In [1]:

```python
import warnings
warnings.filterwarnings('ignore')
```

In [2]:

```python
# Import the numpy and pandas package

import numpy as np
import pandas as pd

# Data Visualisation
import matplotlib.pyplot as plt
import seaborn as sns
```

In [3]:

```python
advertising = pd.DataFrame(pd.read_csv("advertising.csv"))
advertising.head()
```

Out[3]:

	TV	Radio	Newspaper	Sales
0	230.1	37.8	69.2	22.1
1	44.5	39.3	45.1	10.4
2	17.2	45.9	69.3	12.0
3	151.5	41.3	58.5	16.5
4	180.8	10.8	58.4	17.9

In [4]:

```python
# 1. Missing value Treatment

advertising.isnull().sum()
```

Out[4]:

```
TV           0
Radio        0
Newspaper    0
Sales        0
dtype: int64
```

In [5]:

```python
# 2. Multicollineartity

from statsmodels.stats.outliers_influence import variance_inflation_factor

x = advertising[['TV','Radio','Newspaper']]
vif_data= pd.DataFrame()
vif_data["features"] = x.columns

vif_data["VIF"] = [variance_inflation_factor(x.values,i)
                  for i in range(len(x.columns))]

print(vif_data)
```

```
    features       VIF
0         TV  2.486772
1      Radio  3.285462
2  Newspaper  3.055245
```

In [6]:

```python
# 3. Univaraite analysis

advertising.describe()
```

Out[6]:

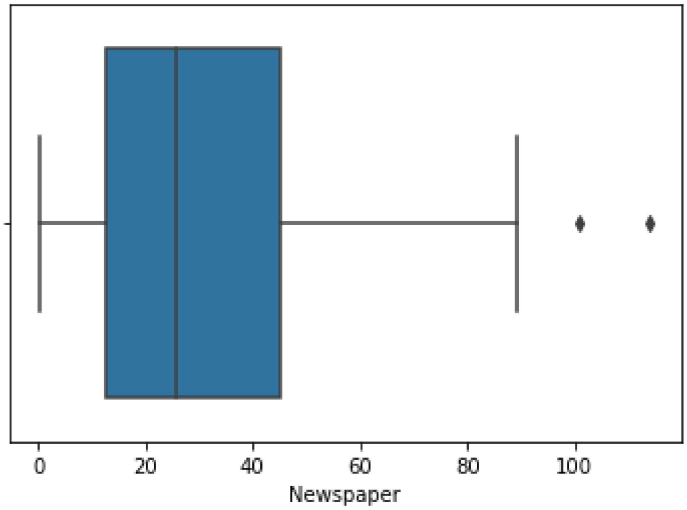
	TV	Radio	Newspaper	Sales
count	200.000000	200.000000	200.000000	200.000000
mean	147.042500	23.264000	30.554000	15.130500
std	85.854236	14.846809	21.778621	5.283892
min	0.700000	0.000000	0.300000	1.600000
25%	74.375000	9.975000	12.750000	11.000000
50%	149.750000	22.900000	25.750000	16.000000
75%	218.825000	36.525000	45.100000	19.050000
max	296.400000	49.600000	114.000000	27.000000

In [7]:

```python
sns.boxplot(advertising['Newspaper'])
```

Out[7]:

```
<AxesSubplot:xlabel='Newspaper'>
```



In [8]:

```python
advertising = advertising[advertising['Newspaper'] < 100 ]
```

In [9]:

