Act 1. Regresion lineal Simple

> CO2 Emission by Vehicles

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Contenidos

1. ¿Cuáles son las caracteríaticas que más influyen en la emisión de CO2?

```
Considerando las pruebas realizadas en esta actividad, las
variables con más influencias en la emisión de Dioxido de Carbono
 (CO2) son:
  * Fuel Consumption Comb (mpg)
  * Fuel Consumption Comb (L/100 km)
  * Fuel Consumption City (L/100 km)

  Pues su correlación es mayor a 0.8
```

2. ¿Habrá alguna diferencia en la emisiones de CO2 cuando el consumo de combustible para la ciudad y carretera se consideran por separado?

```
Si, ya que el consumo de combustime en la ciudad tiene una mayor
correlación con el gasto total. Al combinarlos es más cercana la
predicción a las emisiones de Dioxido de Carbono (CO2) totales.
Esto se da ya que al suponer que las emisiones  Pues así al combiarlas
el consumo
```

Llamado a librerías

In [ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/c
ontent/drive", force_remount=True).
```

In [ ]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from scipy.stats import norm, uniform, skewnorm
```

Importamos los datos a un DataFrame

In [ ]:
```
df = pd.read_csv('/content/drive/Shareddrives/Reto IA/Actividades/CO2_Emissions/CO2 Emissions_
df.head()
```

Out[ ]:

	Make	Model	Vehicle Class	Engine Size(L)	Cylinders	Transmission	Fuel Type	Fuel Consumption City (L/100 km)	Fuel Consumption Hwy (L/100 km)	Fu Consumptic Comb (L/1(km
0	ACURA	ILX	COMPACT	2.0	4	AS5	Z	9.9	6.7	8
1	ACURA	ILX	COMPACT	2.4	4	M6	Z	11.2	7.7	9
2	ACURA	ILX HYBRID	COMPACT	1.5	4	AV7	Z	6.0	5.8	5
3	ACURA	MDX 4WD	SUV - SMALL	3.5	6	AS6	Z	12.7	9.1	11
4	ACURA	RDX AWD	SUV - SMALL	3.5	6	AS6	Z	12.1	8.7	10

In [ ]:
```
df.isnull().sum()
```

Out[ ]:
```
Make                              0
Model                             0
Vehicle Class                     0
Engine Size(L)                    0
Cylinders                         0
Transmission                      0
Fuel Type                         0
Fuel Consumption City (L/100 km)  0
Fuel Consumption Hwy (L/100 km)   0
Fuel Consumption Comb (L/100 km)  0
Fuel Consumption Comb (mpg)       0
CO2 Emissions(g/km)               0
dtype: int64
```

In [ ]:
```
df.shape
```

Out[ ]:
```
(7385, 12)
```

In [ ]:
```
df.columns
```

Out[ ]:
```
Index(['Make', 'Model', 'Vehicle Class', 'Engine Size(L)', 'Cylinders',
       'Transmission', 'Fuel Type', 'Fuel Consumption City (L/100 km)',
       'Fuel Consumption Hwy (L/100 km)', 'Fuel Consumption Comb (L/100 km)',
       'Fuel Consumption Comb (mpg)', 'CO2 Emissions(g/km)'],
      dtype='object')
```

In [ ]:
```
df.describe()
```

Out[ ]:

	Engine Size(L)	Cylinders	Fuel Consumption City (L/100 km)	Fuel Consumption Hwy (L/100 km)	Fuel Consumption Comb (L/100 km)	Fuel Consumption Comb (mpg)	CO2 Emissions(g/km)
count	7385.000000	7385.000000	7385.000000	7385.000000	7385.000000	7385.000000	7385.000000
mean	3.160068	5.615030	12.556534	9.041706	10.975071	27.481652	250.584699
std	1.354170	1.828307	3.500274	2.224456	2.892506	7.231879	58.512679
min	0.900000	3.000000	4.200000	4.000000	4.100000	11.000000	96.000000
25%	2.000000	4.000000	10.100000	7.500000	8.900000	22.000000	208.000000
50%	3.000000	6.000000	12.100000	8.700000	10.600000	27.000000	246.000000
75%	3.700000	6.000000	14.600000	10.200000	12.600000	32.000000	288.000000
max	8.400000	16.000000	30.600000	20.600000	26.100000	69.000000	522.000000

Funciones genereales

In [ ]:
```
def plt_scatter(x, y, xl, yl):
  plt.subplot(1, 2, 1)
  plt.scatter(x, y)
  plt.xlabel(xl)
  plt.ylabel(yl)
  plt.grid()
```

In [ ]:
```
def plt_scatter_w_line(x, y, b0, b1, xl, yl):
  x_line = np.linspace(min(x), max(x), 100)
  y_line = b0 + b1 * x_line
  plt.subplot(1, 2, 2)
  plt.scatter(x,y)
  plt.xlabel(xl)
  plt.ylabel(yl)
  plt.grid()

  plt.plot(x_line, y_line, color='red')
```

In [ ]:
```
def Asimetric_Dist(r, title):
  plt.hist(r, density = True, bins = 'auto', histtype='stepfilled', alpha=0.2)
  plt.title(title)
  plt.grid()
  plt.show()
```

In [ ]:
```
def OLS(x, y):
  x = sm.add_constant(x)
  model = sm.OLS(y, x)
  result = model.fit()
  print('Params:', result.params)
  print('R^2:', result.rsquared)
```

Engine Size(L)

In [ ]:
```
x_ms = df['Engine Size(L)']
y = df['CO2 Emissions(g/km)']
```

In [ ]:
```
X_ms = sm.add_constant(x_ms)
print(X_ms.shape)
print(X_ms)
```

```
(7385, 2)
      const  Engine Size(L)
0       1.0             2.0
1       1.0             2.4
2       1.0             1.5
3       1.0             3.5
4       1.0             3.5
...     ...             ...
7380    1.0             2.0
7381    1.0             2.0
7382    1.0             2.0
7383    1.0             2.0
7384    1.0             2.0

[7385 rows x 2 columns]
```

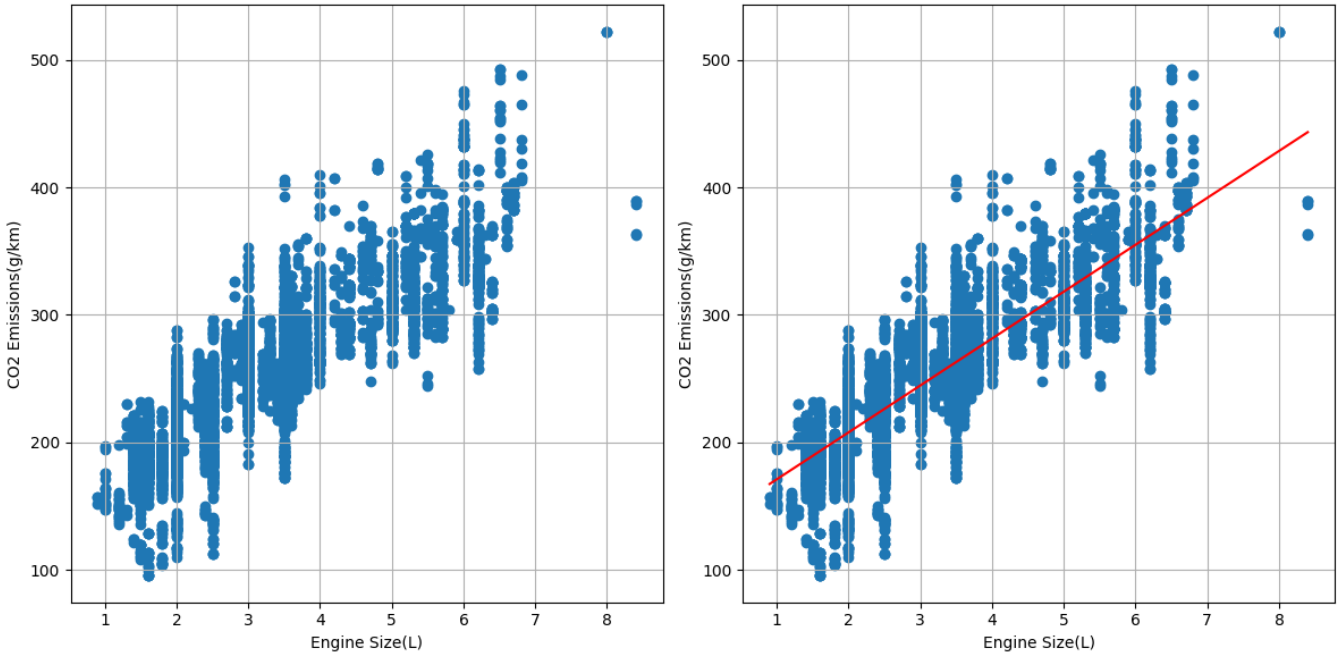
In [ ]:
```
model = sm.OLS(y,X_ms)
result = model.fit()
result.params
```

Out[ ]:
```
const             134.365893
Engine Size(L)     36.777315
dtype: float64
```

In [ ]:
```
print("\nR2: ", result.rsquared)
```

```
R2:  0.7244472046524082
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_ms, y, 'Engine Size(L)', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_ms, y, result.params[0], result.params[1], 'Engine Size(L)', 'CO2 Emissi
plt.tight_layout()
plt.show()
```



Cylinders

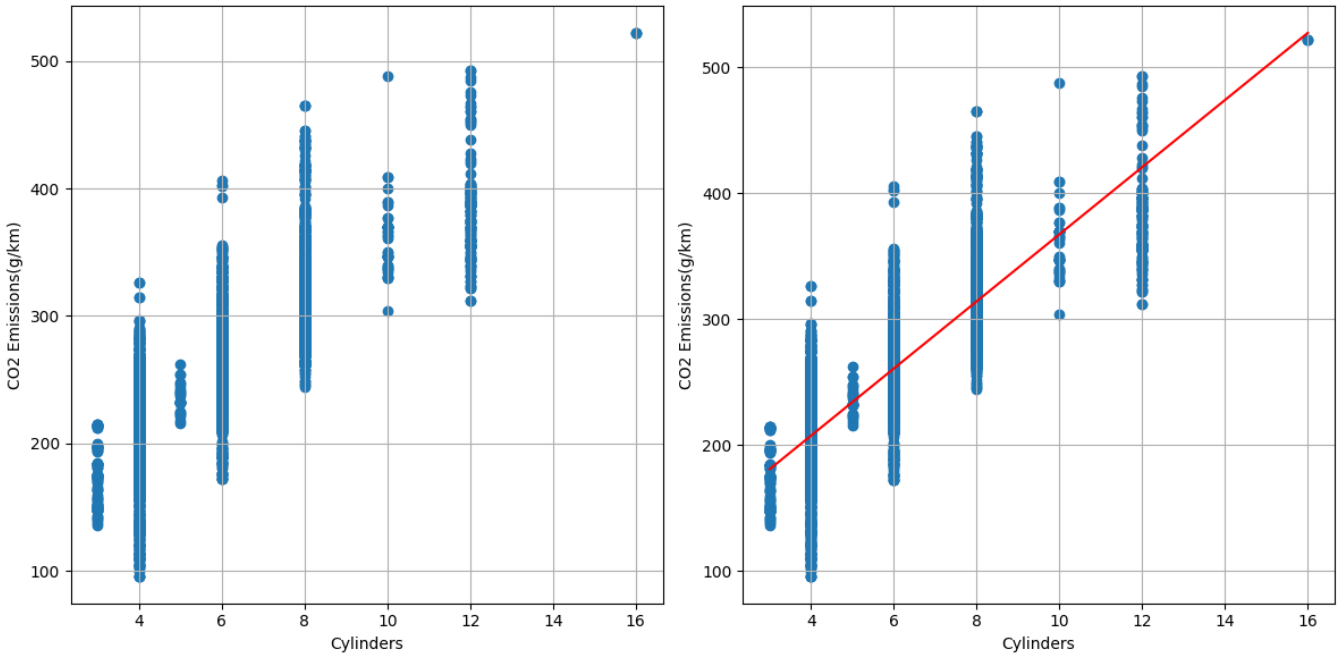
In [ ]:
```
x_cyl = df['Cylinders']
X_cyl = sm.add_constant(x_cyl)
model = sm.OLS(y,X_cyl)
result = model.fit()
result.params
```

Out[ ]:
```
const        100.956915
Cylinders     26.647724
dtype: float64
```

In [ ]:
```
print("\nR2: ", result.rsquared)
```

```
R2:  0.6932953649936133
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_cyl, y, 'Cylinders', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_cyl, y, result.params[0], result.params[1], 'Cylinders', 'CO2 Emissions(
plt.tight_layout()
plt.show()
```

