In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.formula.api as smf
import statsmodels.api as sm
from statsmodels.graphics.regressionplots import influence_plot
```

In [2]:
```
# import dataset
toyo=pd.read_csv('ToyotaCorolla.csv',encoding='latin1')
toyo
```

Out[2]:

	Id	Model	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	Fuel_Type	HP	Met_Col
0	1	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13500	23	10	2002	46986	Diesel	90	
1	2	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13750	23	10	2002	72937	Diesel	90	
2	3	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	13950	24	9	2002	41711	Diesel	90	
3	4	TOYOTA Corolla 2.0 D4D HATCHB TERRA 2/3-Doors	14950	26	7	2002	48000	Diesel	90	
4	5	TOYOTA Corolla 2.0 D4D HATCHB SOL 2/3-Doors	13750	30	3	2002	38500	Diesel	90	
...	...	...	...	...	...	...	...	...	...	
1431	1438	TOYOTA Corolla 1.3 16V HATCHB G6 2/3-Doors	7500	69	12	1998	20544	Petrol	86	
1432	1439	TOYOTA Corolla 1.3 16V HATCHB LINEA TERRA 2/3-...	10845	72	9	1998	19000	Petrol	86	

	Id	Model	Price	Age_08_04	Mfg_Month	Mfg_Year	KM	Fuel_Type	HP	Met_Col
1433	1440	TOYOTA Corolla 1.3 16V HATCHB LINEA TERRA 2/3-...	8500	71	10	1998	17016	Petrol	86	
1434	1441	TOYOTA Corolla 1.3 16V HATCHB LINEA TERRA 2/3-...	7250	70	11	1998	16916	Petrol	86	
1435	1442	TOYOTA Corolla 1.6 LB LINEA TERRA 4/5-Doors	6950	76	5	1998	1	Petrol	110	

1436 rows × 38 columns

EDA