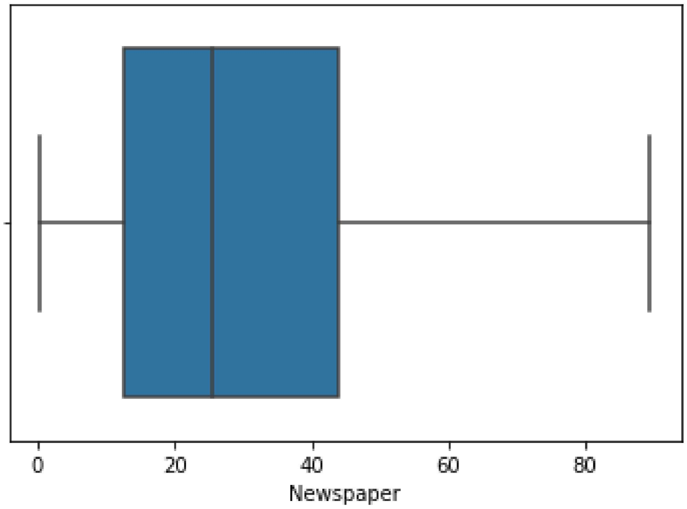
```python
advertising.shape
```

Out[9]:

```
(198, 4)
```

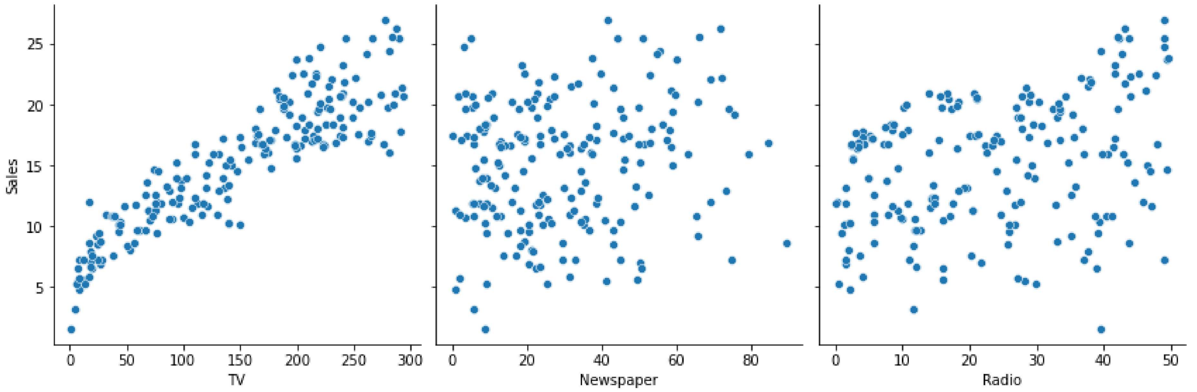
```
In [10]: sns.boxplot(advertising['Newspaper'])
```

```
Out[10]: <AxesSubplot:xlabel='Newspaper'>
```



```
In [ ]:
```

```
In [11]: # 4.Bivariate analysis
         sns.pairplot(advertising, x_vars=['TV', 'Newspaper', 'Radio'], y_vars='Sales',
         plt.show()
```



```
In [12]: advertising.head()
```

Out[12]:

	TV	Radio	Newspaper	Sales
0	230.1	37.8	69.2	22.1
1	44.5	39.3	45.1	10.4
2	17.2	45.9	69.3	12.0
3	151.5	41.3	58.5	16.5
4	180.8	10.8	58.4	17.9

In [13]:
```
# 5. Creating two data
X = advertising[['TV','Radio']]
y = advertising['Sales']
```

In [14]:
```
X.head()
```

Out[14]:

	TV	Radio
0	230.1	37.8
1	44.5	39.3
2	17.2	45.9
3	151.5	41.3
4	180.8	10.8

In [15]:
```
y.head()
```

Out[15]:
```
0     22.1
1     10.4
2     12.0
3     16.5
4     17.9
Name: Sales, dtype: float64
```

In [16]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, train_size=0.75, test
```

In [17]:
```
X_train.shape
```

Out[17]:
```
(148, 2)
```

In [18]:
```
X_test.shape
```

Out[18]:
```
(50, 2)
```

In [19]:
```
# 6 .model building

# model 1 . Sales = F(TV)
# model 2 . sales = F(TV + Radio)
# model 3. sales = F(TV+Radio+newspaper)
```

In [20]:

```
# model_1
X_train
```

Out[20]:

	TV	Radio
187	191.1	28.7
43	206.9	8.4
68	237.4	27.5
195	38.2	3.7
76	27.5	1.6
...	...	...
108	13.1	0.4
14	204.1	32.9
93	250.9	36.5
181	218.5	5.4
104	238.2	34.3

148 rows × 2 columns

In [21]:

```
import statsmodels.api as sm

# Add a constant to get an intercept
X_train_sm = sm.add_constant(X_train)

# Fit the resgression line using 'OLS'
lr = sm.OLS(y_train, X_train_sm).fit()

X_train_sm
```

Out[21]:

	const	TV	Radio
187	1.0	191.1	28.7
43	1.0	206.9	8.4
68	1.0	237.4	27.5
195	1.0	38.2	3.7
76	1.0	27.5	1.6
...	...	...	...
108	1.0	13.1	0.4
14	1.0	204.1	32.9
93	1.0	250.9	36.5
181	1.0	218.5	5.4
104	1.0	238.2	34.3

148 rows × 3 columns

```
In [22]: print(lr.summary())
```

```
                            OLS Regression Results
=============================================================================
=
Dep. Variable:                  Sales   R-squared:                       0.89
2
Model:                            OLS   Adj. R-squared:                  0.89
0
Method:                 Least Squares   F-statistic:                     596.
9
Date:                Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                        22:52:09   Log-Likelihood:                -288.4
5
No. Observations:                 148   AIC:                             582.
9
Df Residuals:                     145   BIC:                             591.
9
Df Model:                           2
Covariance Type:            nonrobust
=============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
-----------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
=============================================================================
=
Omnibus:                       17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.46
1
Skew:                          -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                       4.992   Cond. No.                        43
2.
=============================================================================
=