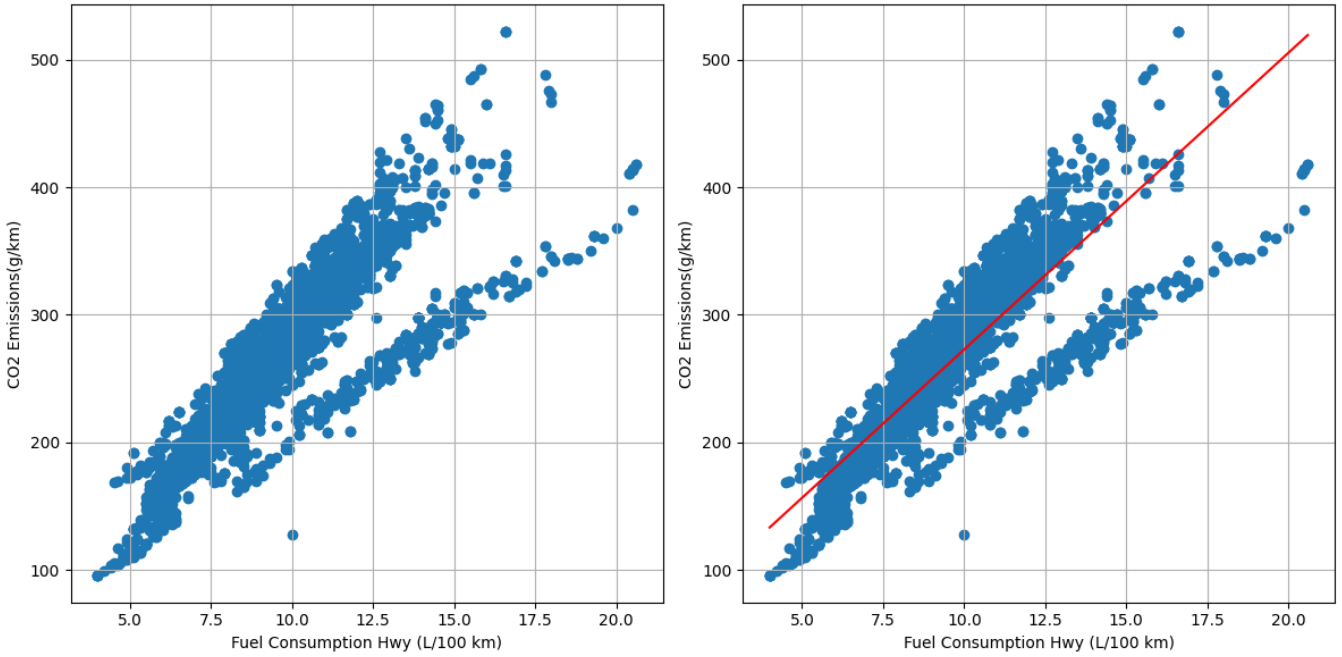


Fuel Consumption Hwy (L/100 km)

In [ ]:
```
x_fch = df['Fuel Consumption Hwy (L/100 km)']
X_fch = sm.add_constant(x_fch)
model = sm.OLS(y,X_fch)
result = model.fit()
print(result.params)
print("\nR2: ", result.rsquared)
```

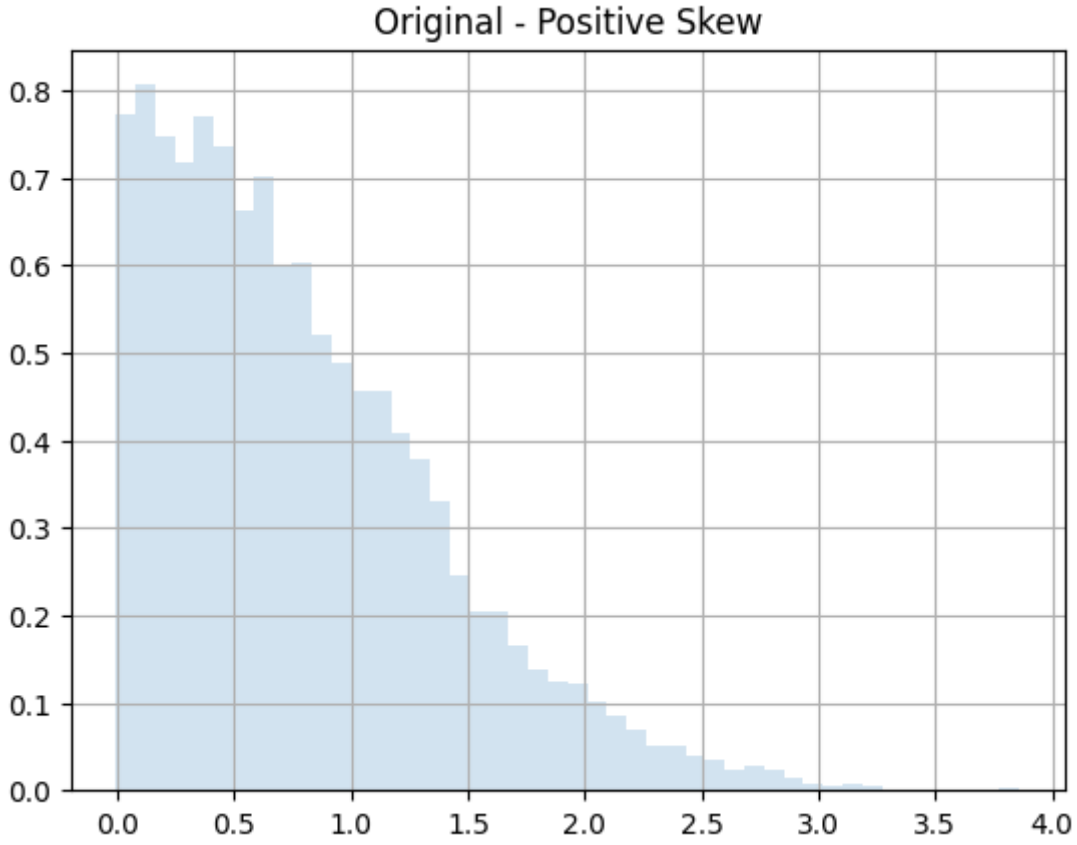
```
const                              40.448581
Fuel Consumption Hwy (L/100 km)    23.240759
dtype: float64

R2:  0.7806357669286315
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_fch, y, 'Fuel Consumption Hwy (L/100 km)', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_fch, y, result.params[0], result.params[1], 'Fuel Consumption Hwy (L/100
plt.tight_layout()
plt.show()
```

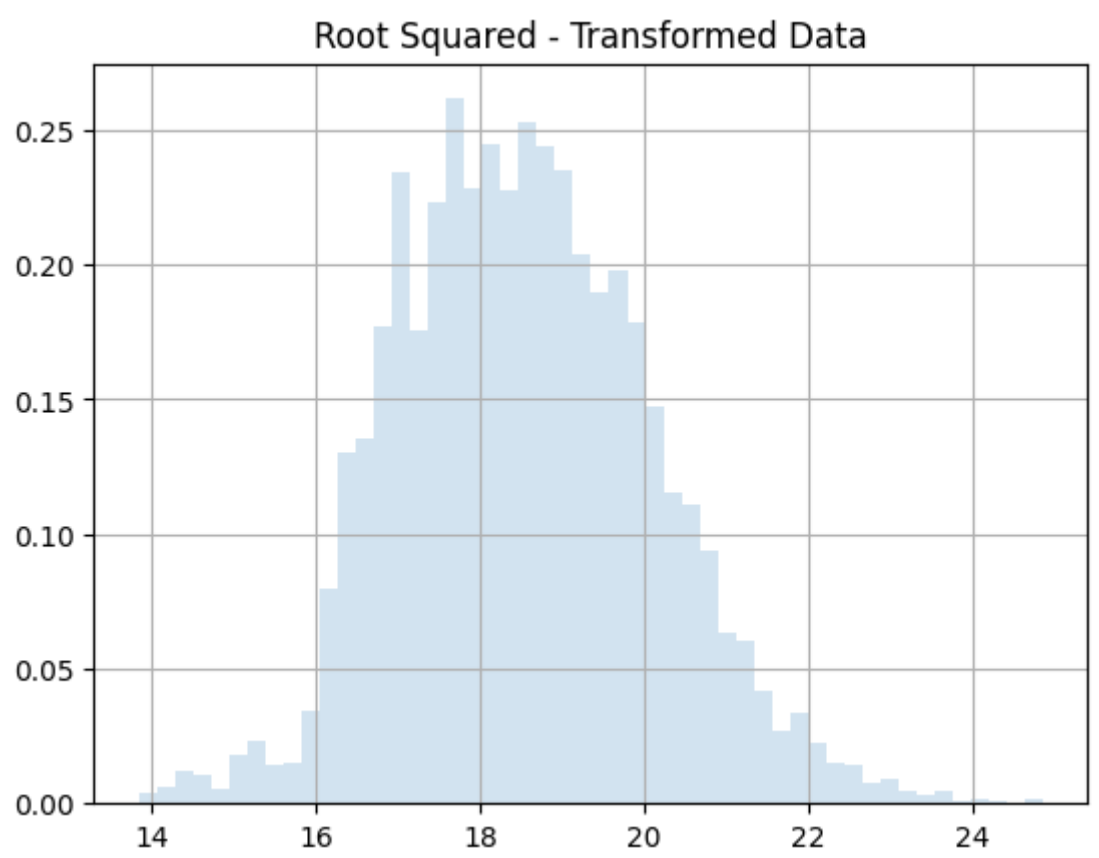


Análisis de distribuciones

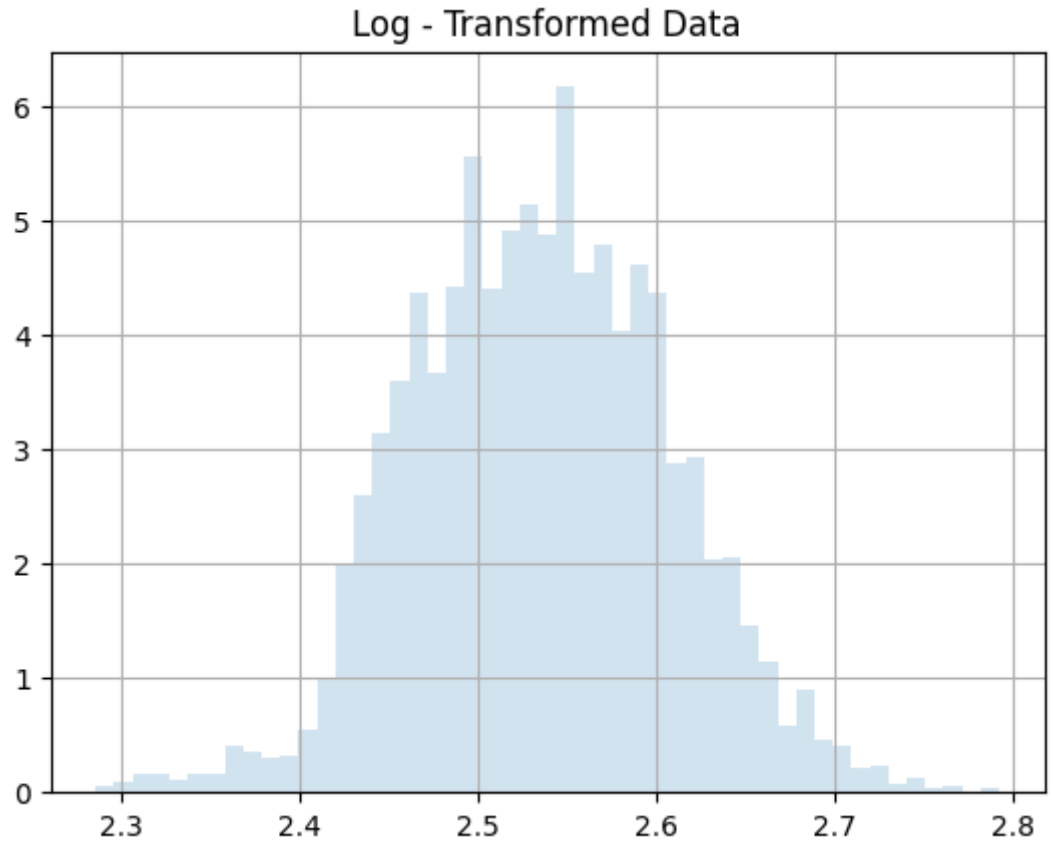
In [ ]:
```
y_skew = skewnorm.rvs(y)
Asimetric_Dist(y_skew, 'Original - Positive Skew')
```