```
In [3]: toyo.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1436 entries, 0 to 1435
Data columns (total 38 columns):
 #   Column            Non-Null Count  Dtype 
---  ------            --------------  ----- 
 0   Id                1436 non-null   int64 
 1   Model             1436 non-null   object
 2   Price             1436 non-null   int64 
 3   Age_08_04         1436 non-null   int64 
 4   Mfg_Month         1436 non-null   int64 
 5   Mfg_Year          1436 non-null   int64 
 6   KM                1436 non-null   int64 
 7   Fuel_Type         1436 non-null   object
 8   HP                1436 non-null   int64 
 9   Met_Color         1436 non-null   int64 
 10  Color             1436 non-null   object
 11  Automatic         1436 non-null   int64 
 12  cc                1436 non-null   int64 
 13  Doors             1436 non-null   int64 
 14  Cylinders         1436 non-null   int64 
 15  Gears             1436 non-null   int64 
 16  Quarterly_Tax     1436 non-null   int64 
 17  Weight            1436 non-null   int64 
 18  Mfr_Guarantee     1436 non-null   int64 
 19  BOVAG_Guarantee   1436 non-null   int64 
 20  Guarantee_Period  1436 non-null   int64 
 21  ABS               1436 non-null   int64 
 22  Airbag_1          1436 non-null   int64 
 23  Airbag_2          1436 non-null   int64 
 24  Airco             1436 non-null   int64 
 25  Automatic_airco   1436 non-null   int64 
 26  Boardcomputer     1436 non-null   int64 
 27  CD_Player         1436 non-null   int64 
 28  Central_Lock      1436 non-null   int64 
 29  Powered_Windows   1436 non-null   int64 
 30  Power_Steering    1436 non-null   int64 
 31  Radio             1436 non-null   int64 
 32  Mistlamps         1436 non-null   int64 
 33  Sport_Model       1436 non-null   int64 
 34  Backseat_Divider  1436 non-null   int64 
 35  Metallic_Rim      1436 non-null   int64 
 36  Radio_cassette    1436 non-null   int64 
 37  Tow_Bar           1436 non-null   int64 
dtypes: int64(35), object(3)
memory usage: 426.4+ KB
```

In [4]:
```
toyo2=pd.concat([toyo.iloc[:,2:4],toyo.iloc[:,6:7],toyo.iloc[:,8:9],toyo.iloc[:,1
toyo2
```

Out[4]:

	Price	Age_08_04	KM	HP	cc	Doors	Gears	Quarterly_Tax	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1431	7500	69	20544	86	1300	3	5	69	1025
1432	10845	72	19000	86	1300	3	5	69	1015
1433	8500	71	17016	86	1300	3	5	69	1015
1434	7250	70	16916	86	1300	3	5	69	1015
1435	6950	76	1	110	1600	5	5	19	1114

1436 rows × 9 columns

In [5]:
```
toyo3=toyo2.rename({'Age_08_04':'Age','cc':'CC','Quarterly_Tax':'QT'},axis=1)
toyo3
```

Out[5]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1431	7500	69	20544	86	1300	3	5	69	1025
1432	10845	72	19000	86	1300	3	5	69	1015
1433	8500	71	17016	86	1300	3	5	69	1015
1434	7250	70	16916	86	1300	3	5	69	1015
1435	6950	76	1	110	1600	5	5	19	1114

1436 rows × 9 columns

In [6]:
```
toyo3[toyo3.duplicated()]
```
Out[6]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
113	24950	8	13253	116	2000	5	5	234	1320

In [7]:
```
toyo4=toyo3.drop_duplicates().reset_index(drop=True)
toyo4
```
Out[7]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1430	7500	69	20544	86	1300	3	5	69	1025
1431	10845	72	19000	86	1300	3	5	69	1015
1432	8500	71	17016	86	1300	3	5	69	1015
1433	7250	70	16916	86	1300	3	5	69	1015
1434	6950	76	1	110	1600	5	5	19	1114

1435 rows × 9 columns

In [8]:
```
toyo4.describe()
```
Out[8]:

	Price	Age	KM	HP	CC	Doors	G
count	1435.000000	1435.000000	1435.000000	1435.000000	1435.000000	1435.000000	1435.00
mean	10720.915679	55.980488	68571.782578	101.491986	1576.560976	4.032753	5.02
std	3608.732978	18.563312	37491.094553	14.981408	424.387533	0.952667	0.18
min	4350.000000	1.000000	1.000000	69.000000	1300.000000	2.000000	3.00
25%	8450.000000	44.000000	43000.000000	90.000000	1400.000000	3.000000	5.00
50%	9900.000000	61.000000	63451.000000	110.000000	1600.000000	4.000000	5.00
75%	11950.000000	70.000000	87041.500000	110.000000	1600.000000	5.000000	5.00
max	32500.000000	80.000000	243000.000000	192.000000	16000.000000	5.000000	6.00

Correlation Analysis

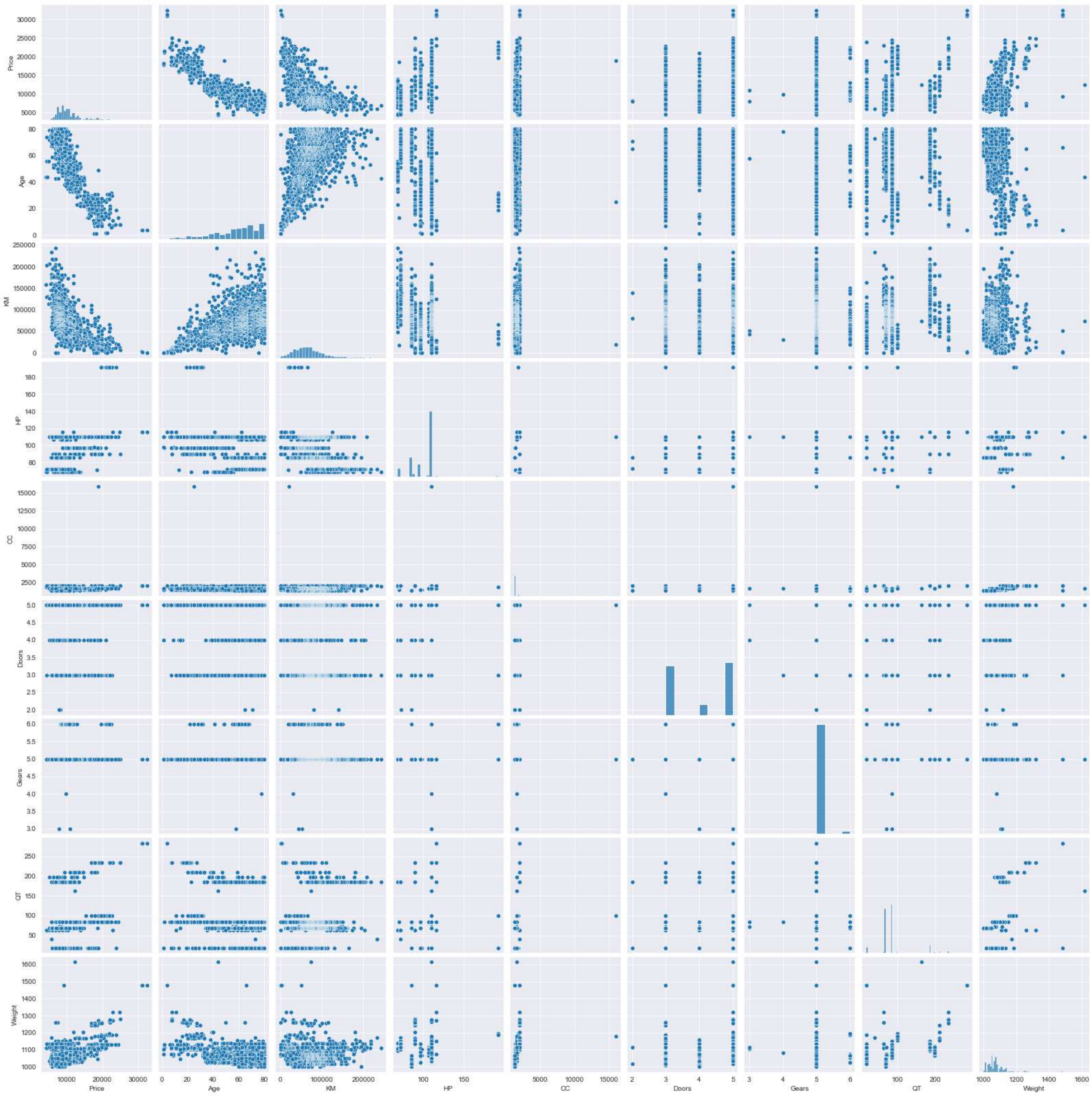
In [9]:
```
toyo4.corr()
```

Out[9]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	W
Price	1.000000	-0.876273	-0.569420	0.314134	0.124375	0.183604	0.063831	0.211508	0.57
Age	-0.876273	1.000000	0.504575	-0.155293	-0.096549	-0.146929	-0.005629	-0.193319	-0.46
KM	-0.569420	0.504575	1.000000	-0.332904	0.103822	-0.035193	0.014890	0.283312	-0.02
HP	0.314134	-0.155293	-0.332904	1.000000	0.035207	0.091803	0.209642	-0.302287	0.08
CC	0.124375	-0.096549	0.103822	0.035207	1.000000	0.079254	0.014732	0.305982	0.33
Doors	0.183604	-0.146929	-0.035193	0.091803	0.079254	1.000000	-0.160101	0.107353	0.30
Gears	0.063831	-0.005629	0.014890	0.209642	0.014732	-0.160101	1.000000	-0.005125	0.02
QT	0.211508	-0.193319	0.283312	-0.302287	0.305982	0.107353	-0.005125	1.000000	0.62
Weight	0.575869	-0.466484	-0.023969	0.087143	0.335077	0.301734	0.021238	0.621988	1.00

In [10]:
```
sns.set_style(style='darkgrid')
sns.pairplot(toyo4)
```

Out[10]:
```
<seaborn.axisgrid.PairGrid at 0x28277a52e50>
```



Model Building

In [11]:
```
model=smf.ols('Price~Age+KM+HP+CC+Doors+Gears+QT+Weight',data=toyo4).fit()
```

Model Testing

In [12]:
```
# Finding Coefficient parameters
model.params
```

Out[12]:
```
Intercept   -5472.540368
Age          -121.713891
KM             -0.020737
HP             31.584612
CC             -0.118558
Doors          -0.920189
Gears         597.715894
QT              3.858805
Weight         16.855470
dtype: float64
```

In [13]:
```python
# Finding tvalues and pvalues
model.tvalues , np.round(model.pvalues,5)
```

Out[13]:
```
(Intercept    -3.875273
 Age         -46.551876
 KM          -16.552424
 HP           11.209719
 CC           -1.316436
 Doors        -0.023012
 Gears         3.034563
 QT            2.944198
 Weight       15.760663
 dtype: float64,
 Intercept    0.00011
 Age          0.00000
 KM           0.00000
 HP           0.00000
 CC           0.18824
 Doors        0.98164
 Gears        0.00245
 QT           0.00329
 Weight       0.00000
 dtype: float64)
```

In [14]:
```python
# Finding rsquared values
model.rsquared , model.rsquared_adj   # Model accuracy is 86.17%
```

Out[14]:
```
(0.8625200256946999, 0.8617487495415145)
```

In [15]:
```python
# Build SLR and MLR models for insignificant variables 'CC' and 'Doors'
# Also find their tvalues and pvalues
```

In [16]:
```python
slr_c=smf.ols('Price~CC',data=toyo4).fit()
slr_c.tvalues , slr_c.pvalues # CC has significant pvalue
```

Out[16]:
```
(Intercept    24.879592
 CC            4.745039
 dtype: float64,
 Intercept    7.236022e-114
 CC            2.292856e-06
 dtype: float64)
```

In [17]:
```python
slr_d=smf.ols('Price~Doors',data=toyo4).fit()
slr_d.tvalues , slr_d.pvalues # Doors has significant pvalue
```

Out[17]:
```
(Intercept    19.421546
 Doors         7.070520
 dtype: float64,
 Intercept    8.976407e-75
 Doors        2.404166e-12
 dtype: float64)
```

In [18]:
```python
mlr_cd=smf.ols('Price~CC+Doors',data=toyo4).fit()
mlr_cd.tvalues , mlr_cd.pvalues # CC & Doors have significant pvalue
```

Out[18]:
```
(Intercept    12.786341
 CC            4.268006
 Doors         6.752236
 dtype: float64,
 Intercept    1.580945e-35
 CC           2.101878e-05
 Doors        2.109558e-11
 dtype: float64)
```

Model Validation Techniques

Two Techniques: 1. Collinearity Check & 2. Residual Analysis

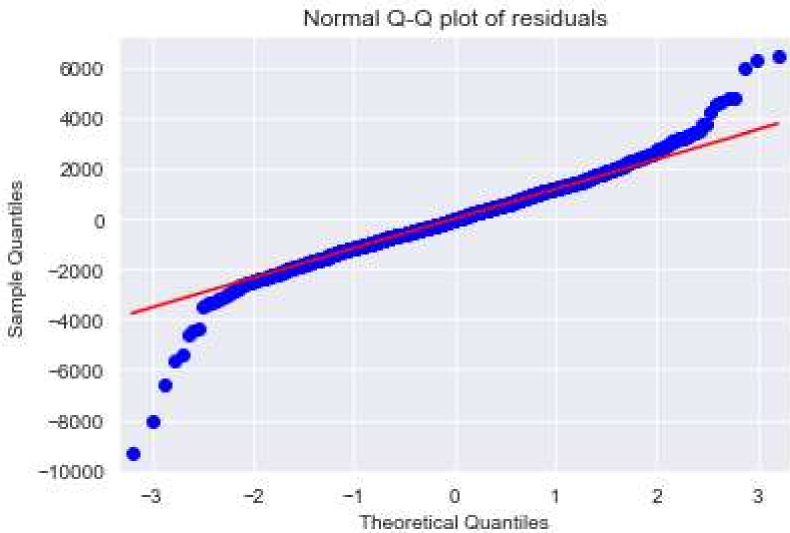
In [19]:
```
# 1) Collinearity Problem Check
# Calculate VIF = 1/(1-Rsquare) for all independent variables