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

```
In [23]: print(lr.summary())
```

```
                            OLS Regression Results                            
==============================================================================
=
Dep. Variable:                   Sales   R-squared:                       0.89
2
Model:                             OLS   Adj. R-squared:                  0.89
0
Method:                  Least Squares   F-statistic:                     596.
9
Date:                 Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                         22:52:09   Log-Likelihood:                -288.4
5
No. Observations:                  148   AIC:                             582.
9
Df Residuals:                      145   BIC:                             591.
9
Df Model:                            2                                         
Covariance Type:             nonrobust                                         
==============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
------------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
==============================================================================
=
Omnibus:                        17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                   0.000   Jarque-Bera (JB):               32.46
1
Skew:                           -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                        4.992   Cond. No.                         43
2.
==============================================================================
=

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

```
In [24]: print(lr.summary())
```

```
                            OLS Regression Results
=============================================================================
=
Dep. Variable:                  Sales   R-squared:                       0.89
2
Model:                            OLS   Adj. R-squared:                  0.89
0
Method:                 Least Squares   F-statistic:                     596.
9
Date:                Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                        22:52:09   Log-Likelihood:                -288.4
5
No. Observations:                 148   AIC:                             582.
9
Df Residuals:                     145   BIC:                             591.
9
Df Model:                           2
Covariance Type:            nonrobust
=============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
-----------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
=============================================================================
=
Omnibus:                       17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.46
1
Skew:                          -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                       4.992   Cond. No.                         43
2.
=============================================================================
=

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

In [25]:

```
print(lr.summary())
```

```
                            OLS Regression Results
=============================================================================
=
Dep. Variable:                  Sales   R-squared:                       0.89
2
Model:                            OLS   Adj. R-squared:                  0.89
0
Method:                 Least Squares   F-statistic:                     596.
9
Date:                Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                        22:52:09   Log-Likelihood:                -288.4
5
No. Observations:                 148   AIC:                             582.
9
Df Residuals:                     145   BIC:                             591.
9
Df Model:                           2
Covariance Type:            nonrobust
=============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
-----------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
=============================================================================
=
Omnibus:                       17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.46
1
Skew:                          -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                       4.992   Cond. No.                         43
2.
=============================================================================
=

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

In [27]:

```
y_test
```

Out[27]:

```
66     11.0
116    12.2
17     24.4
143    10.4
158     7.3
128    24.7
142    20.1
31     11.9
19     14.6
169    20.0
160    16.4
15     22.4
56      5.5
57     13.2
117     9.4
46     10.6
126     6.6
9      15.6
149    10.1
86     12.0
115    12.6
163    18.0
61     24.2
189     6.7
74     17.0
69     22.3
121     7.0
165    16.9
119     6.6
177    16.7
70     18.3
77     14.2
127    11.9
83     13.6
25     17.0
193    19.6
97     20.5
173    16.7
20     18.0
152    16.6
139    20.7
5       7.2
67     13.4
140    10.9
106     7.2
172     7.6
99     17.2
113    20.9
12      9.2
36     25.4
Name: Sales, dtype: float64
```

In [28]:

```
X_test_sm = sm.add_constant(X_test)
X_test_sm
```

Out[28]:

	const	TV	Radio
66	1.0	31.5	24.6
116	1.0	139.2	14.3
17	1.0	281.4	39.6
143	1.0	104.6	5.7
158	1.0	11.7	36.9
128	1.0	220.3	49.0
142	1.0	220.5	33.2
31	1.0	112.9	17.4
19	1.0	147.3	23.9
169	1.0	284.3	10.6
160	1.0	172.5	18.1
15	1.0	195.4	47.7
56	1.0	7.3	28.1
57	1.0	136.2	19.2
117	1.0	76.4	0.8
46	1.0	89.7	9.9
126	1.0	7.8	38.9
9	1.0	199.8	2.6
149	1.0	44.7	25.8
86	1.0	76.3	27.5
115	1.0	75.1	35.0
163	1.0	163.5	36.8
61	1.0	261.3	42.7
189	1.0	18.7	12.1
74	1.0	213.4	24.6
69	1.0	216.8	43.9
121	1.0	18.8	21.7
165	1.0	234.5	3.4
119	1.0	19.4	16.0
177	1.0	170.2	7.8
70	1.0	199.1	30.6
77	1.0	120.5	28.5
127	1.0	80.2	0.0
83	1.0	68.4	44.5
25	1.0	262.9	3.5

	const	TV	Radio
193	1.0	166.8	42.0
97	1.0	184.9	21.0
173	1.0	168.4	7.1
20	1.0	218.4	27.7
152	1.0	197.6	23.3
139	1.0	184.9	43.9
5	1.0	8.7	48.9
67	1.0	139.3	14.5
140	1.0	73.4	17.0
106	1.0	25.0	11.0
172	1.0	19.6	20.1
99	1.0	135.2	41.7
113	1.0	209.6	20.6
12	1.0	23.8	35.1
36	1.0	266.9	43.8