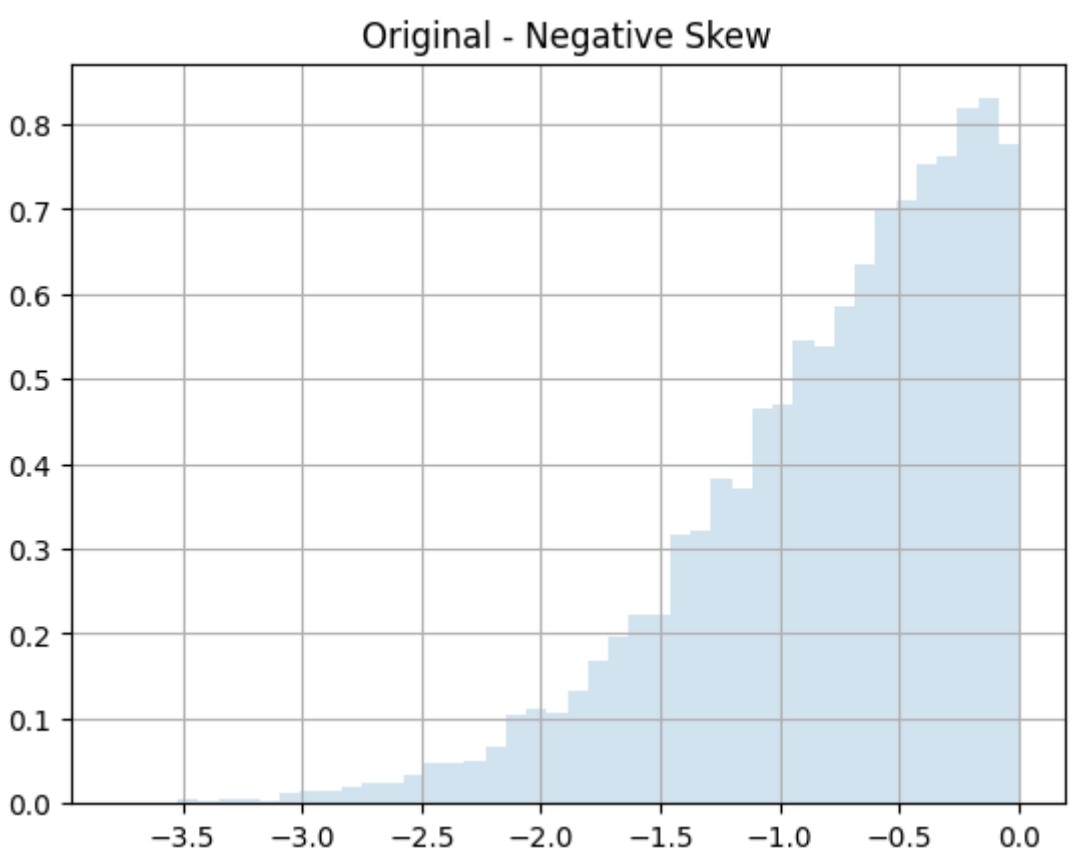
In [ ]:
```
y_root = np.sqrt(y + abs(min(y)))
Asimetric_Dist(y_root, 'Root Squared - Transformed Data')
```



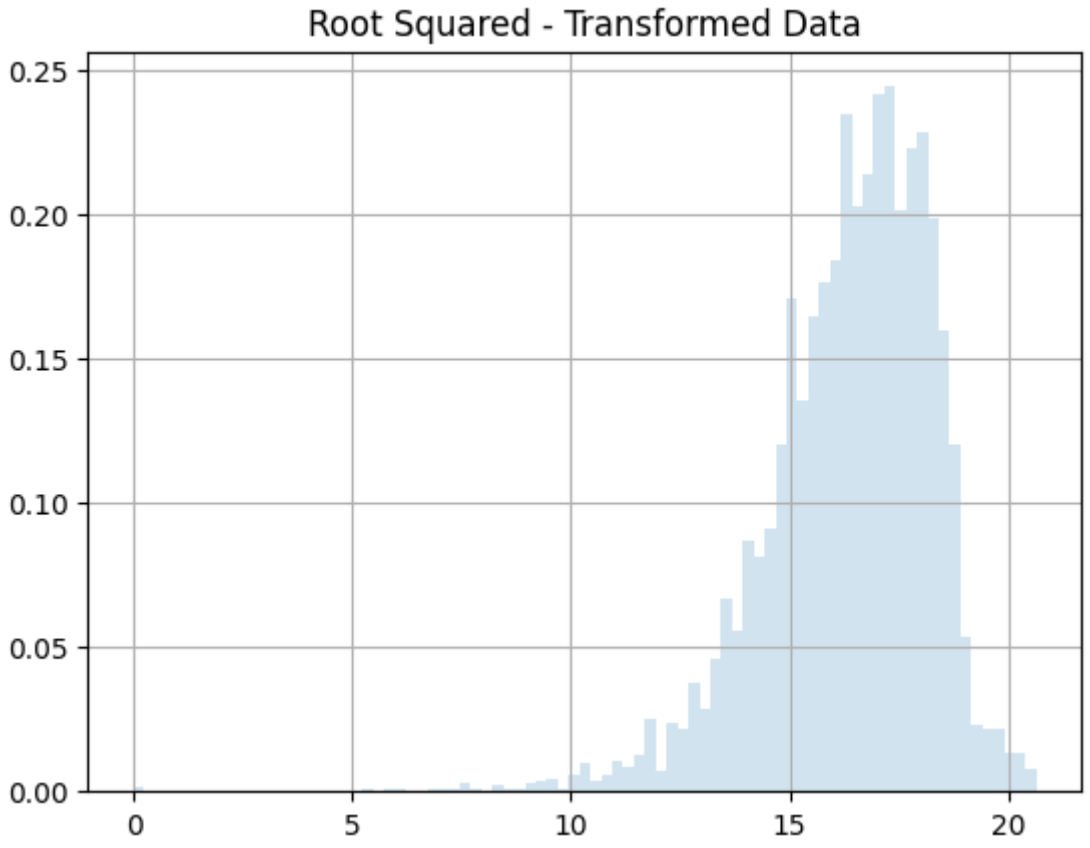
In [ ]:
```
y_log = np.log10(1 + y + abs(min(y)))
Asimetric_Dist(y_log, 'Log - Transformed Data')
```



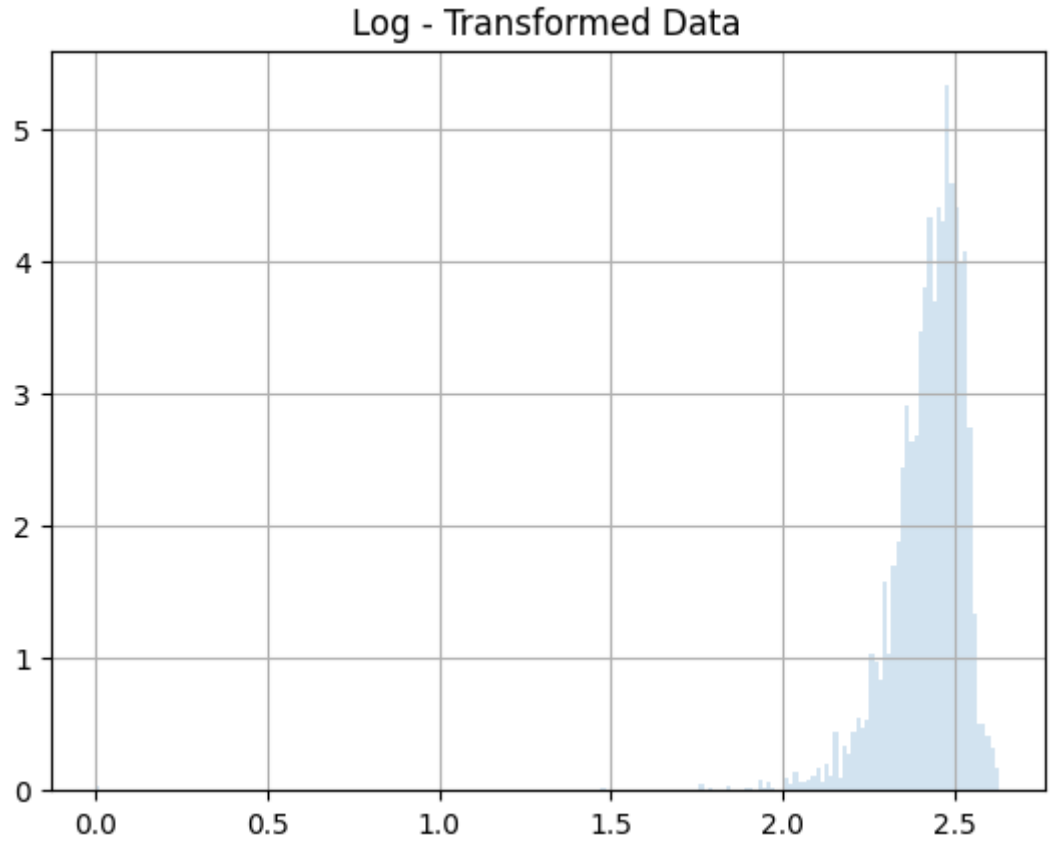
In [ ]:
```
y_skew_neg = -skewnorm.rvs(y)
Asimetric_Dist(y_skew_neg, 'Original - Negative Skew')
```



In [ ]:
```
y_pos = y + abs(min(y))
y_root_neg = np.sqrt(max(y_pos) - y_pos)
Asimetric_Dist(y_root_neg, 'Root Squared - Transformed Data')
```



In [ ]:
```
y_positive = y + abs(min(y))
y_log_neg = np.log10(1 + max(y_positive) - y_positive)
Asimetric_Dist(y_log_neg, 'Log - Transformed Data')
```

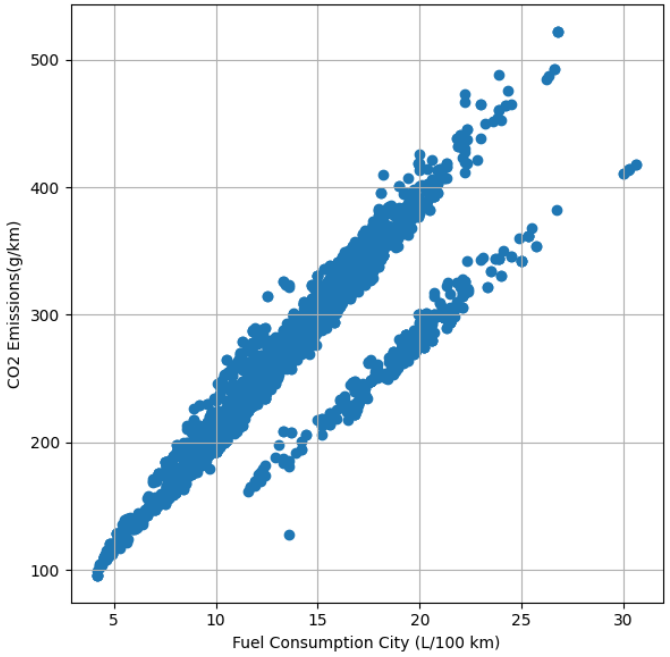


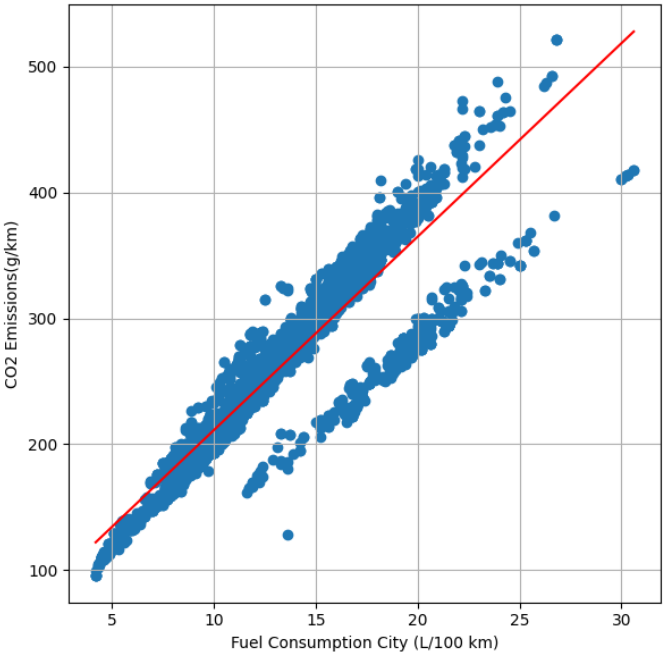
Fuel Consumption City (L/100 km)

In [ ]:
```
x_fcct = df['Fuel Consumption City (L/100 km)']
X_fcct = sm.add_constant(x_fcct)
model = sm.OLS(y,X_fcct)
result = model.fit()
print(result.params)
print("\nR2: ", result.rsquared)
```

```
const                               57.559903
Fuel Consumption City (L/100 km)    15.372459
dtype: float64

R2:  0.8456503198972763
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_fcct, y, 'Fuel Consumption City (L/100 km)', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_fcct, y, result.params[0], result.params[1], 'Fuel Consumption City (L/10
plt.tight_layout()
plt.show()
```