rsq_age=smf.ols('Age~KM+HP+CC+Doors+Gears+QT+Weight',data=toyo4).fit().rsquared
vif_age=1/(1-rsq_age)

rsq_KM=smf.ols('KM~Age+HP+CC+Doors+Gears+QT+Weight',data=toyo4).fit().rsquared
vif_KM=1/(1-rsq_KM)

rsq_HP=smf.ols('HP~Age+KM+CC+Doors+Gears+QT+Weight',data=toyo4).fit().rsquared
vif_HP=1/(1-rsq_HP)

rsq_CC=smf.ols('CC~Age+KM+HP+Doors+Gears+QT+Weight',data=toyo4).fit().rsquared
vif_CC=1/(1-rsq_CC)

rsq_DR=smf.ols('Doors~Age+KM+HP+CC+Gears+QT+Weight',data=toyo4).fit().rsquared
vif_DR=1/(1-rsq_DR)

rsq_GR=smf.ols('Gears~Age+KM+HP+CC+Doors+QT+Weight',data=toyo4).fit().rsquared
vif_GR=1/(1-rsq_GR)

rsq_QT=smf.ols('QT~Age+KM+HP+CC+Doors+Gears+Weight',data=toyo4).fit().rsquared
vif_QT=1/(1-rsq_QT)

rsq_WT=smf.ols('Weight~Age+KM+HP+CC+Doors+Gears+QT',data=toyo4).fit().rsquared
vif_WT=1/(1-rsq_WT)

# Putting the values in Dataframe format
d1={'Variables':['Age','KM','HP','CC','Doors','Gears','QT','Weight'],
    'Vif':[vif_age,vif_KM,vif_HP,vif_CC,vif_DR,vif_GR,vif_QT,vif_WT]}
Vif_df=pd.DataFrame(d1)
Vif_df
```

Out[19]:

	Variables	Vif
0	Age	1.876236
1	KM	1.757178
2	HP	1.419180
3	CC	1.163470
4	Doors	1.155890
5	Gears	1.098843
6	QT	2.295375
7	Weight	2.487180

In [20]:
```
# None variable has VIF>20, No Collinearity, so consider all varaibles in Regress
```

In [21]:
```python
# 2) Residual Analysis
# Test for Normality of Residuals (Q-Q Plot) using residual model (model.resid)
sm.qqplot(model.resid,line='q') # 'q' - A line is fit through the quartiles # lir
plt.title("Normal Q-Q plot of residuals")
plt.show()
```



In [22]:
```python
list(np.where(model.resid>6000))  # outliar detection from above QQ plot of resic
```

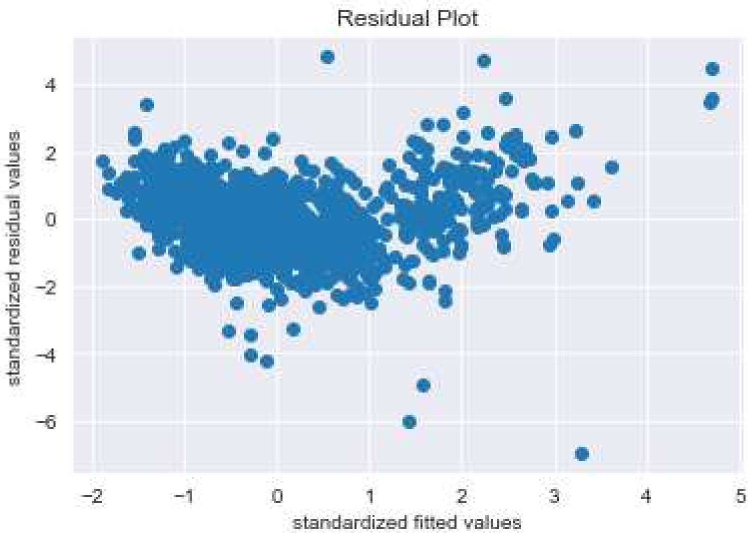
Out[22]:
```
[array([109, 146, 522], dtype=int64)]
```

In [23]:
```python
list(np.where(model.resid<-6000))
```

Out[23]:
```
[array([220, 600, 959], dtype=int64)]
```

In [24]:
```python
# Test for Homoscedasticity or Heteroscedasticity (plotting model's standardized