```
In [29]: y_pred = lr.predict(X_test_sm)
```

In [30]:
```
y_pred
```

Out[30]:
```
66      9.119808
116    13.755840
17     23.989330
143    11.007458
158     9.367648
128    21.735233
142    20.075518
31     12.685557
19     15.201300
169    21.077656
160    15.927673
15     20.274209
56      8.203440
57     14.114391
117     8.990432
46     10.659446
126     9.371775
9      15.740207
149     9.948333
86     11.807791
115    12.536890
163    17.426196
61     23.248616
189     7.117931
74     18.788932
69     21.010024
121     8.138141
165    17.669304
119     7.567441
177    14.716516
70     18.663106
77     14.263016
127     9.107851
83     13.185066
25     19.189514
193    18.151346
97     16.893393
173    14.546832
20     19.382440
152    17.811629
139    19.314339
5      10.476797
67     13.782300
140    10.543598
106     7.336526
172     8.011517
99     16.439893
113    18.164066
12      9.820546
36     23.662581
dtype: float64
```

In [31]:

```
from sklearn.metrics import r2_score
r_squared = r2_score(y_test, y_pred)
r_squared
```

Out[31]:

```
0.9233579214065604
```

In [32]:

```
0.89

0.84

0.85
```

Out[32]:

```
0.85
```

```
In [33]: print(lr.summary())
```

```
                            OLS Regression Results                            
=============================================================================
=
Dep. Variable:                  Sales   R-squared:                       0.89
2
Model:                            OLS   Adj. R-squared:                  0.89
0
Method:                 Least Squares   F-statistic:                     596.
9
Date:                Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                        22:52:10   Log-Likelihood:                -288.4
5
No. Observations:                 148   AIC:                             582.
9
Df Residuals:                     145   BIC:                             591.
9
Df Model:                           2                                         
Covariance Type:            nonrobust                                         
=============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
-----------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
=============================================================================
=
Omnibus:                       17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.46
1
Skew:                          -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                       4.992   Cond. No.                          43
2.
=============================================================================
=

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

In [34]:
```python
print(lr.summary())
```

```
                            OLS Regression Results
=============================================================================
=
Dep. Variable:                  Sales   R-squared:                       0.89
2
Model:                            OLS   Adj. R-squared:                  0.89
0
Method:                 Least Squares   F-statistic:                     596.
9
Date:                Tue, 11 Jul 2023   Prob (F-statistic):           1.03e-7
0
Time:                        22:52:10   Log-Likelihood:                -288.4
5
No. Observations:                 148   AIC:                             582.
9
Df Residuals:                     145   BIC:                             591.
9
Df Model:                           2
Covariance Type:            nonrobust
=============================================================================
=
                 coef    std err          t      P>|t|      [0.025      0.97
5]
-----------------------------------------------------------------------------
-
const          4.8447      0.349     13.870      0.000       4.154       5.53
5
TV             0.0532      0.002     32.010      0.000       0.050       0.05
6
Radio          0.1057      0.009     11.220      0.000       0.087       0.12
4
=============================================================================
=
Omnibus:                       17.987   Durbin-Watson:                   2.25
7
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.46
1
Skew:                          -0.569   Prob(JB):                     8.94e-0
8
Kurtosis:                       4.992   Cond. No.                         43
2.
=============================================================================
=

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

In [35]:

```
# Add a constant to X_test
X_test_sm = sm.add_constant(X_test)

# Predict the y values corresponding to X_test_sm
y_pred = lr.predict(X_test_sm)

from sklearn.metrics import r2_score
r_squared = r2_score(y_test, y_pred)
r_squared
```

Out[35]:

```
0.9233579214065604
```

In [36]:

```
X_test.head()
```

Out[36]:

	TV	Radio
66	31.5	24.6
116	139.2	14.3
17	281.4	39.6
143	104.6	5.7
158	11.7	36.9

In [37]:

```
y_test.head()
```

Out[37]:

```
66      11.0
116     12.2
17      24.4
143     10.4
158      7.3
Name: Sales, dtype: float64
```

In [38]:

```
X_test_sm = sm.add_constant(X_test)

# Predict the y values corresponding to X_test_sm
y_pred = lr.predict(X_test_sm)

y_pred.head()
```

Out[38]:

```
66       9.119808
116     13.755840
17      23.989330
143     11.007458
158      9.367648
dtype: float64
```

In [39]:

```
from sklearn.metrics import r2_score
r_squared = r2_score(y_test, y_pred)
r_squared
```

Out[39]:

```
0.9233579214065604
```

Thankyou