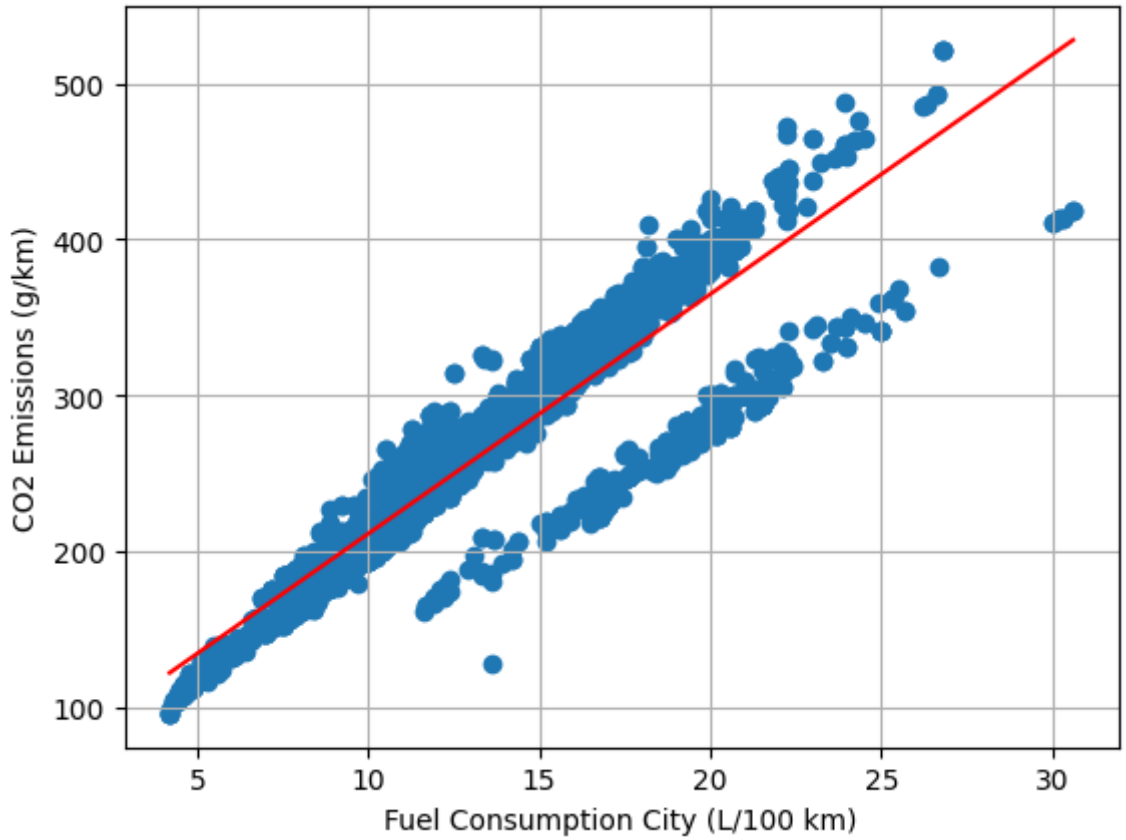




In [ ]:
```
print(result.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     CO2 Emissions(g/km)   R-squared:                       0.846
Model:                             OLS   Adj. R-squared:                  0.846
Method:                  Least Squares   F-statistic:                 4.045e+04
Date:                 Sat, 07 Oct 2023   Prob (F-statistic):               0.00
Time:                         02:13:24   Log-Likelihood:                -33630.
No. Observations:                7385   AIC:                         6.726e+04
Df Residuals:                    7383   BIC:                         6.728e+04
Df Model:                           1
Covariance Type:            nonrobust
=================================================================================================
                                    coef    std err          t      P>|t|      [0.025
-------------------------------------------------------------------------------------------------
const                            57.5599      0.996     57.772      0.000      55.607
Fuel Consumption City (L/100 km)  15.3725      0.076    201.122      0.000      15.223
==============================================================================
Omnibus:                     3089.403   Durbin-Watson:                   1.913
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            16424.392
Skew:                          -1.963   Prob(JB):                         0.00
Kurtosis:                       9.161   Cond. No.                         48.8
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

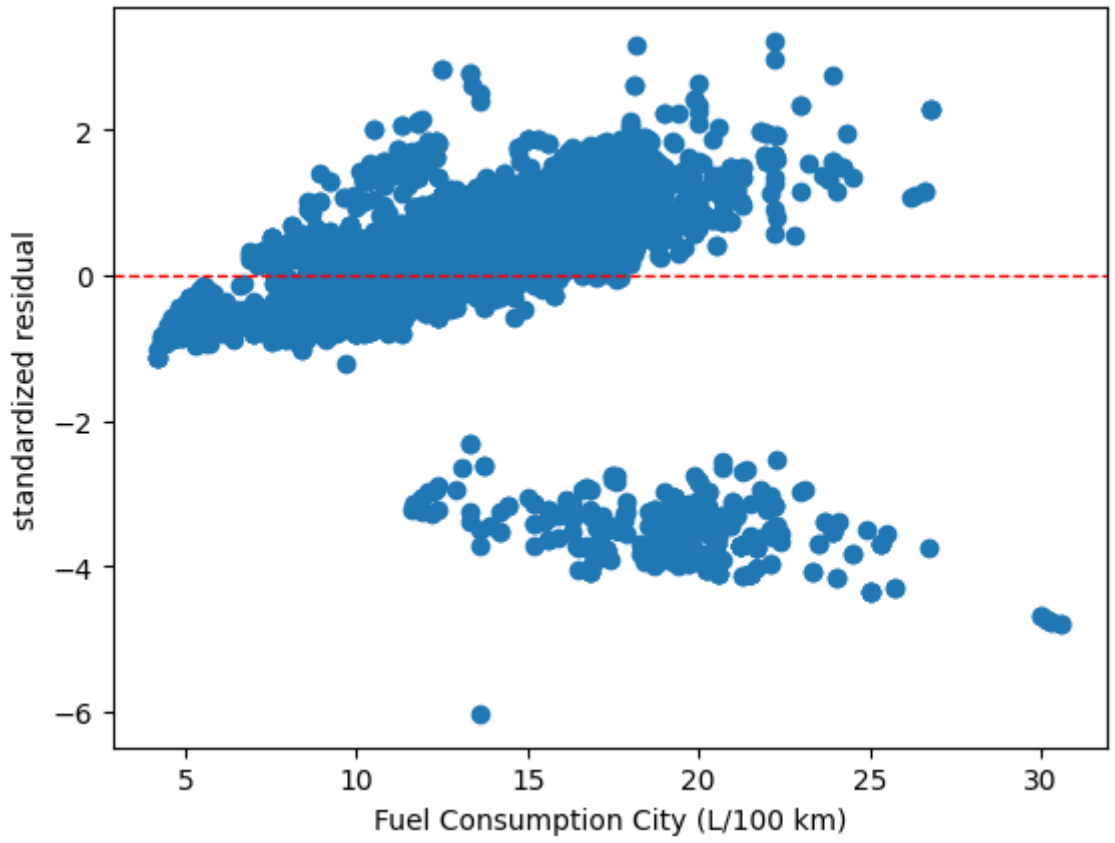
In [ ]:
```
x_line = np.linspace(min(x_fcct), max(x_fcct), 100)
y_line = result.params[0] + result.params[1] * x_line
plt.scatter(x_fcct,y)
plt.xlabel('Fuel Consumption City (L/100 km)')
plt.ylabel('CO2 Emissions (g/km)')
plt.grid()

plt.plot(x_line, y_line, color='red')

plt.show()
```



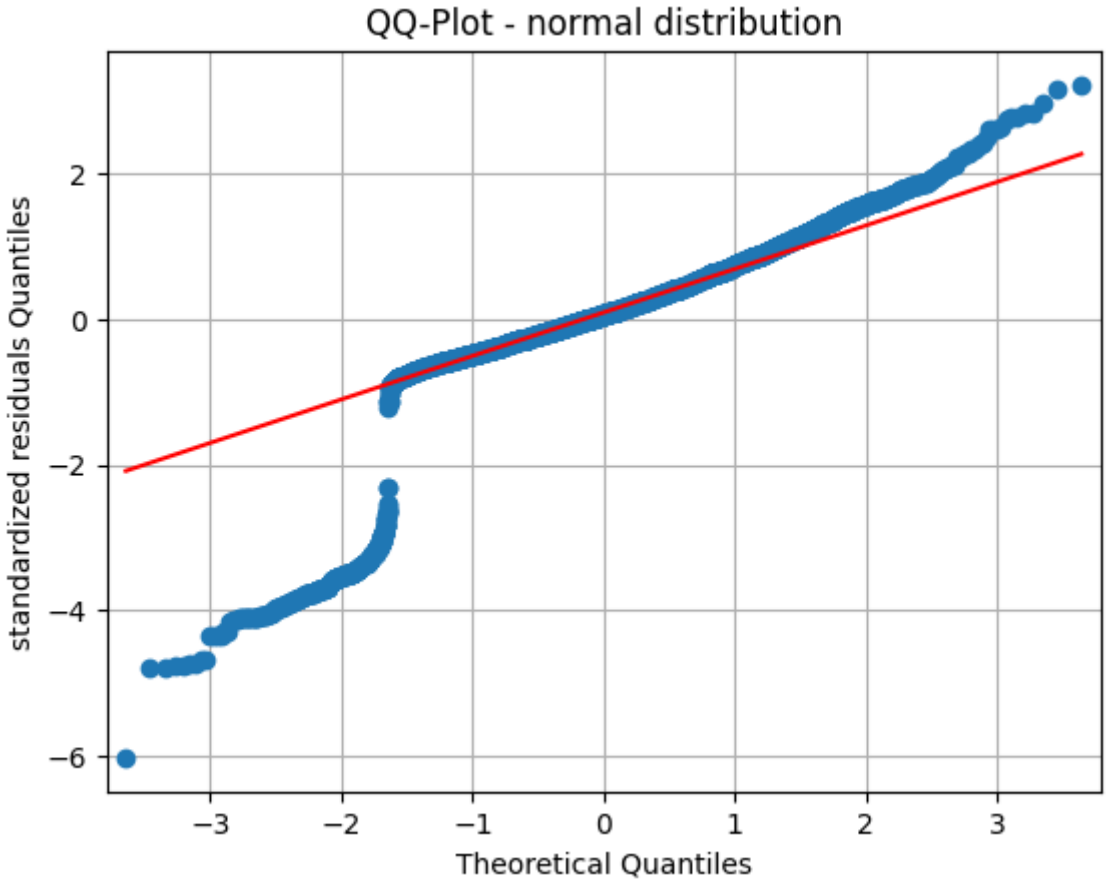
In [ ]:
```
influence = result.get_influence()
std_residual = influence.resid_studentized_internal
print(std_residual)
```

```
[-0.5980394  -0.37982853 -0.60022109 ...  0.11233374  0.09868503
  0.12598264]
```

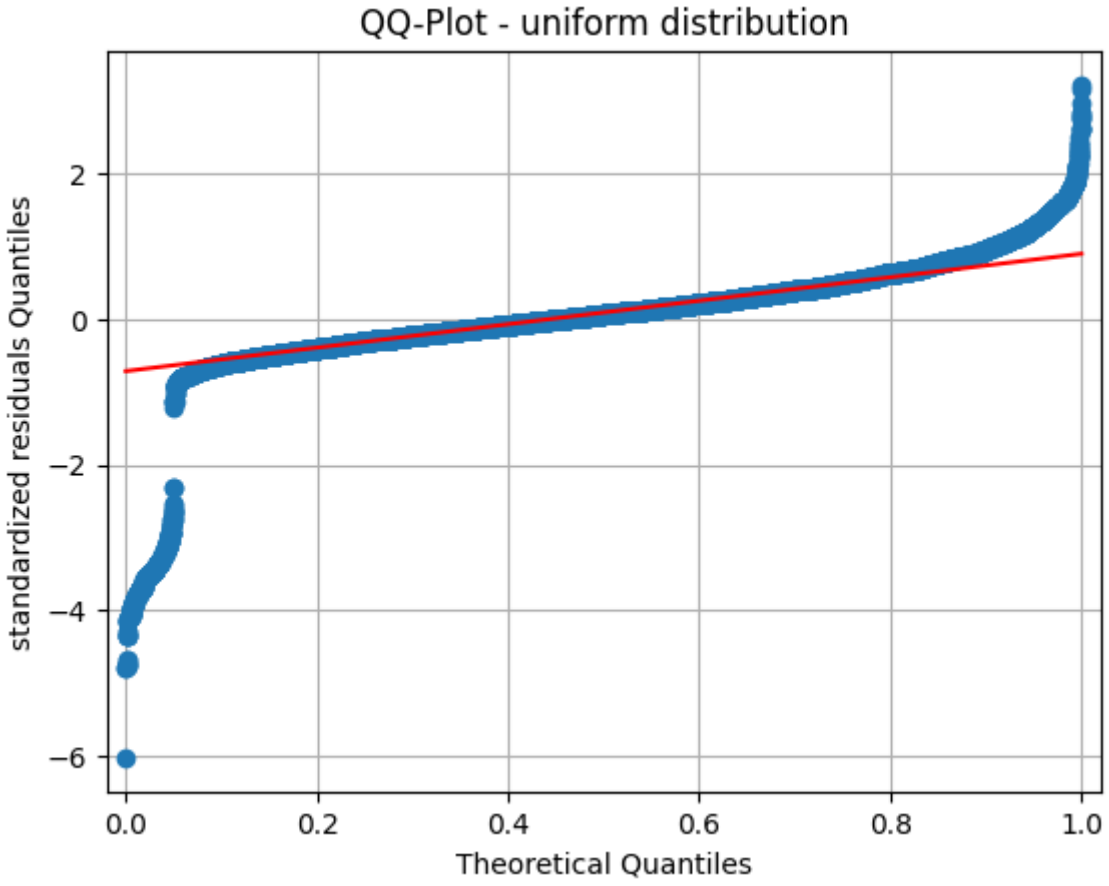
In [ ]:
```
plt.scatter(x_fcct, std_residual)
plt.xlabel('Fuel Consumption City (L/100 km)')
plt.ylabel('standardized residual')
plt.axhline(y=0, color='red', linestyle='--', linewidth=1)
plt.show()
```



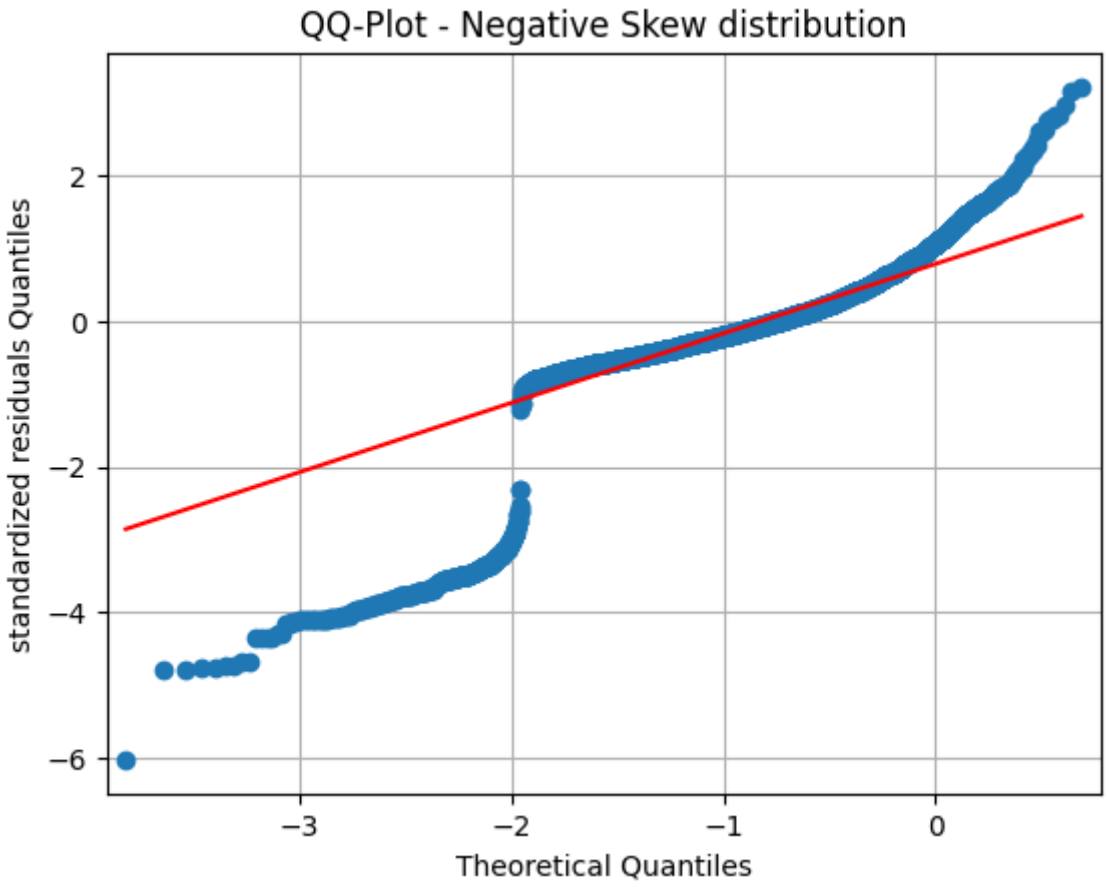
In [ ]:
```
fig = sm.qqplot(std_residual, dist=norm, line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - normal distribution")
plt.grid()
```



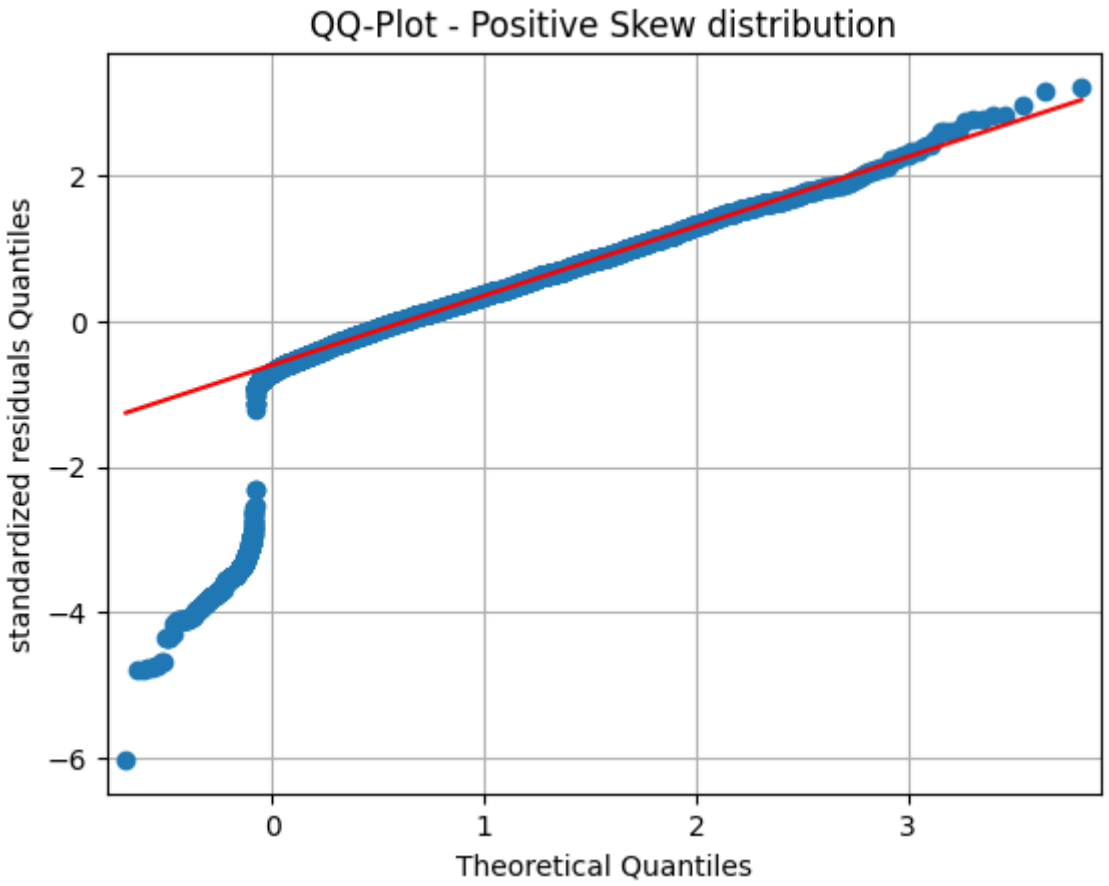
In [ ]:
```
fig = sm.qqplot(std_residual, dist=uniform, line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - uniform distribution")
plt.grid()
```



In [ ]:
```
fig = sm.qqplot(std_residual, skewnorm(-4), line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Negative Skew distribution")
plt.grid()
```



In [ ]:
```
fig = sm.qqplot(std_residual, skewnorm(4), line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Positive Skew distribution")
plt.grid()
```



In [ ]:
```
OLS(x_fcct, y_root)
```

```
Params: const                              13.419645
Fuel Consumption City (L/100 km)     0.408706
dtype: float64
R^2: 0.844322646434444
```

In [ ]:
```
OLS(x_fcct, y_log)
```

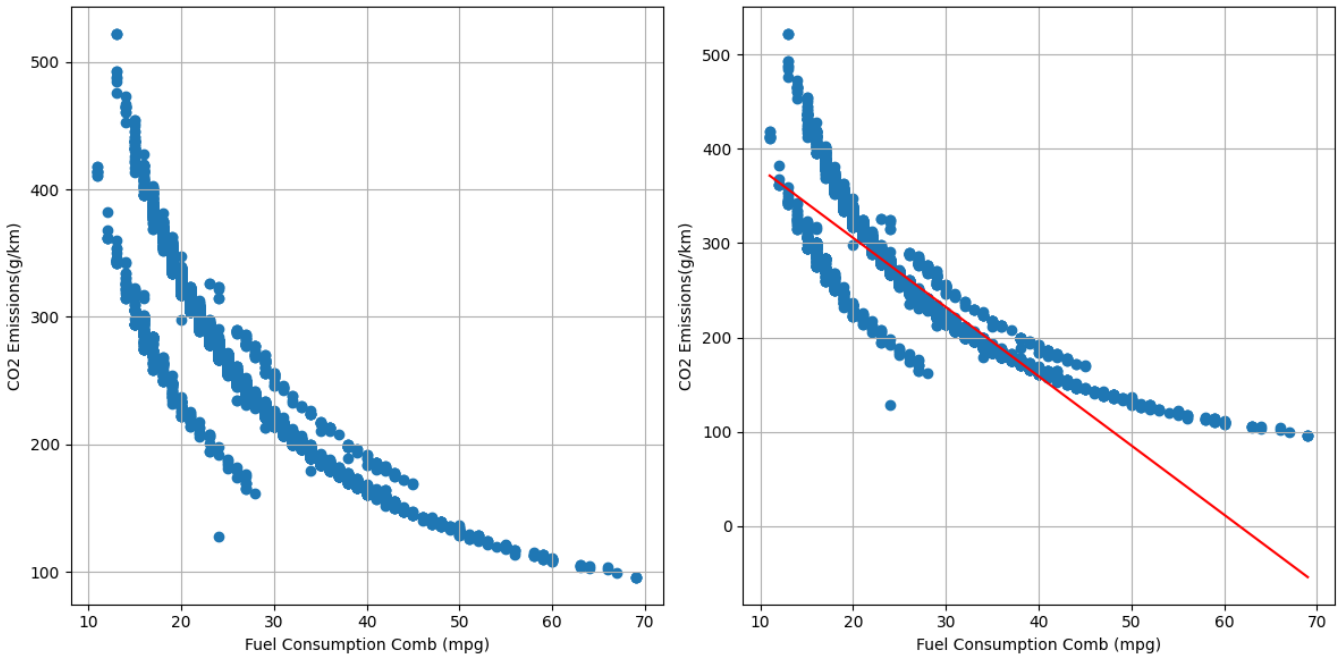
```
Params: const                              2.296990
Fuel Consumption City (L/100 km)    0.018955
dtype: float64
R^2: 0.836968070475829
```

Fuel Consumption Comb (mpg)

In [ ]:
```
x_fcc = df['Fuel Consumption Comb (mpg)']
X_fcc = sm.add_constant(x_fcc)
model = sm.OLS(y,X_fcc)
result = model.fit()
print(result.params)
print("\nR2: ", result.rsquared)
```

```
const                           452.353036
Fuel Consumption Comb (mpg)      -7.341929
dtype: float64

R2:  0.8234224657110062
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_fcc, y, 'Fuel Consumption Comb (mpg)', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_fcc, y, result.params[0], result.params[1], 'Fuel Consumption Comb (mpg)
plt.tight_layout()
plt.show()
```



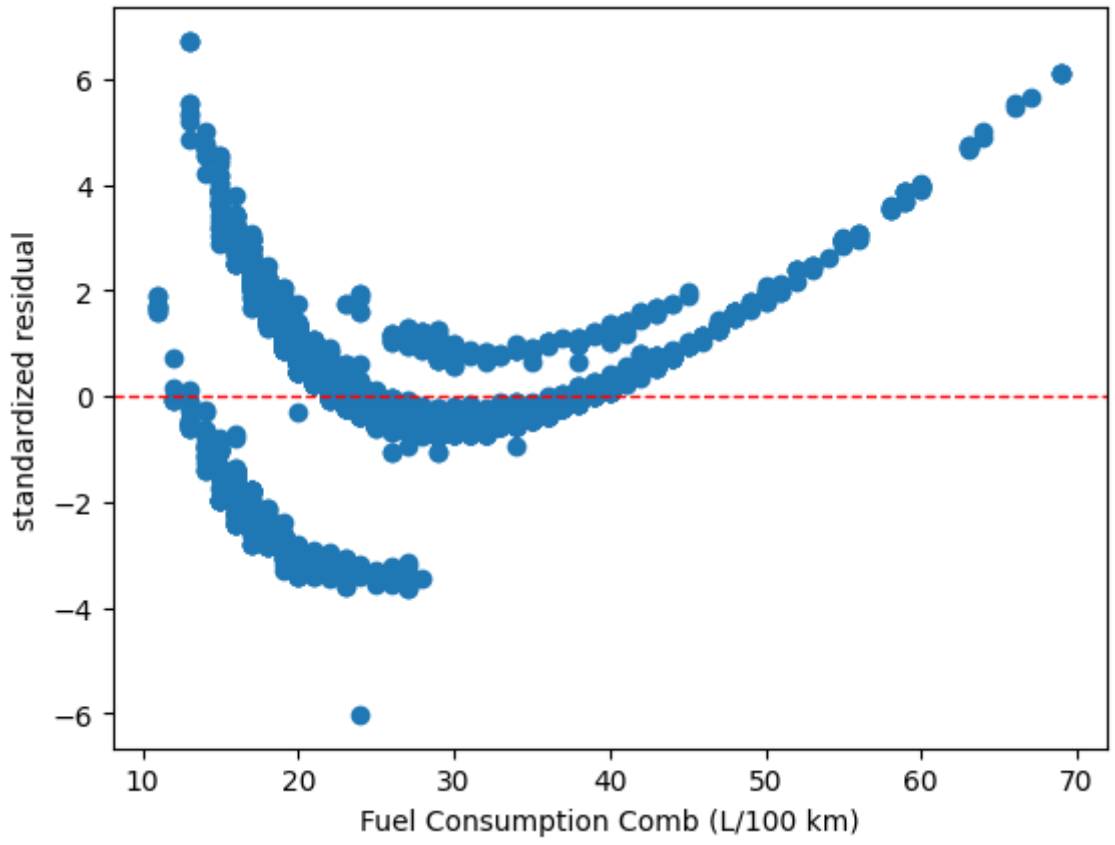
In [ ]:
```
print(result.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     CO2 Emissions(g/km)   R-squared:                       0.823
Model:                             OLS   Adj. R-squared:                  0.823
Method:                  Least Squares   F-statistic:                 3.443e+04
Date:                 Sat, 07 Oct 2023   Prob (F-statistic):               0.00
Time:                         02:13:29   Log-Likelihood:                -34127.
No. Observations:                7385   AIC:                          6.826e+04
Df Residuals:                    7383   BIC:                          6.827e+04
Df Model:                           1
Covariance Type:            nonrobust
================================================================================================
                                   coef    std err          t      P>|t|      [0.025      0.975
------------------------------------------------------------------------------------------------
const                          452.3530      1.124    402.297      0.000     450.149     454.55
Fuel Consumption Comb (mpg)     -7.3419      0.040   -185.550      0.000      -7.419      -7.26
==============================================================================
Omnibus:                     1935.010   Durbin-Watson:                   1.326
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            13170.162
Skew:                           1.080   Prob(JB):                         0.00
Kurtosis:                       9.176   Cond. No.                         112.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

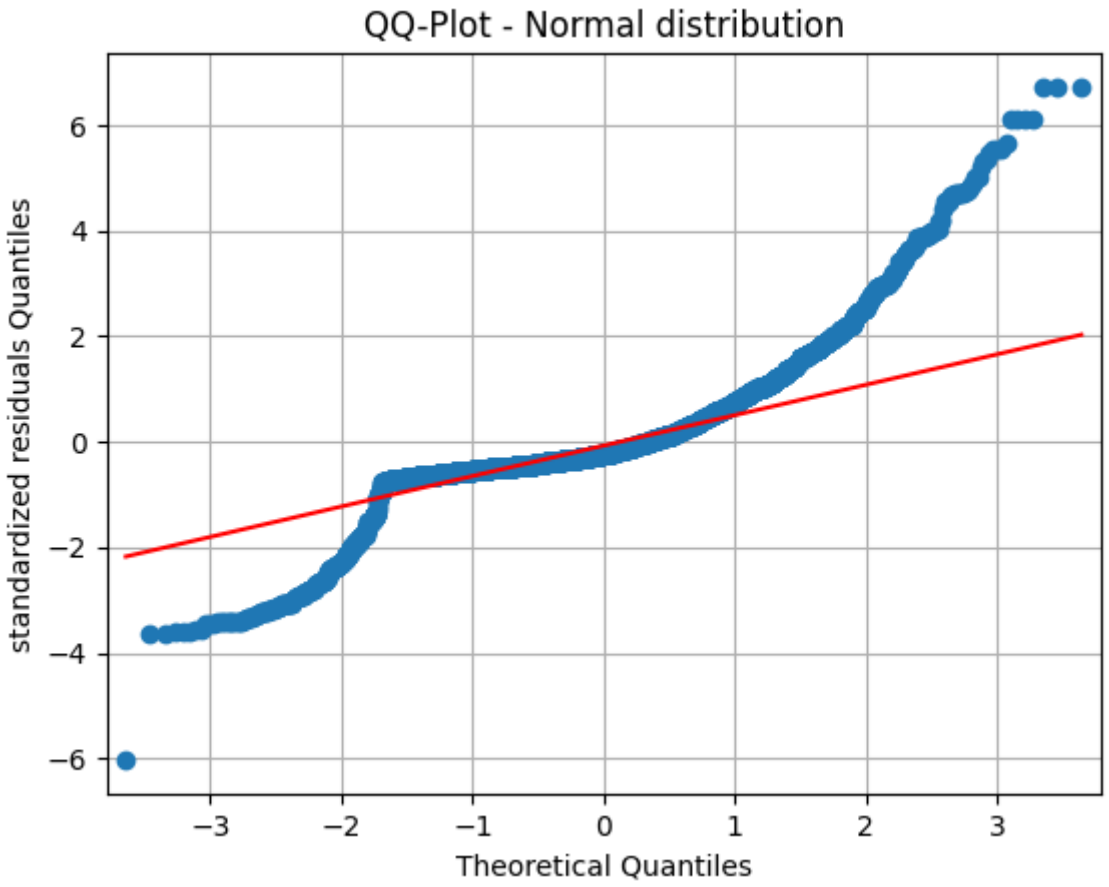
In [ ]:
```
influence = result.get_influence()
std_residual = influence.resid_studentized_internal
print(std_residual)
```

```
[-0.57223492 -0.74985292  1.46736968 ... -0.57431008 -0.30247323
 -0.54754722]
```

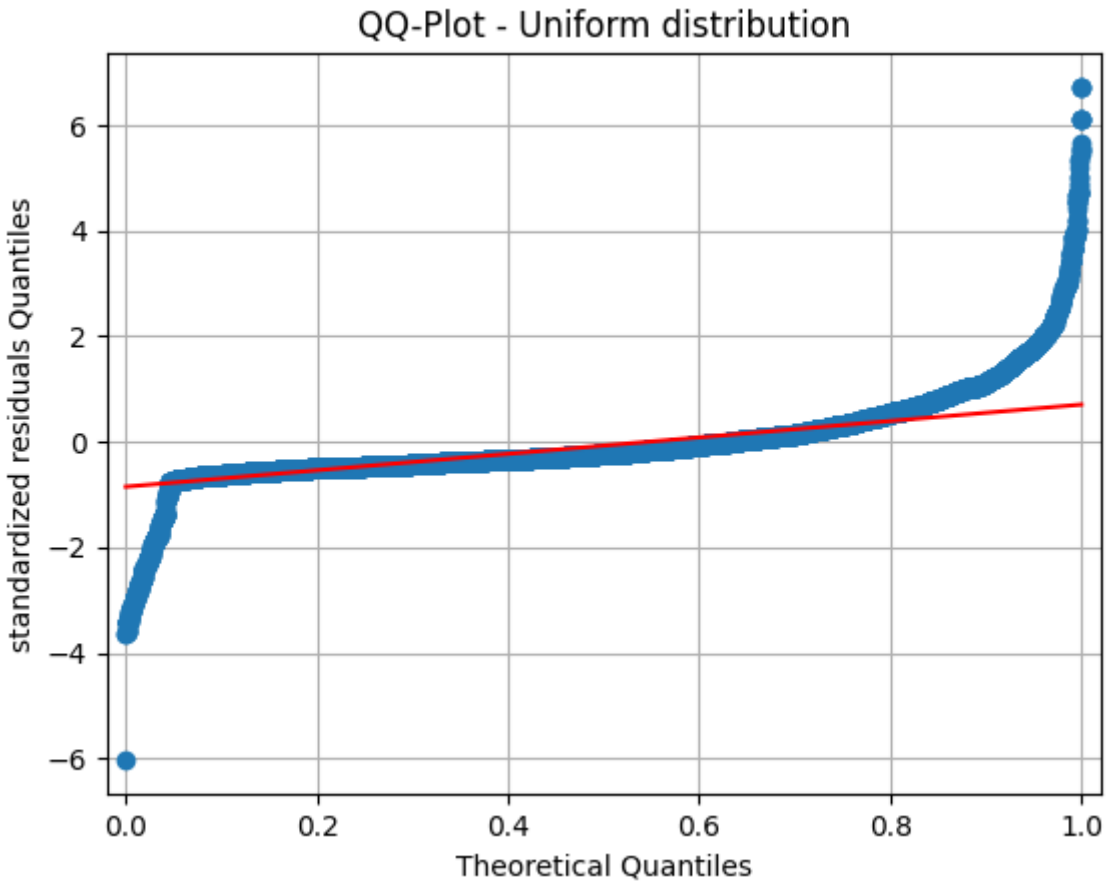
In [ ]:
```
plt.scatter(x_fcc, std_residual)
plt.xlabel('Fuel Consumption Comb (L/100 km)')
plt.ylabel('standardized residual')
plt.axhline(y=0, color='red', linestyle='--', linewidth=1)
plt.show()
```



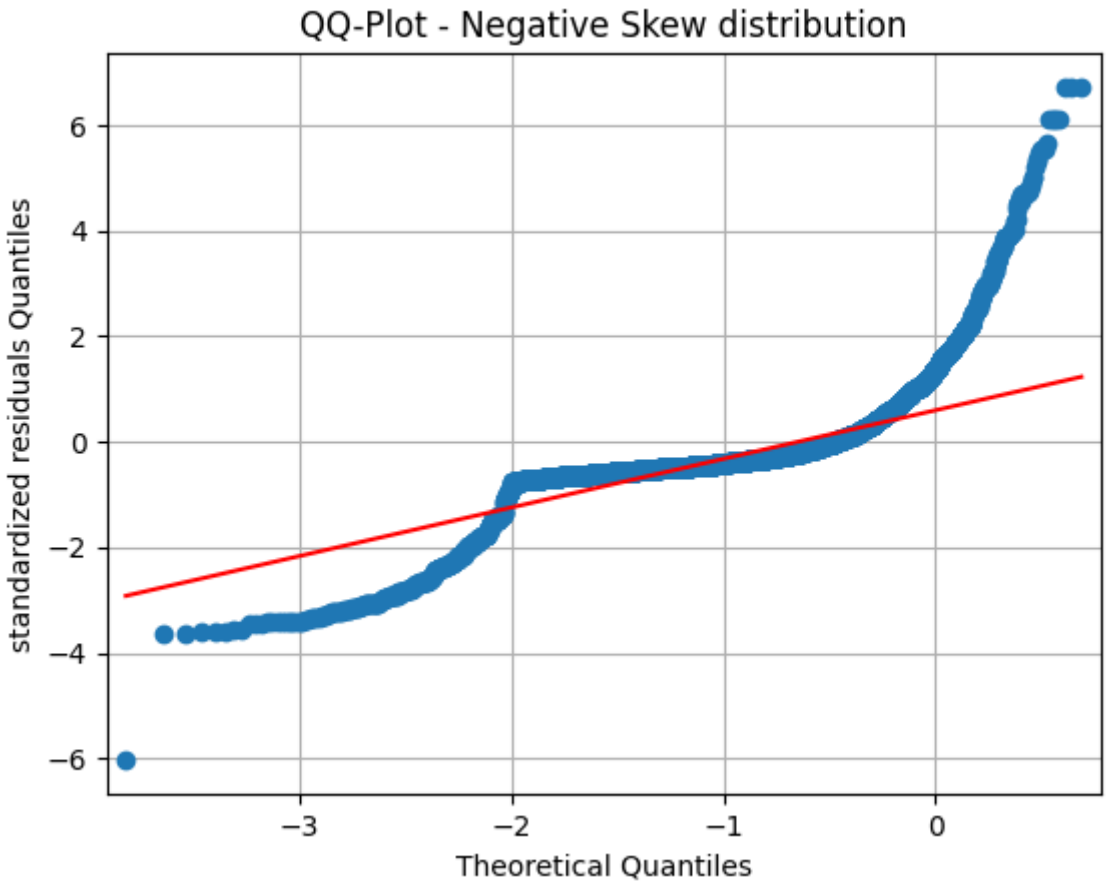
In [ ]:
```
fig = sm.qqplot(std_residual, dist=norm, line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Normal distribution")
plt.grid()
```



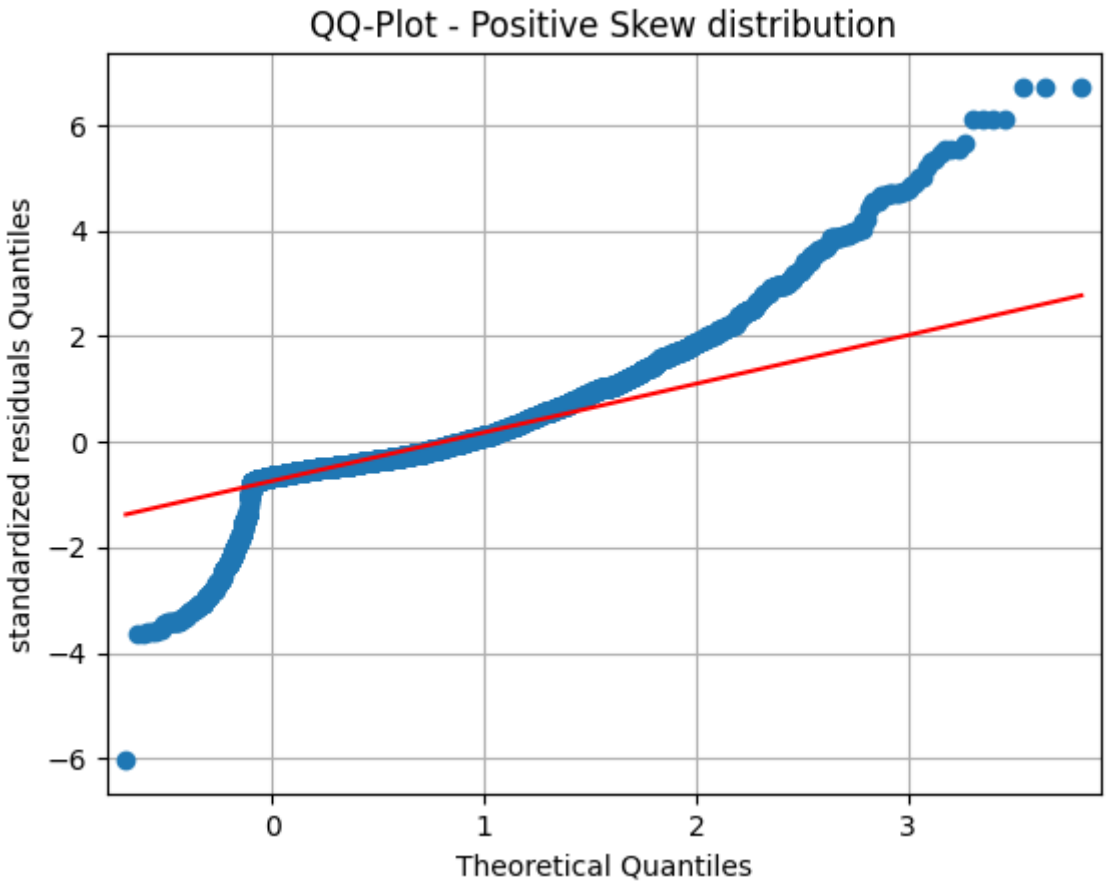
In [ ]:
```
fig = sm.qqplot(std_residual, dist=uniform, line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Uniform distribution")
plt.grid()
```



In [ ]:
```
fig = sm.qqplot(std_residual, skewnorm(-4), line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Negative Skew distribution")
plt.grid()
```



In [ ]:
```
fig = sm.qqplot(std_residual, skewnorm(4), line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Positive Skew distribution")
plt.grid()
```



In [ ]:
```
OLS(x_fcc, y_root)
```

```
Params: const                          24.024339
Fuel Consumption Comb (mpg)    -0.199142
dtype: float64
R^2: 0.8556794221893714
```

In [ ]:
```
OLS(x_fcc, y_log)
```

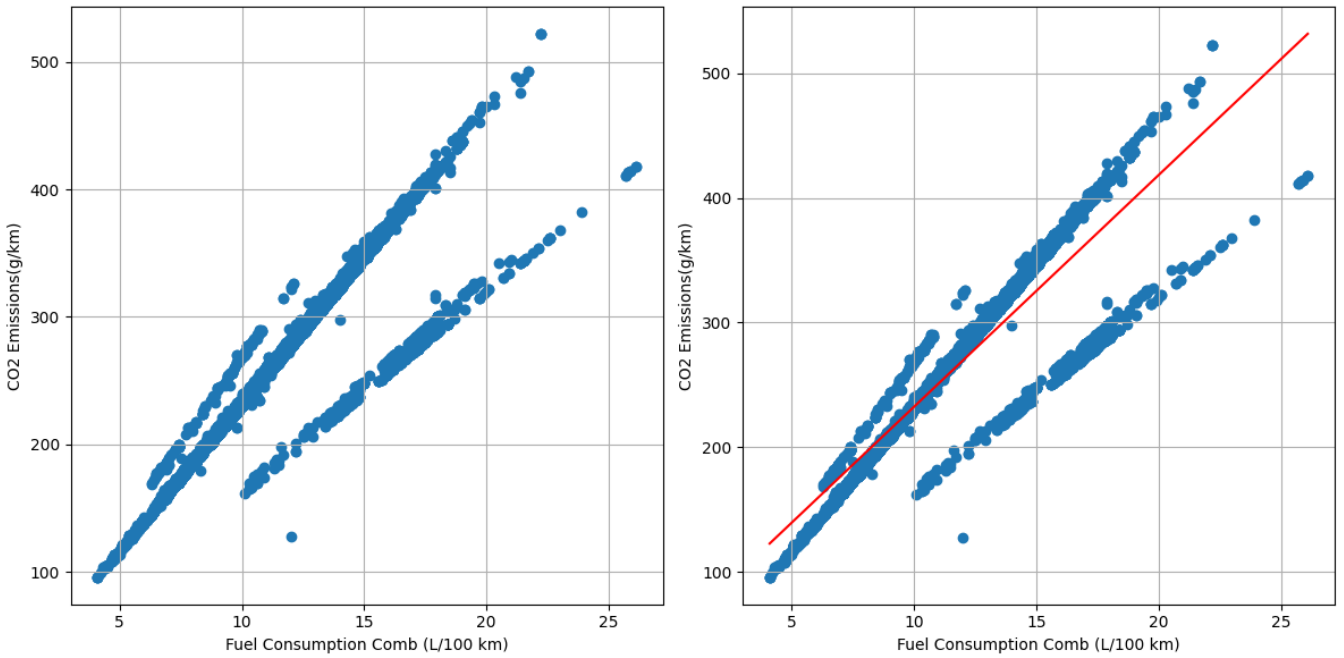
```
Params: const                          2.793990
Fuel Consumption Comb (mpg)   -0.009424
dtype: float64
R^2: 0.8831148871092463
```

Fuel Consumption Comb (L/100 km)

In [ ]:
```
x_fccl = df['Fuel Consumption Comb (L/100 km)']
X_fccl = sm.add_constant(x_fccl)
model = sm.OLS(y,X_fccl)
result = model.fit()
print(result.params)
print("\nR2: ", result.rsquared)
```

```
const                                46.763152
Fuel Consumption Comb (L/100 km)     18.571319
dtype: float64

R2:  0.8428186895623988
```

In [ ]:
```
plt.figure(figsize=(12, 6))
plt_scatter(x_fccl, y, 'Fuel Consumption Comb (L/100 km)', 'CO2 Emissions(g/km)')
plt_scatter_w_line(x_fccl, y, result.params[0], result.params[1], 'Fuel Consumption Comb (L/1
plt.tight_layout()
plt.show()
```



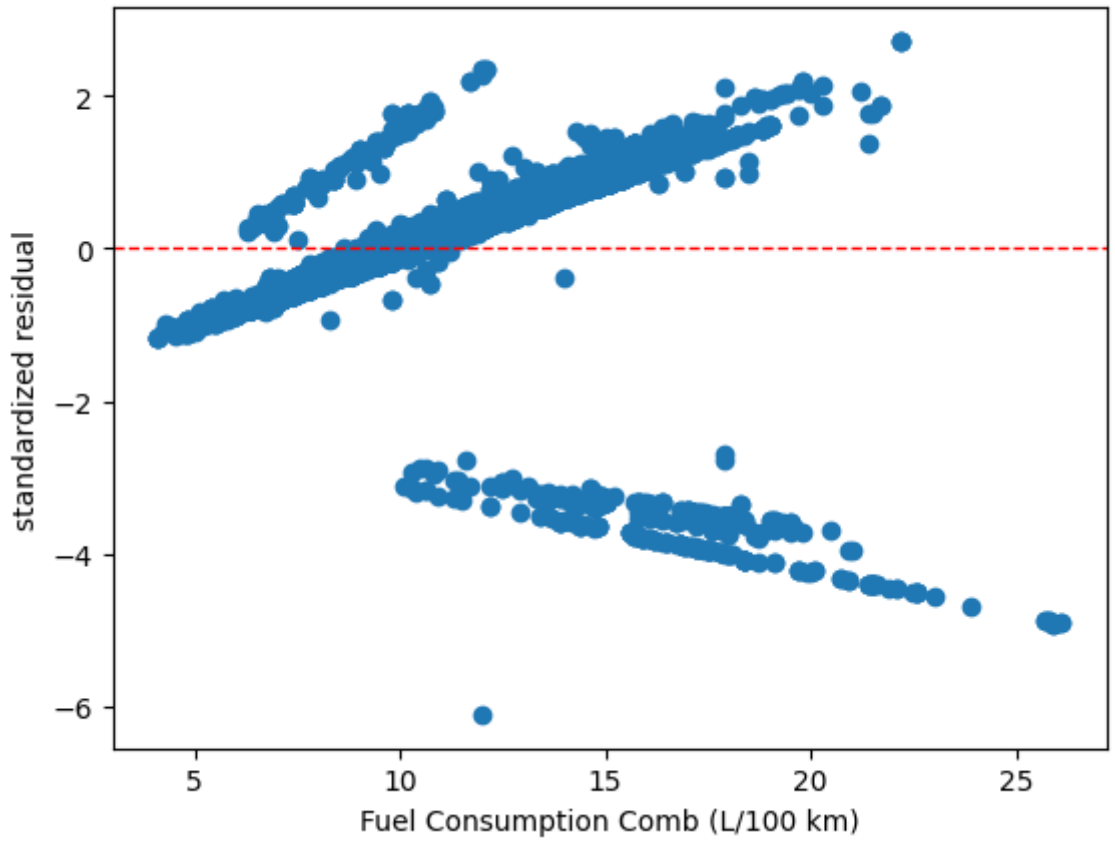
In [ ]:
```
print(result.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     CO2 Emissions(g/km)   R-squared:                       0.843
Model:                             OLS   Adj. R-squared:                  0.843
Method:                  Least Squares   F-statistic:                 3.959e+04
Date:                 Sat, 07 Oct 2023   Prob (F-statistic):               0.00
Time:                         02:13:27   Log-Likelihood:                -33697.
No. Observations:                7385   AIC:                         6.740e+04
Df Residuals:                    7383   BIC:                         6.741e+04
Df Model:                           1
Covariance Type:            nonrobust
================================================================================================
                                   coef    std err          t      P>|t|      [0.025
------------------------------------------------------------------------------------------------
const                           46.7632      1.059     44.142      0.000      44.686
Fuel Consumption Comb (L/100 km)    18.5713      0.093    198.968      0.000      18.388
==============================================================================
Omnibus:                     3592.018   Durbin-Watson:                   1.986
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            22309.895
Skew:                          -2.290   Prob(JB):                         0.00
Kurtosis:                      10.178   Cond. No.                         44.9
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

In [ ]:
```
influence = result.get_influence()
std_residual = influence.resid_studentized_internal
print(std_residual)
```

```
[-0.37157485 -0.17449253 -0.87672126 ...  0.0841568   0.05952249
  0.10879112]
```

In [ ]:
```
plt.scatter(df['Fuel Consumption Comb (L/100 km)'], std_residual)
plt.xlabel('Fuel Consumption Comb (L/100 km)')
plt.ylabel('standardized residual')
plt.axhline(y=0, color='red', linestyle='--', linewidth=1)
plt.show()
```



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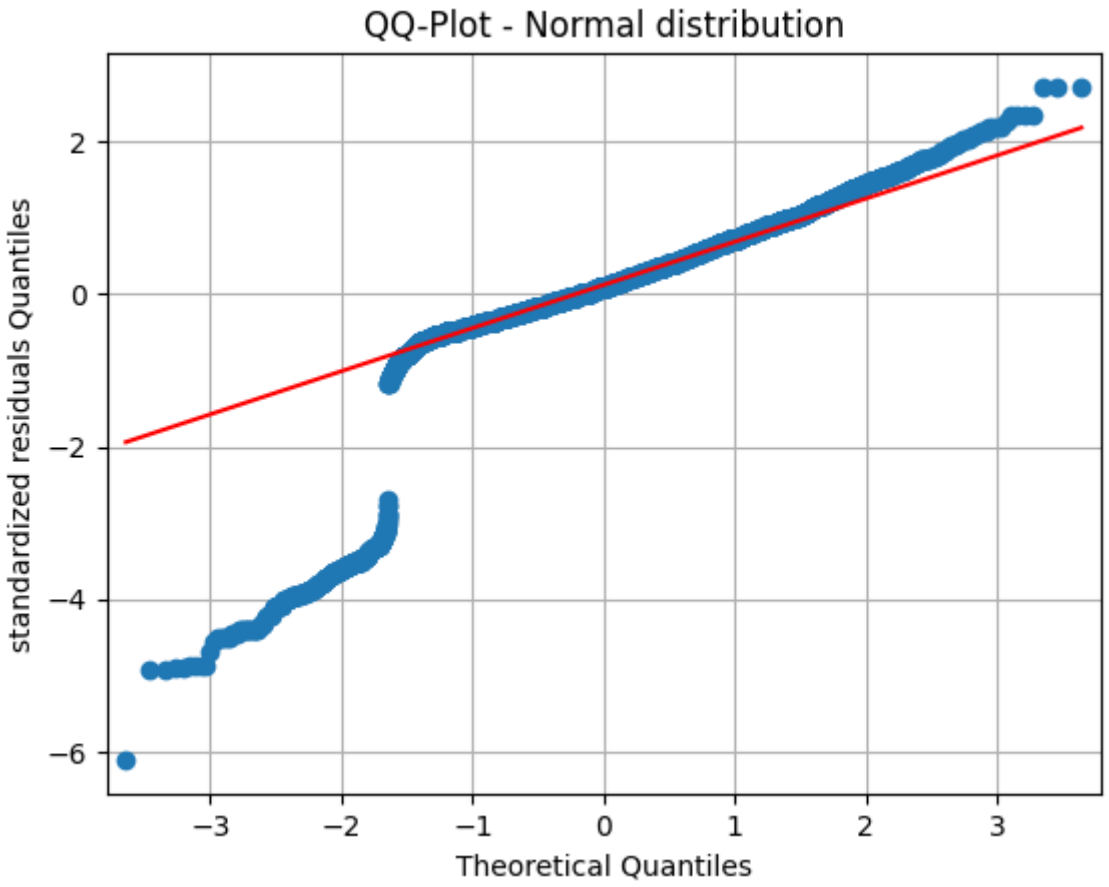
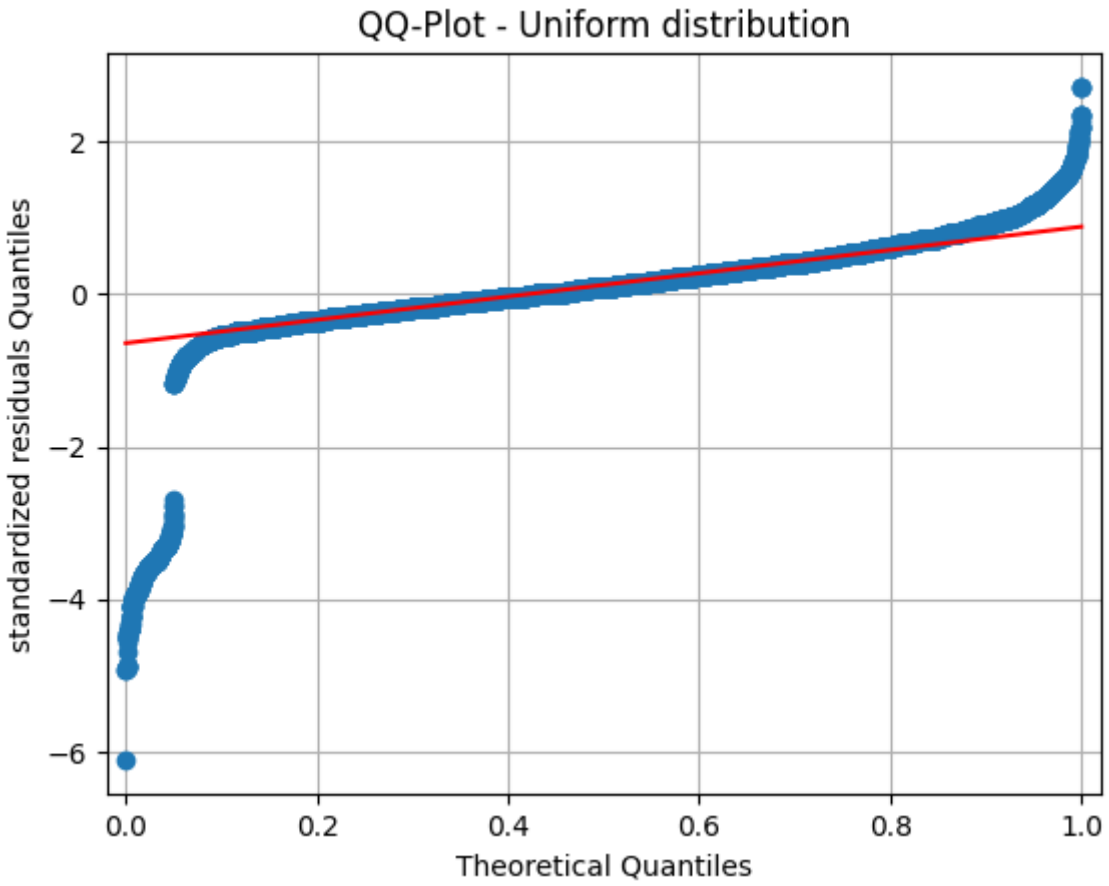


In [ ]:
```
fig = sm.qqplot(std_residual, dist=uniform, line="q")
plt.ylabel("standardized residuals Quantiles")
plt.title("QQ-Plot - Uniform distribution")
plt.grid()
```



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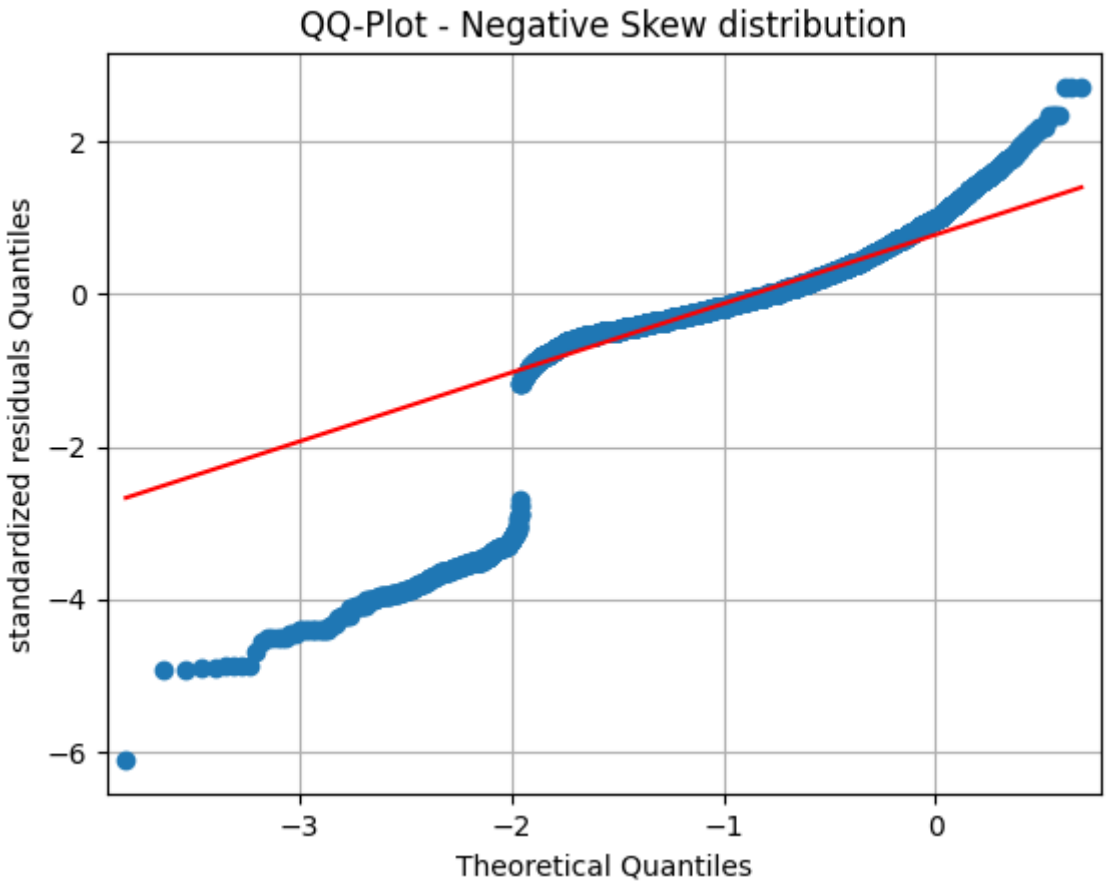

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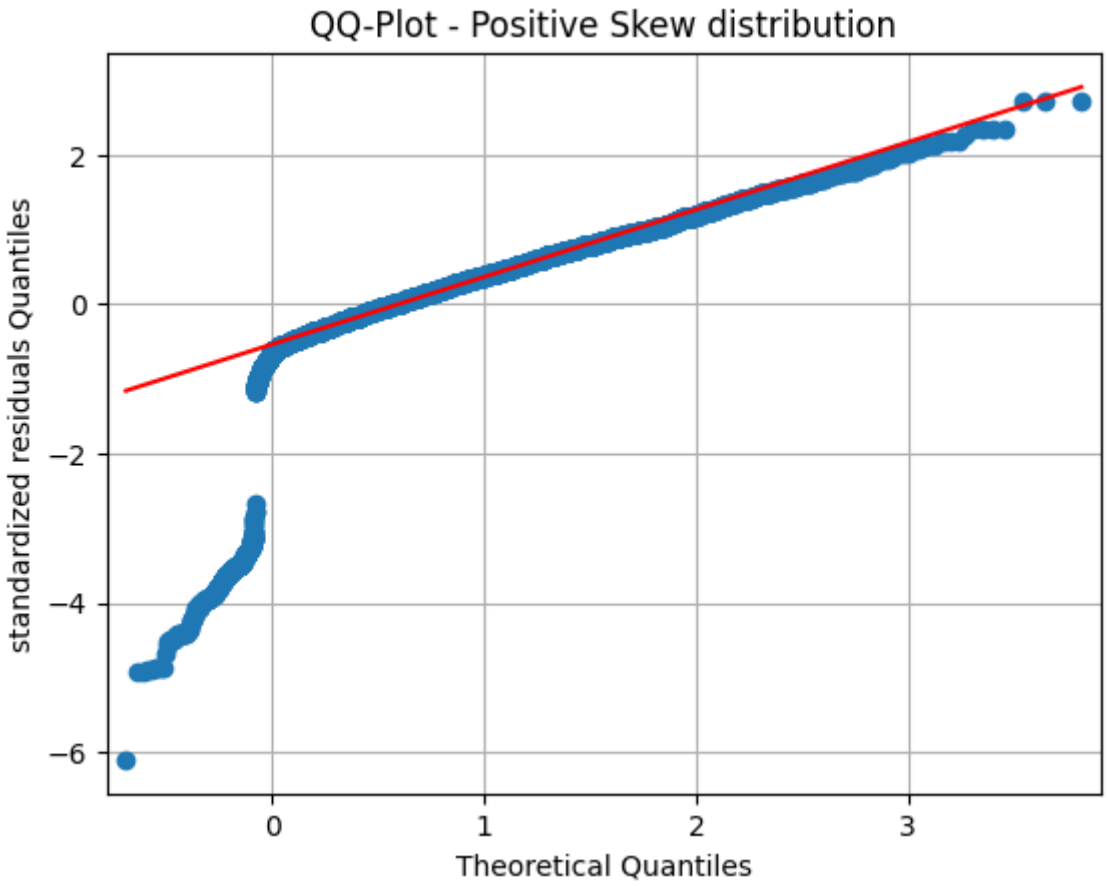

In [ ]:
```
OLS(x_fccl, y_root)
```

```
Params: const                              13.134986
Fuel Consumption Comb (L/100 km)     0.493536
dtype: float64
R^2: 0.8407523790886398
```

In [ ]:
```
OLS(x_fccl, y_log)
```

```
Params: const                              2.283923
Fuel Consumption Comb (L/100 km)    0.022877
dtype: float64
R^2: 0.8325284987248827
```