def standard_values(vals) : return (vals-vals.mean())/vals.std()  # User defined
```

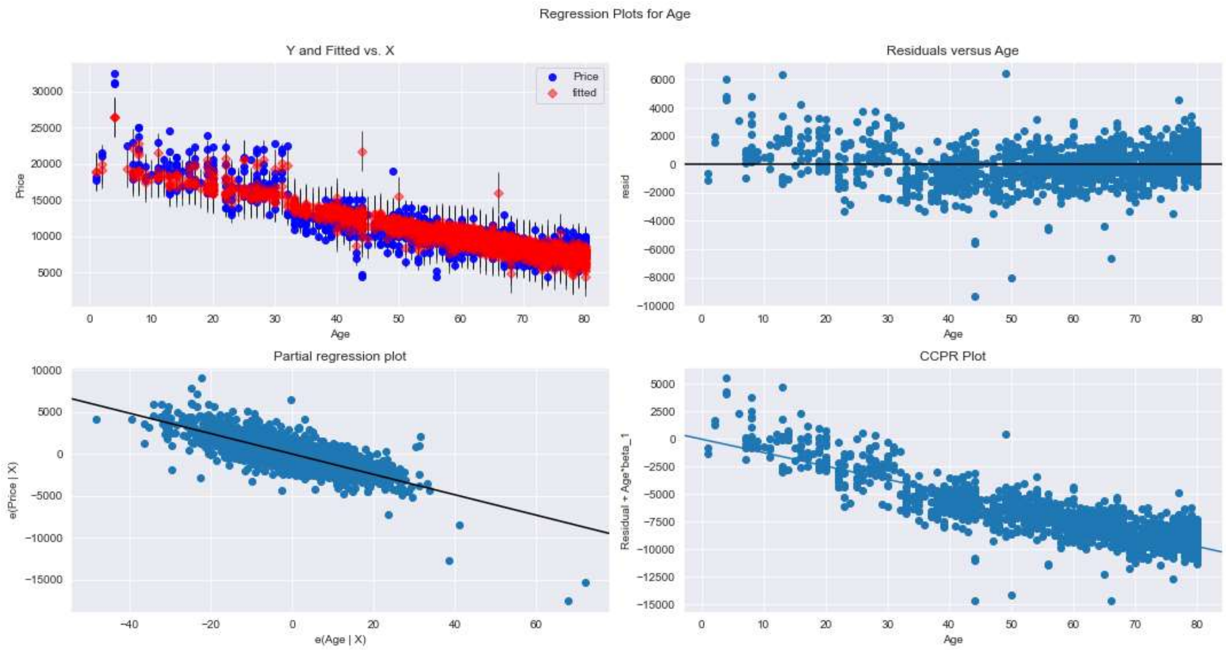
In [25]:
```
plt.scatter(standard_values(model.fittedvalues),standard_values(model.resid))
plt.title('Residual Plot')
plt.xlabel('standardized fitted values')
plt.ylabel('standardized residual values')
plt.show()
```



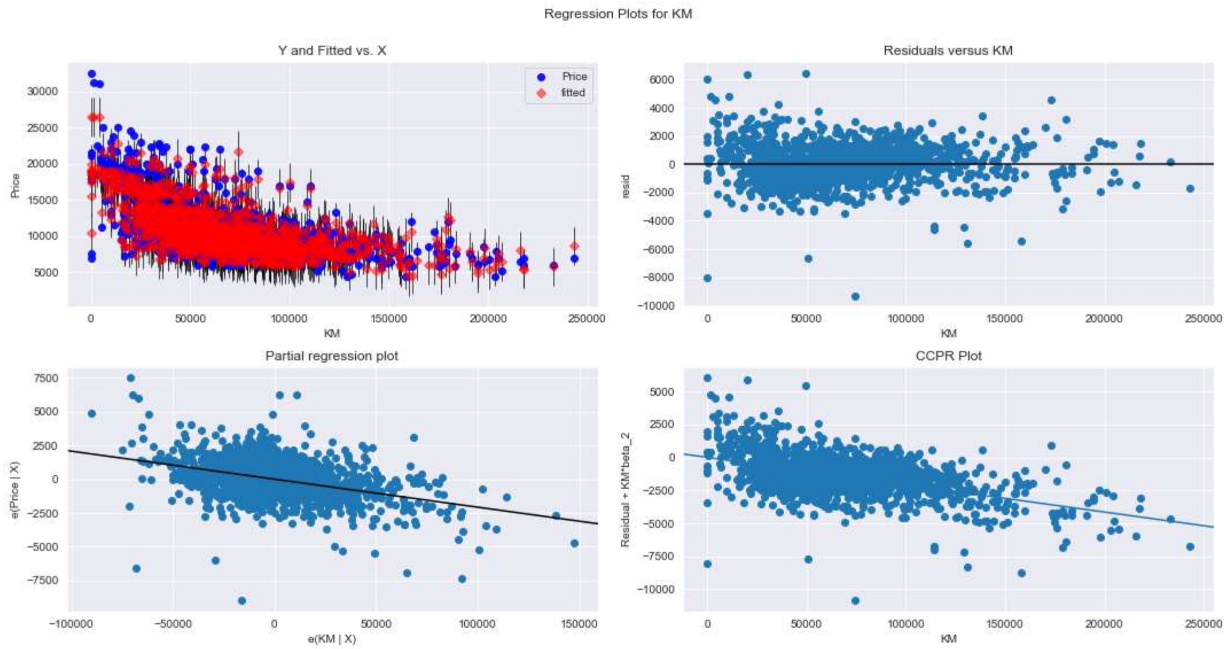
In [26]:
```
# Test for errors or Residuals Vs Regressors or independent 'x' variables or pred
# using Residual Regression Plots code graphics.plot_regress_exog(model,'x',fig)
```

In [27]:

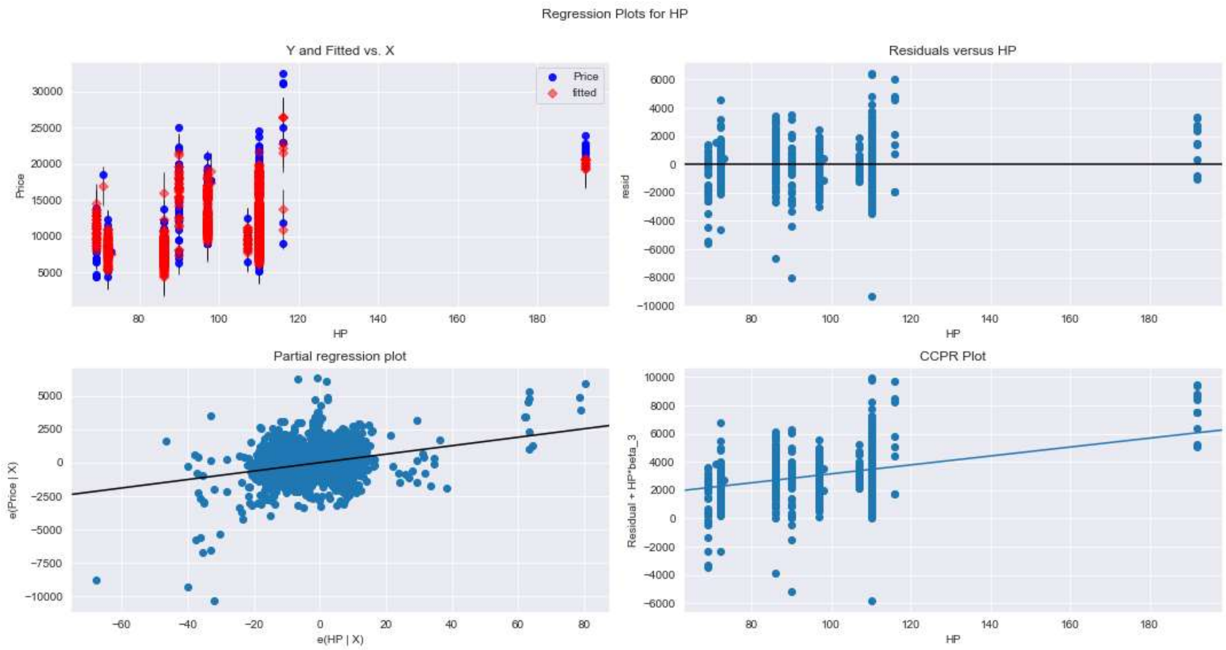
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'Age',fig=fig)
plt.show()
```



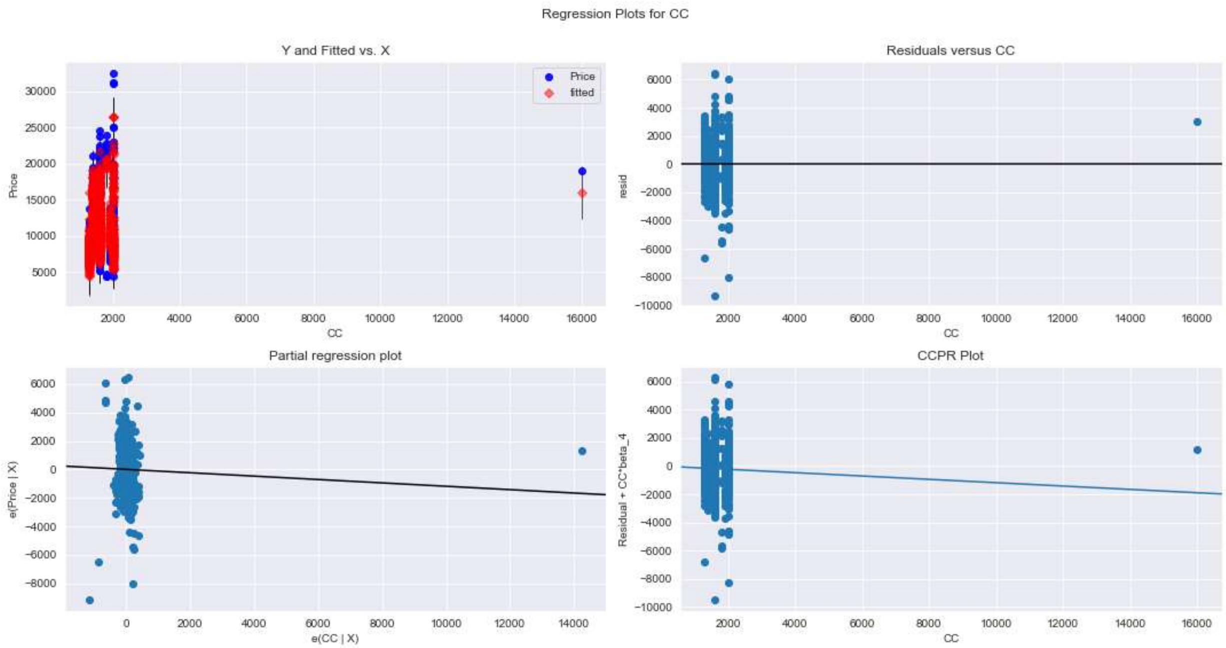
In [28]:
```python
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'KM',fig=fig)
plt.show()
```



In [29]:
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'HP',fig=fig)
plt.show()
```

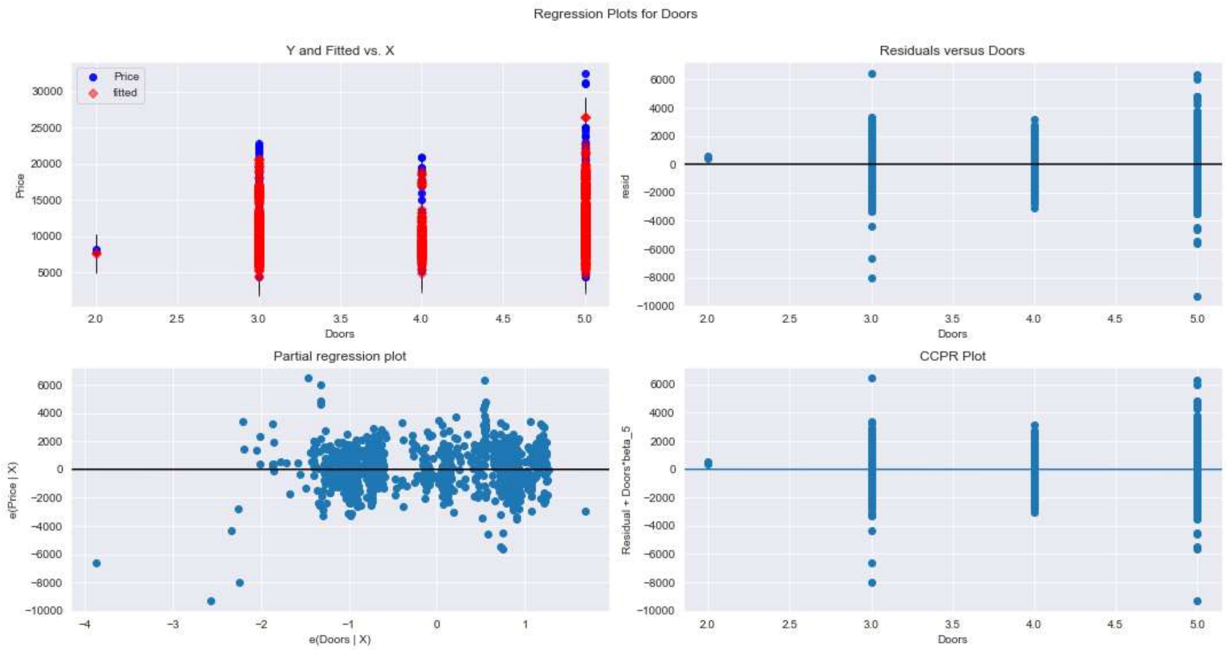


In [30]:
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'CC',fig=fig)
plt.show()
```

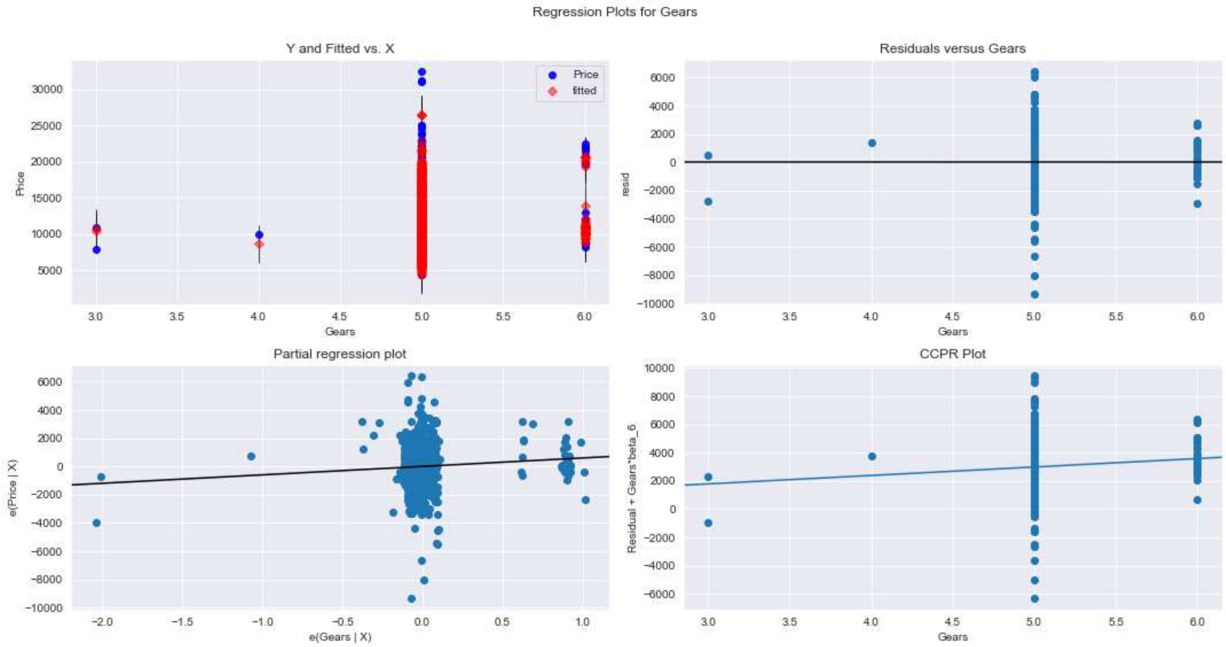


In [31]:

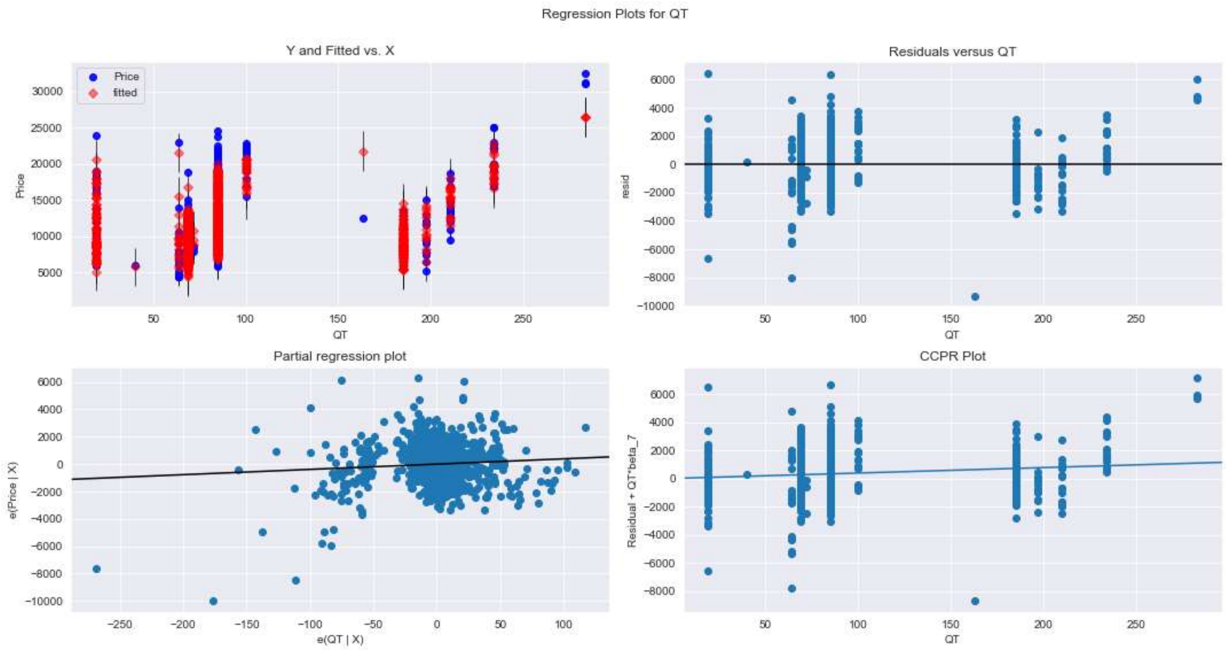
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'Doors',fig=fig)
plt.show()
```



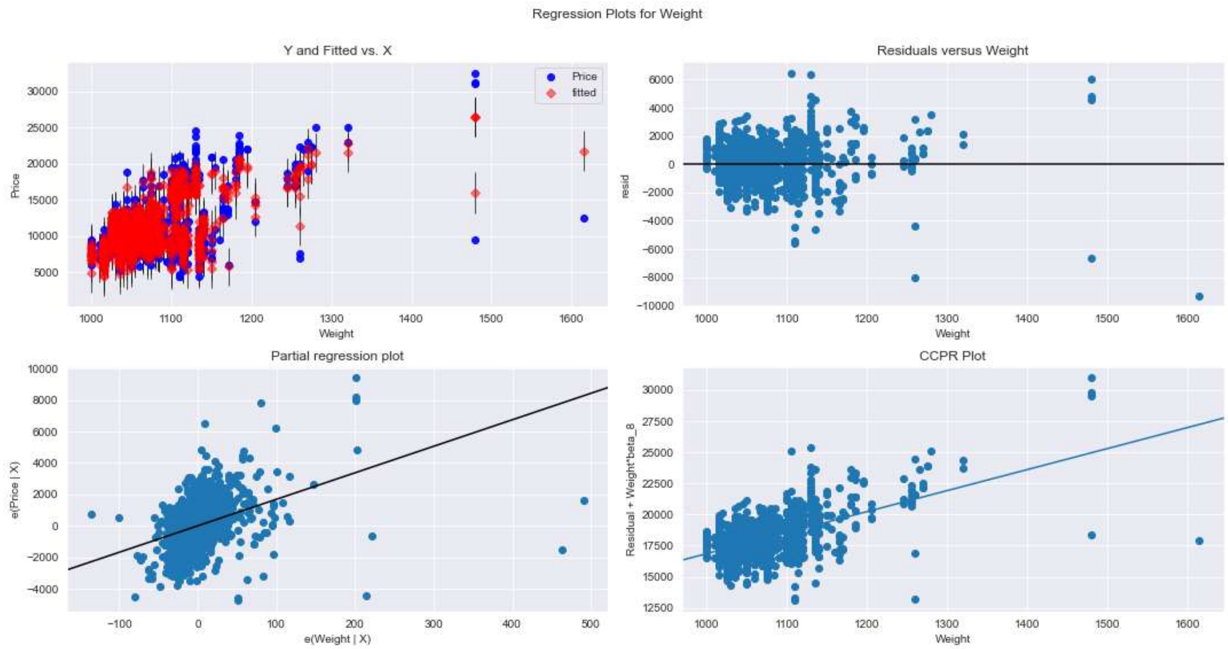
In [32]:
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'Gears',fig=fig)
plt.show()
```



In [33]:
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'QT',fig=fig)
plt.show()
```



In [34]:
```
fig=plt.figure(figsize=(15,8))
sm.graphics.plot_regress_exog(model,'Weight',fig=fig)
plt.show()
```



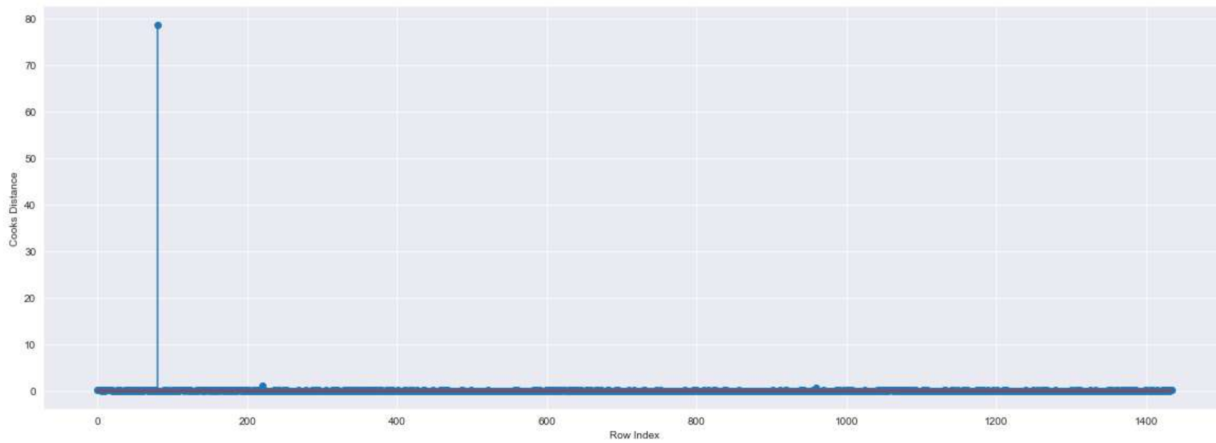
Model Deletion Diagnostics (checking Outliers or Influencers)

Two Techniques : 1. Cook's Distance & 2. Leverage value

In [35]:
```
# Get influencers using cook's distance
(c,_)=model.get_influence().cooks_distance
c
```

Out[35]:
```
array([7.22221054e-03, 3.94547973e-03, 5.44224039e-03, ...,
       8.04110550e-07, 6.99854767e-04, 1.08408002e-02])
```

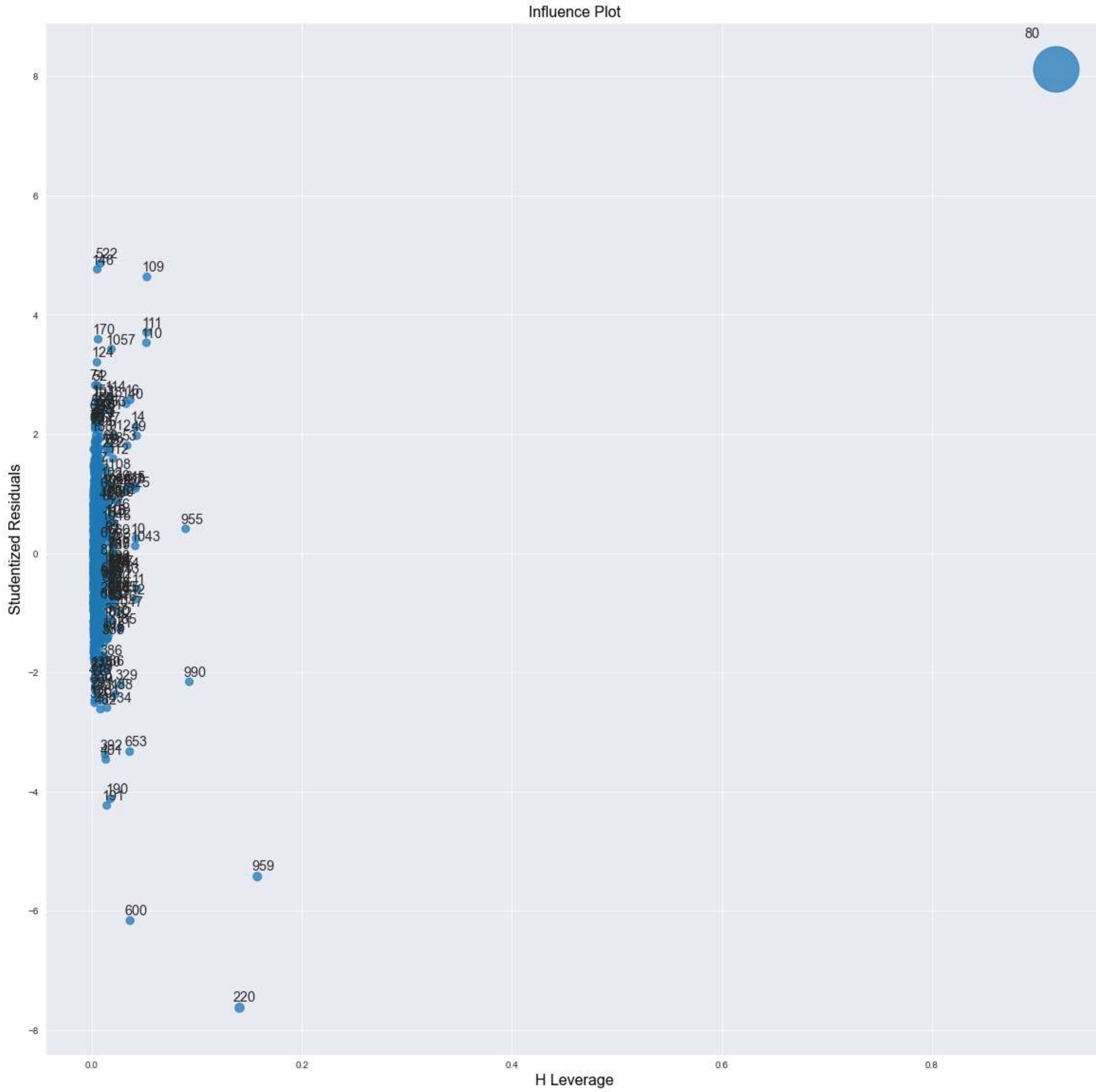
In [36]:
```
# Plot the influencers using the stem plot
fig=plt.figure(figsize=(20,7))
plt.stem(np.arange(len(toyo4)),np.round(c,3))
plt.xlabel('Row Index')
plt.ylabel('Cooks Distance')
plt.show()
```



In [37]:
```
# Index and value of influencer where C>0.5
np.argmax(c) , np.max(c)
```

Out[37]:
```
(80, 78.7295058224556)
```

In [38]:
```
# 2. Leverage Value using High Influence Points : Points beyond Leverage_cutoff v
fig,ax=plt.subplots(figsize=(20,20))
fig=influence_plot(model,ax = ax)
```



In [39]:
```
# Leverage Cuttoff Value = 3*(k+1)/n ; k = no.of features/columns & n = no. of da
k=toyo4.shape[1]
n=toyo4.shape[0]
leverage_cutoff = (3*(k+1))/n
leverage_cutoff
```

Out[39]: 0.020905923344947737

In [40]:
```
toyo4[toyo4.index.isin([80])]
```

Out[40]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
80	18950	25	20019	110	16000	5	5	100	1180

Improving the Model

In [41]:
```
# Creating a copy of data so that original dataset is not affected
toyo_new=toyo4.copy()
toyo_new
```

Out[41]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1430	7500	69	20544	86	1300	3	5	69	1025
1431	10845	72	19000	86	1300	3	5	69	1015
1432	8500	71	17016	86	1300	3	5	69	1015
1433	7250	70	16916	86	1300	3	5	69	1015
1434	6950	76	1	110	1600	5	5	19	1114

1435 rows × 9 columns

In [42]:
```
# Discard the data points which are influencers and reassign the row number (rese
toyo5=toyo_new.drop(toyo_new.index[[80]],axis=0).reset_index(drop=True)
toyo5
```

Out[42]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1429	7500	69	20544	86	1300	3	5	69	1025
1430	10845	72	19000	86	1300	3	5	69	1015
1431	8500	71	17016	86	1300	3	5	69	1015
1432	7250	70	16916	86	1300	3	5	69	1015
1433	6950	76	1	110	1600	5	5	19	1114

1434 rows × 9 columns

Model Deletion Diagnostics and Final Model

In [43]:
```
 while np.max(c)>0.5 :
    model=smf.ols('Price~Age+KM+HP+CC+Doors+Gears+QT+Weight',data=toyo5).fit()
    (c,_)=model.get_influence().cooks_distance
    c
    np.argmax(c) , np.max(c)
    toyo5=toyo5.drop(toyo5.index[[np.argmax(c)]],axis=0).reset_index(drop=True)
    toyo5
else:
    final_model=smf.ols('Price~Age+KM+HP+CC+Doors+Gears+QT+Weight',data=toyo5).fi
    final_model.rsquared , final_model.aic
    print("Thus model accuracy is improved to",final_model.rsquared)
```

```
Thus model accuracy is improved to 0.8882395145171204
```

In [44]:
```
if np.max(c)>0.5:
    model=smf.ols('Price~Age+KM+HP+CC+Doors+Gears+QT+Weight',data=toyo5).fit()
    (c,_)=model.get_influence().cooks_distance
    c
    np.argmax(c) , np.max(c)
    toyo5=toyo5.drop(toyo5.index[[np.argmax(c)]],axis=0).reset_index(drop=True)
    toyo5
elif np.max(c)<0.5:
    final_model=smf.ols('Price~Age+KM+HP+CC+Doors+Gears+QT+Weight',data=toyo5).fi
    final_model.rsquared , final_model.aic
    print("Thus model accuracy is improved to",final_model.rsquared)
```

```
Thus model accuracy is improved to 0.8882395145171204
```

In [45]:
```
final_model.rsquared
```

Out[45]:
```
0.8882395145171204
```

In [46]:
```
toyo5
```

Out[46]:

	Price	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	13500	23	46986	90	2000	3	5	210	1165
1	13750	23	72937	90	2000	3	5	210	1165
2	13950	24	41711	90	2000	3	5	210	1165
3	14950	26	48000	90	2000	3	5	210	1165
4	13750	30	38500	90	2000	3	5	210	1170
...	...	...	...	...	...	...	...	...	...
1426	7500	69	20544	86	1300	3	5	69	1025
1427	10845	72	19000	86	1300	3	5	69	1015
1428	8500	71	17016	86	1300	3	5	69	1015
1429	7250	70	16916	86	1300	3	5	69	1015
1430	6950	76	1	110	1600	5	5	19	1114

1431 rows × 9 columns

Model Predictions

In [47]:
```
# say New data for prediction is
new_data=pd.DataFrame({'Age':12,"KM":40000,"HP":80,"CC":1300,"Doors":4,"Gears":5,
new_data
```

Out[47]:

	Age	KM	HP	CC	Doors	Gears	QT	Weight
0	12	40000	80	1300	4	5	69	1012

In [48]:
```
# Manual Prediction of Price
final_model.predict(new_data)
```

Out[48]:
```
0    14341.570181
dtype: float64
```

In [49]:
```
# Automatic Prediction of Price with 90.02% accurcy
pred_y=final_model.predict(toyo5)
pred_y
```

Out[49]:
```
0       16345.352610
1       15886.635544
2       16328.224968
3       15996.318854
4       15883.424182
            ...
1426     9161.230587
1427     8536.091326
1428     8681.531063
1429     8793.668694
1430    10860.695492
Length: 1431, dtype: float64
```

In [ ]: