson:**	1.564
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	1569.510
Skew:	-0.381	**Prob(JB):**	0.00
Kurtosis:	8.065	**Cond. No.**	4.98e+20

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The smallest eigenvalue is 3.53e-29. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.

In [24]:

```
model_test1 = smf.ols ('Price~Doors', data=cars_cl).fit()
```

In [25]:

```
model_test1.pvalues
```

Out[25]:

```
Intercept    1.094732e-73
Doors        1.461237e-12
dtype: float64
```

In [26]:

```
model_test1.rsquared
```

Out[26]:

```
0.03434555943109807
```

In [27]:

```
model_test1.rsquared_adj
```

Out[27]:

```
0.03367216023962749
```

In [28]:

```
cars_cl.columns
```

Out[28]:

```
Index(['Price', 'Age_08_04', 'Mfg_Month', 'Mfg_Year', 'KM', 'Fuel_Type', 'HP',
       'Met_Color', 'Color', 'Automatic', 'cc', 'Doors', 'Cylinders', 'Gears',
       'Quarterly_Tax', 'Weight', 'Mfr_Guarantee', 'BOVAG_Guarantee',
       'Guarantee_Period', 'ABS', 'Airbag_1', 'Airbag_2', 'Airco',
       'Automatic_airco', 'Boardcomputer', 'CD_Player', 'Central_Lock',
       'Powered_Windows', 'Power_Steering', 'Radio', 'Mistlamps',
       'Sport_Model', 'Backseat_Divider', 'Metallic_Rim', 'Radio_cassette',
       'Tow_Bar'],
      dtype='object')
```

In [29]:

```python
rsq_1 = smf.ols ('Age_08_04~KM+HP+Doors+Cylinders+Gears+Weight',data=cars_cl).fit().rsquared
vif_1 = 1/(1-rsq_1)

rsq_2 = smf.ols ('KM~Age_08_04+HP+Doors+Cylinders+Gears+Weight',data=cars_cl).fit().rsquared
vif_2 = 1/(1-rsq_2)

rsq_3 = smf.ols ('HP~Age_08_04+KM+Doors+Cylinders+Gears+Weight',data=cars_cl).fit().rsquared
vif_3 = 1/(1-rsq_3)

rsq_4 = smf.ols ('Doors~Age_08_04+KM+HP+Cylinders+Gears+Weight',data=cars_cl).fit().rsquared
vif_4 = 1/(1-rsq_4)

rsq_5 = smf.ols ('Cylinders~Age_08_04+KM+HP+Doors+Gears+Weight',data=cars_cl).fit().rsquared
vif_5 = 1/(1-rsq_5)

rsq_6 = smf.ols ('Gears~Age_08_04+KM+HP+Doors+Cylinders+Weight',data=cars_cl).fit().rsquared
vif_6 = 1/(1-rsq_6)

rsq_7 = smf.ols ('Weight~Age_08_04+KM+HP+Doors+Cylinders+Gears',data=cars_cl).fit().rsquared
vif_7 = 1/(1-rsq_7)

# Storing vif values in a data frame
df1 = {'Variables': ['Age_08_04','KM','HP','Doors','Cylinders','Gears','Weight'],
       'VIF':[vif_1,vif_2,vif_3,vif_4,vif_5,vif_6,vif_7]}
Vif_frame = pd.DataFrame(df1)
Vif_frame
```

```
C:\Users\acer\anaconda3\lib\site-packages\statsmodels\regression\linear_model.py:1715: RuntimeWarning:
divide by zero encountered in double_scalars
  return 1 - self.ssr/self.centered_tss
```

Out[29]:

	Variables	VIF
0	Age_08_04	1.874542
1	KM	1.627039
2	HP	1.214909
3	Doors	1.149301
4	Cylinders	0.000000
5	Gears	1.096501
6	Weight	1.508041

In [30]:

```python
cars_cl.corr()
```

Out[30]:

	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	HP	Met_Color	Automatic	cc	Doors	...	Central_Lo
Price	1.000000	-0.876590	-0.018138	0.885159	-0.569960	0.314990	0.108905	0.033081	0.126389	0.185326	...	0.3434
Age_08_04	-0.876590	1.000000	-0.123255	-0.983661	0.505672	-0.156622	-0.108150	0.031717	-0.098084	-0.148359	...	-0.2796
Mfg_Month	-0.018138	-0.123255	1.000000	-0.057416	-0.020630	-0.039312	0.030266	0.009146	0.037387	-0.012069	...	0.0100
Mfg_Year	0.885159	-0.983661	-0.057416	1.000000	-0.504974	0.164697	0.103310	-0.033567	0.091892	0.151442	...	0.2794
KM	-0.569960	0.505672	-0.020630	-0.504974	1.000000	-0.333538	-0.080503	-0.081854	0.102683	-0.036197	...	-0.1251
HP	0.314990	-0.156622	-0.039312	0.164697	-0.333538	1.000000	0.058712	0.013144	0.035856	0.092424	...	0.2501

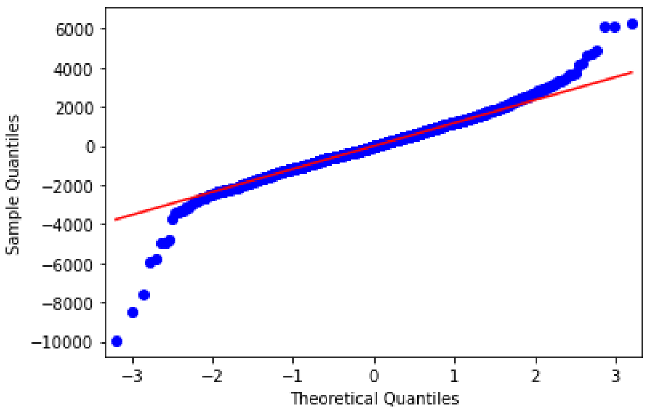
	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	HP	Met_Color	Automatic	cc	Doors	...	Central_Lo
Met_Color	0.108905	-0.108150	0.030266	0.103310	-0.080503	0.058712	1.000000	-0.019335	0.031812	0.085243	...	0.1533
Automatic	0.033081	0.031717	0.009146	-0.033567	-0.081854	0.013144	-0.019335	1.000000	0.066740	-0.027654	...	-0.0025
cc	0.126389	-0.098084	0.037387	0.091892	0.102683	0.035856	0.031812	0.066740	1.000000	0.079903	...	0.0726
Doors	0.185326	-0.148359	-0.012069	0.151442	-0.036197	0.092424	0.085243	-0.027654	0.079903	1.000000	...	0.1320
Cylinders	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	N
Gears	0.063104	-0.005364	-0.013063	0.007766	0.015023	0.209477	0.018601	-0.098555	0.014629	-0.160141	...	0.1269
Quarterly_Tax	0.219197	-0.198431	0.031373	0.193934	0.278165	-0.298432	0.011326	-0.055371	0.306996	0.109363	...	0.0320
Weight	0.581198	-0.470253	-0.002167	0.473478	-0.028598	0.089614	0.057929	0.057249	0.335637	0.302618	...	0.2346
Mfr_Guarantee	0.197802	-0.164658	-0.005771	0.166697	-0.212851	0.140026	0.154850	0.026194	-0.057407	0.037689	...	0.0399
BOVAG_Guarantee	0.028133	0.006865	-0.003863	-0.006206	0.001438	0.022701	0.010783	0.023393	-0.081725	-0.014311	...	-0.0230
Guarantee_Period	0.146627	-0.152563	0.029010	0.148218	-0.138942	0.076163	0.009295	-0.002256	-0.017683	0.053654	...	0.0589
ABS	0.306138	-0.412887	0.072532	0.402215	-0.177203	0.057832	0.022298	-0.016128	0.037806	0.063733	...	0.0994
Airbag_1	0.093588	-0.105406	0.003756	0.105359	-0.018012	0.025137	0.100055	-0.011895	0.022678	0.053828	...	0.1202
Airbag_2	0.248974	-0.329017	0.076749	0.317075	-0.139275	0.017644	0.038416	0.001171	0.024738	0.021734	...	0.0248
Airco	0.429259	-0.403600	0.057088	0.395674	-0.133057	0.241134	0.114190	-0.028353	0.119888	0.170544	...	0.5405
Automatic_airco	0.588262	-0.426259	-0.049017	0.437718	-0.258221	0.244957	0.027977	0.059057	0.162669	0.054809	...	0.1957
Boardcomputer	0.601292	-0.719449	0.017715	0.720567	-0.353862	0.129715	0.089886	-0.037069	0.009312	0.089606	...	0.2031
CD_Player	0.481374	-0.510895	-0.016736	0.517008	-0.266826	0.102300	0.198220	-0.010967	0.057787	0.094653	...	0.1940
Central_Lock	0.343458	-0.279631	0.010055	0.279490	-0.125177	0.250122	0.153307	-0.002502	0.072634	0.132092	...	1.0000
Powered_Windows	0.356518	-0.283856	0.025185	0.280996	-0.156242	0.265593	0.145147	-0.005864	0.055299	0.107626	...	0.8755
Power_Steering	0.064275	-0.069192	-0.055495	0.079676	0.007397	0.048850	0.086544	-0.004469	0.032933	0.059792	...	0.1296
Radio	-0.041887	0.013791	0.031601	-0.019607	0.013661	0.020998	0.072756	-0.014600	-0.000361	-0.008318	...	-0.0112
Mistlamps	0.222083	-0.126895	-0.033504	0.133737	-0.074327	0.210571	0.023821	0.003077	0.017326	0.064705	...	0.4874
Sport_Model	0.164121	-0.110988	0.052789	0.102080	-0.044784	-0.006027	0.003779	0.013175	-0.035195	-0.129881	...	-0.0031
Backseat_Divider	0.102569	-0.116751	0.023245	0.113237	-0.045658	0.010908	0.037741	-0.018876	-0.055711	-0.022542	...	0.0584
Metallic_Rim	0.108564	-0.040045	0.023506	0.036022	-0.013599	0.206784	0.053829	-0.078095	0.003236	-0.039555	...	0.2813
Radio_cassette	-0.043179	0.012857	0.032576	-0.018844	0.015770	0.019919	0.071530	-0.014150	-0.000470	-0.008265	...	-0.0169
Tow_Bar	-0.172369	0.188720	-0.042170	-0.182206	0.084153	0.068271	0.148536	0.018786	0.002725	0.102292	...	-0.0077

34 rows × 34 columns

In [32]:

```
import statsmodels.api as sm
```

```
qqplot=sm.qqplot(model.resid,line='q')
```



In [33]:

```
qqplot.get_size_inches()
```

Out[33]:

```
array([6., 4.])
```

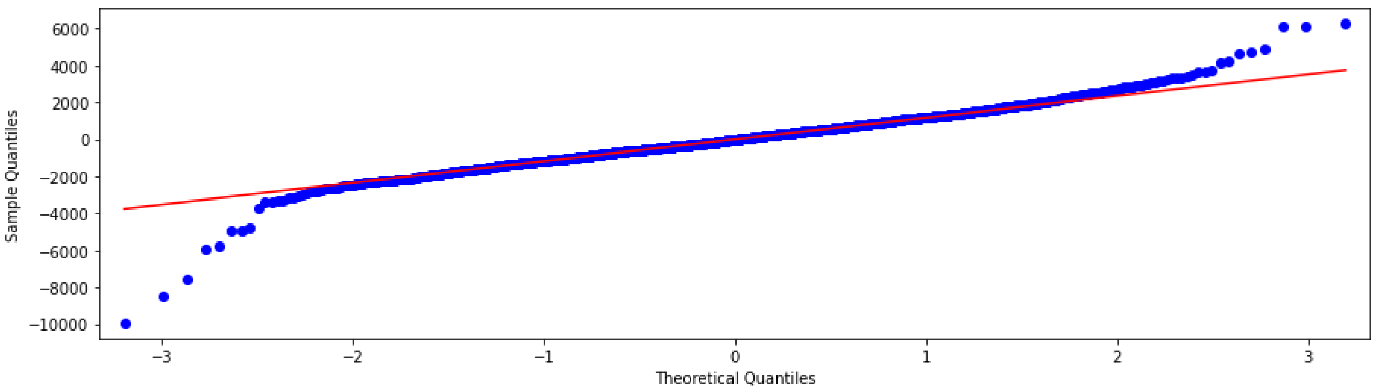
In [34]:

```
qqplot.set_size_inches(15,4)
```

In [35]:

```
qqplot
```

Out[35]:

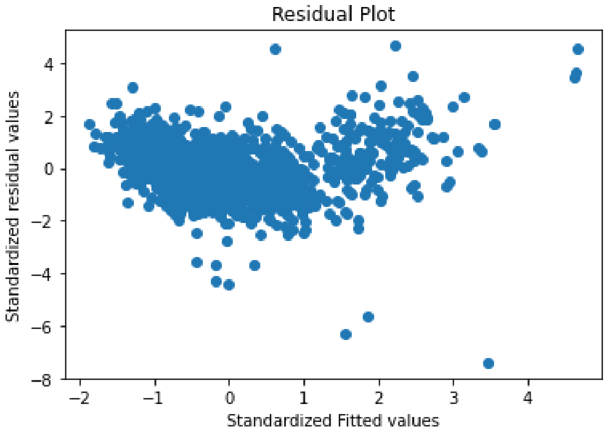


In [36]:

```
def get_standardized_values( vals ):
    return (vals - vals.mean())/vals.std()
```

In [37]:

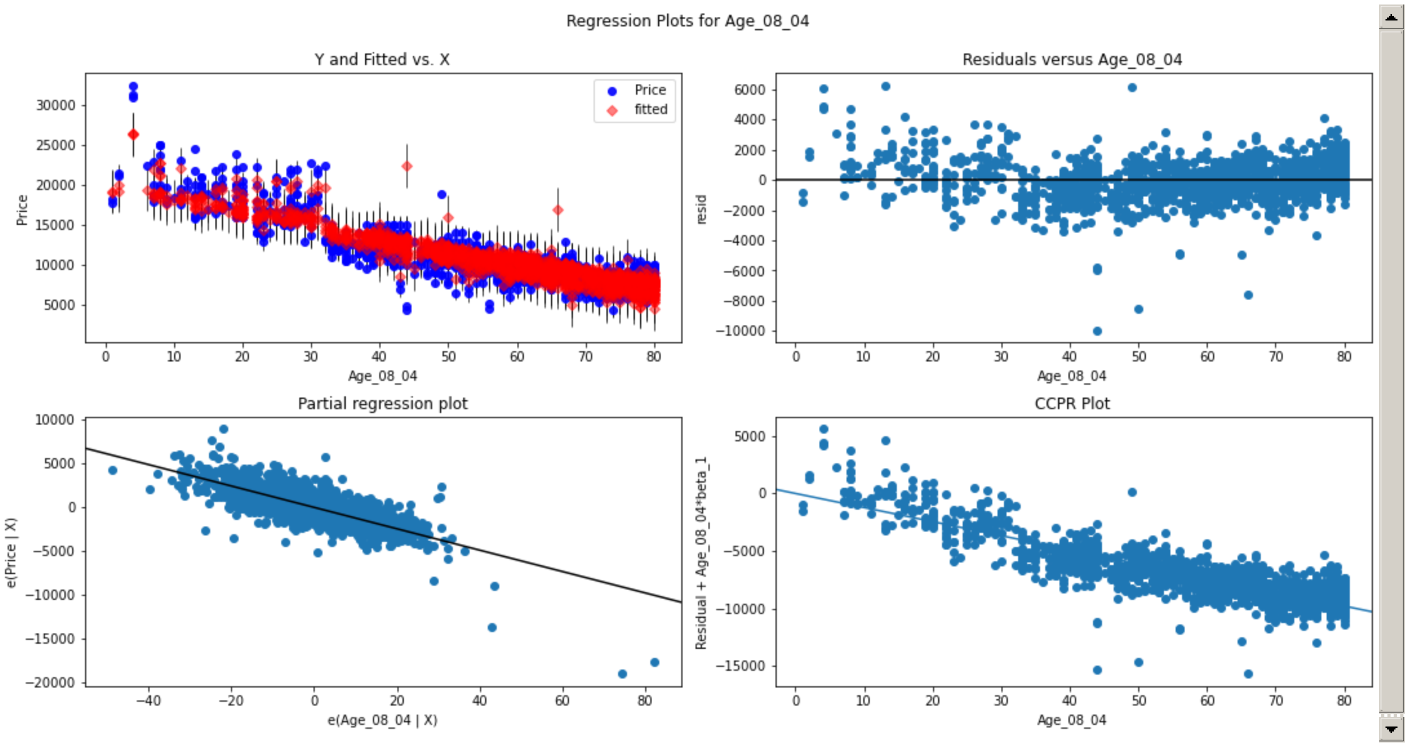
```
plt.scatter(get_standardized_values(model.fittedvalues),
            get_standardized_values(model.resid))

plt.title('Residual Plot')
plt.xlabel('Standardized Fitted values')
plt.ylabel('Standardized residual values')
plt.show()
```



In [38]:

```
fig = plt.figure(figsize=(15,8))
fig = sm.graphics.plot_regress_exog(model, "Age_08_04", fig=fig)
```

```
plt.show()
```

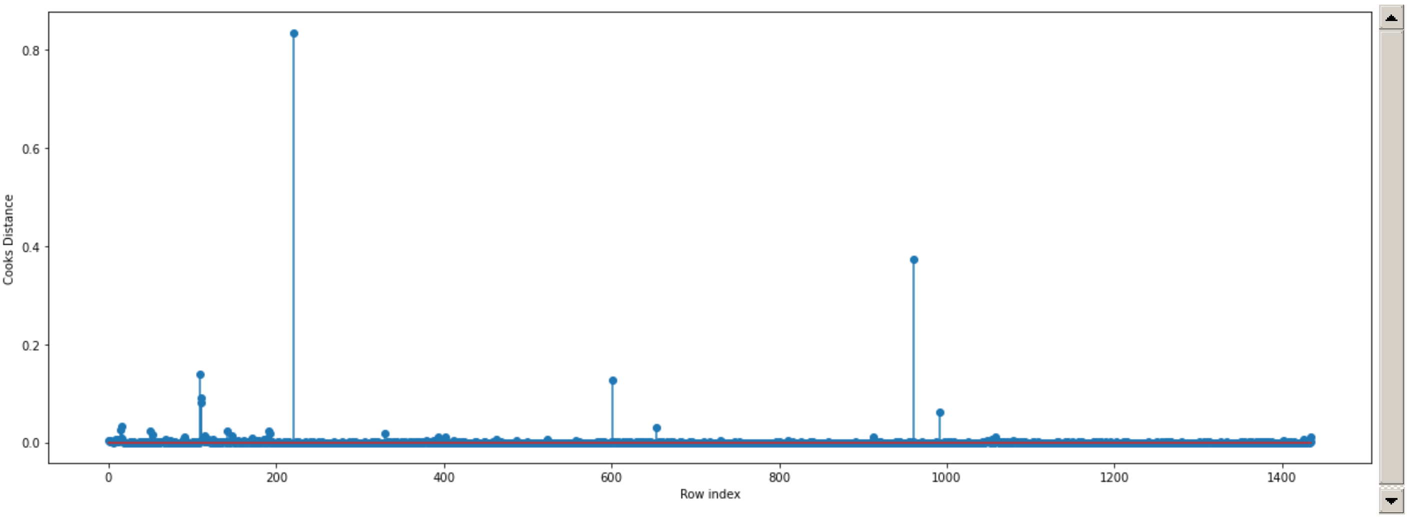


In [39]:

```
model_influence = model.get_influence()
(c, _) = model_influence.cooks_distance
```

In [40]:

```
#Plot the influencers values using stem plot
fig = plt.subplots(figsize=(20, 7))
plt.stem(np.arange(len(cars_cl)), np.round(c, 3))
plt.xlabel('Row index')
plt.ylabel('Cooks Distance')
plt.show()
```



In [41]:

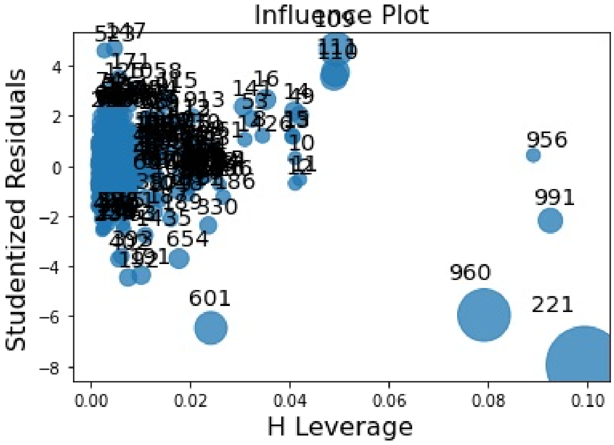
```
#index and value of influencer where c is more than .5
(np.argmax(c),np.max(c))
```

Out[41]:

```
(221, 0.835900750885391)
```

In [42]:

```
from statsmodels.graphics.regressionplots import influence_plot
influence_plot(model)
plt.show()
```



In [43]:

```
k = cars_cl.shape[1]
n = cars_cl.shape[0]
leverage_cutoff = 3*((k + 1)/n)
```

In [ ]: