Importing all required libraries we will use in this notebook

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import yfinance as yf
from statsmodels.tsa.stattools import acf,acovf,pacf
from statsmodels.tsa.stattools import adfuller
from statsmodels.tsa.arima.model import ARIMA
from sklearn.metrics import mean_squared_error
import pmdarima
import warnings
warnings.filterwarnings('ignore')
```

Extracting BRL/USD exchange rate from yfinance in timeperiod from 2019-2021

In [2]:
```
df=yf.Ticker('BRLUSD=X').history(start='2019-01-02',end='2021-01-01')
```

Printing data which we obtained through yfinance

In [3]:
```
df
```

Out[3]:

Date	Open	High	Low	Close	Volume	Dividends	Stock Splits
2019-01-01	0.257732	0.257739	0.257732	0.257732	0	0	0
2019-01-02	0.257739	0.262860	0.256680	0.257739	0	0	0
2019-01-03	0.264089	0.267544	0.262833	0.264110	0	0	0
2019-01-04	0.266312	0.269433	0.264299	0.266304	0	0	0
2019-01-07	0.269273	0.270959	0.268608	0.273134	0	0	0
...	...	...	...	...	...	...	...
2020-12-25	0.191744	0.192352	0.191652	0.191744	0	0	0
2020-12-28	0.193222	0.193705	0.188484	0.191744	0	0	0
2020-12-29	0.190650	0.193616	0.190614	0.190625	0	0	0
2020-12-30	0.191990	0.193948	0.191181	0.191990	0	0	0
2020-12-31	0.192655	0.193331	0.192620	0.192647	0	0	0

522 rows × 7 columns

Printing length of data

In [4]:
```
len(df)
```

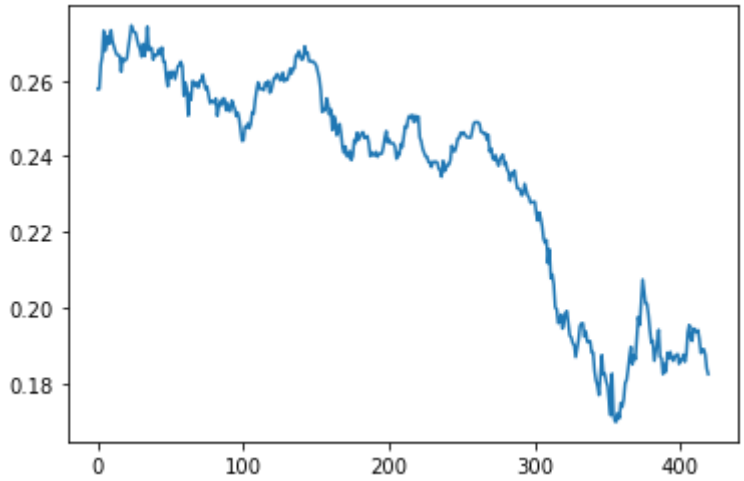
Out[4]:
```
522
```

splitting the df into training and testing in 80:20 ratio

In [5]:
```
data=df[:420]
test_data=df[420:len(df)]
```

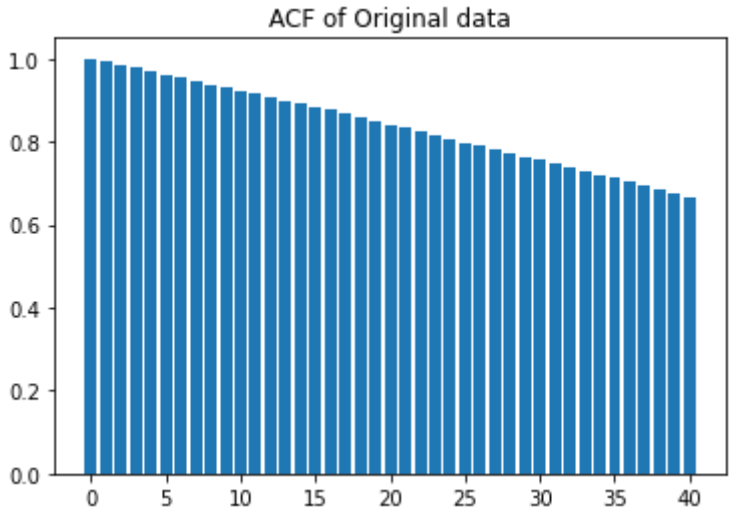
Plotting the data

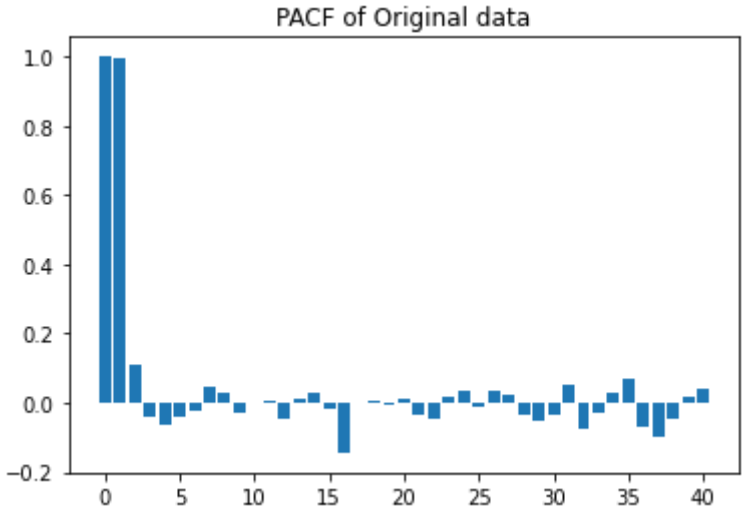
In [6]:
```
x=np.arange(len(data))
plt.plot(x,data['Close'])
plt.show()
```



Plotting acf and pacf of original data

In [7]:
```
data_acf=acf(data['Close'],nlags=40,fft=False)
plt.bar(np.arange(41),data_acf)
plt.title("ACF of Original data")
plt.show()
data_pacf=pacf(data['Close'],nlags=40)
plt.bar(np.arange(41),data_pacf)
plt.title("PACF of Original data")
plt.show()
```





From here we can see that pacf of data is not going to zero and also acf of data is not going to zero hence AR and MA model cant fit to the data.Hence lets try to check for stationary of data and also try to fit the ARMA,ARIMA and SARIMA model.

Stationarity test for original data by adfuller method

In [8]:
```
adf=adfuller(data['Close'])
print("ADF Statistic: ",adf[0])
print("Critical Values: ",adf[4])
```

```
ADF Statistic:  -0.29567364005086894
Critical Values:  {'1%': -3.4461675720270404, '5%': -2.8685128587855955, '10%': -2.5
704843086630915}
```

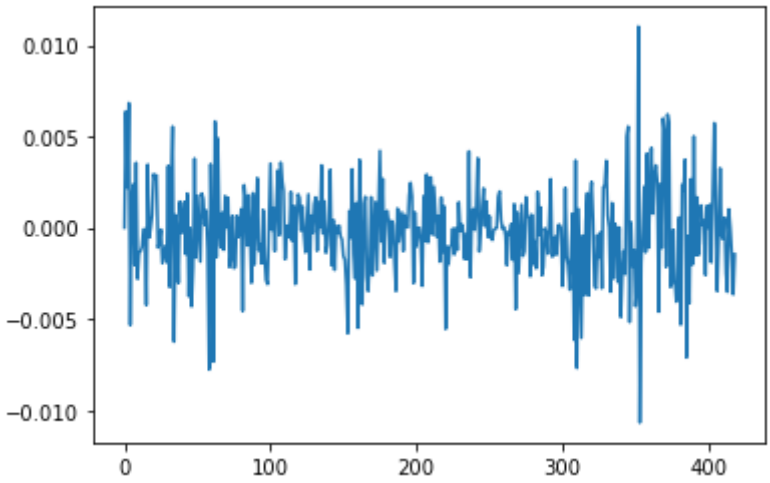
From above we can see that adf statistic value is greater than all critical values.Hence we accept the null hypothesis and null hypothesis is that the time series is non-stationary and the alternative hypothesis is that the time series is stationary.Hence time series is not stationary.Hence we apply differencing to make data stationary

Applying differencing technique to make data stationary

In [9]:
```
new_close=list(data['Close'])
new_close_list=[]
for i in range(1,len(new_close)):
    new_close_list.append(new_close[i]-new_close[i-1])
```

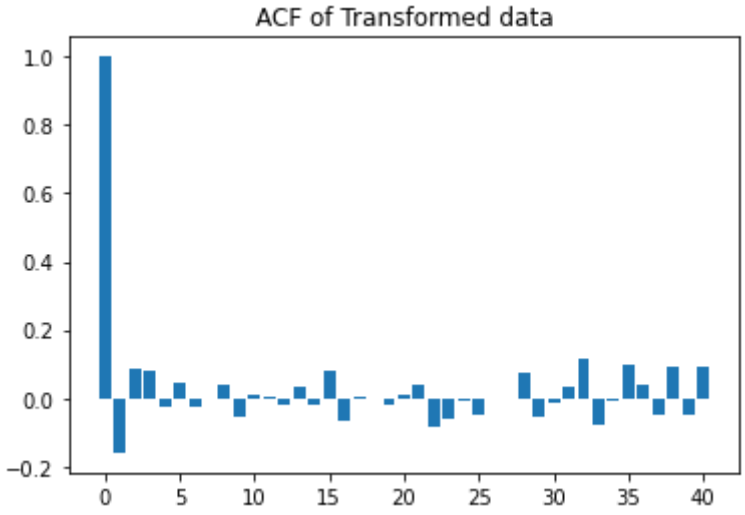
plotting the data after applying differencing technique

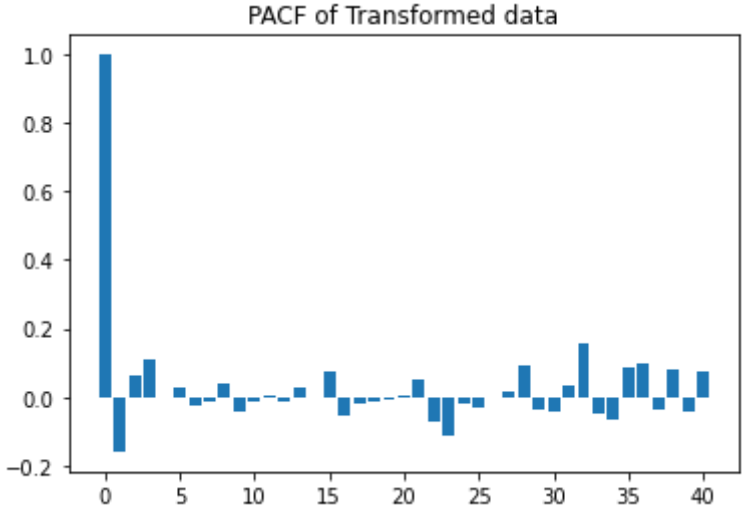
In [10]:
```
x=np.arange(len(new_close_list))
plt.plot(x,new_close_list)
plt.show()
```



Plotting acf and pacf of transformed data i.e obtained after applying differencing technique

In [11]:
```
data_t_acf=acf(new_close_list,nlags=40,fft=False)
plt.bar(np.arange(41),data_t_acf)
plt.title("ACF of Transformed data")
plt.show()
data_t_pacf=pacf(new_close_list,nlags=40)
plt.bar(np.arange(41),data_t_pacf)
plt.title("PACF of Transformed data")
plt.show()
```





Applying adfuller test to the data obtained after applying

differencing to check whether data became stationary or not

In [12]:
```
adf=adfuller(new_close_list)
print("ADF Statistic: ",adf[0])
print("Critical Values: ",adf[4])
```

```
ADF Statistic:  -10.721669837503347
Critical Values:  {'1%': -3.4461675720270404, '5%': -2.8685128587855955, '10%': -2.5
704843086630915}
```

From the above we can see that adf statistic is less than all critical values.Hence we reject the null hypothesis that time series is not stationary.Hence data is stationary

As data became stationary after applying differencing once hence d=1 and also as d is not equal to 0.Hence arma model doesnt fit into this data.Hence lets try to fix arima model and also if we observe the original graph we can see that there is no seasonality in the graph.Hence sarima also doesnt fit into this data.

Fitting the arima model

In the below cell we are using auto_arima function from pmdarima to get p,q values it uses aic value only while comparison

In [13]:
```
import pmdarima as pmd
autoarima_model=pmd.auto_arima(data['Close'],start_p=0,start_q=0,test="adf",trace=Tr
autoarima_model.summary()
```

```
Performing stepwise search to minimize aic
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=-3823.322, Time=1.34 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=-3832.100, Time=0.39 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=-3829.911, Time=0.14 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=-3823.186, Time=0.10 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=-3831.867, Time=0.62 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=-3830.562, Time=0.35 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=-3817.318, Time=0.62 sec
 ARIMA(1,1,0)(0,0,0)[0]             : AIC=-3831.187, Time=0.22 sec

Best model:  ARIMA(1,1,0)(0,0,0)[0] intercept
Total fit time: 3.809 seconds
```

Out[13]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	420
Model:	SARIMAX(1, 1, 0)	**Log Likelihood**	1919.050
Date:	Fri, 06 May 2022	**AIC**	-3832.100
Time:	23:36:19	**BIC**	-3819.987
Sample:	0	**HQIC**	-3827.312
	- 420		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	-0.0002	0.000	-1.706	0.088	-0.000	3.11e-05

ar.L1	-0.1596	0.036	-4.458	0.000	-0.230	-0.089
sigma2	6.158e-06	3.31e-07	18.595	0.000	5.51e-06	6.81e-06

Ljung-Box (L1) (Q):	0.04	**Jarque-Bera (JB):**	34.14
Prob(Q):	0.83	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.65	**Skew:**	0.11
Prob(H) (two-sided):	0.00	**Kurtosis:**	4.38

Warnings:

[1] Covariance matrix calculated using the outer product of gradients (complex-step).

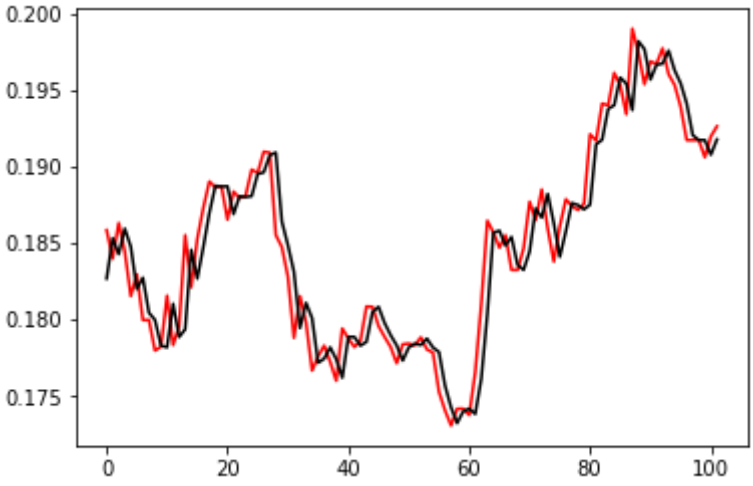
From above we can see that it is giving that p=1,q=0 is the best params and arima(1,1,0) is the best fitted model for the given data

Here we are doing dynamic forecasting that is when we are predicting the nth value for that we are fitting the model that using values from 0 to n-1 then predicting on the nth value it gives the value predicted at that point of time.

In [14]:
```
prediction_data=[]
p=1
q=0
for i in range(len(data),len(df)):
    model_arima=ARIMA(df['Close'][:i],order=(1,1,0))
    model=model_arima.fit()
    prediction_data.append(list(model.predict(start=i,end=i))[0])
```

Plotting the actual data and the predicted data

In [15]:
```
x=np.arange(len(test_data))
plt.plot(x,test_data['Close'],c='red')
plt.plot(x,prediction_data,c='black')
plt.show()
```



Printing MSE value

In [16]:
```
print(mean_squared_error(test_data['Close'],prediction_data))
```

```
4.360081438392454e-06
```

Hence the best fit for this data is arima(1,1,0)

In [17]:
```
# p=6
# q=6
# d=1
# orders=[(p,d,q) for p in range(1,6) for q in range(1,6)]
# models=[]
# model_errors=[]
# predictions=[]
# for order in orders:
#     prediction_1=[]
#     for i in range(len(data),len(df)):
#         model_arima=ARIMA(df['Close'][:i],order=order)
#         model=model_arima.fit()
#         prediction_1.append(list(model.predict(start=i,end=i))[0])
#     model_errors.append(mean_squared_error(test_data['Close'],prediction_1))
#     predictions.append(prediction_1)
#       x=np.arange(len(test_data))
#       plt.plot(x,test_data['Close'],c='red')
#       plt.plot(x,prediction_1,c='black')
#       plt.show()
```

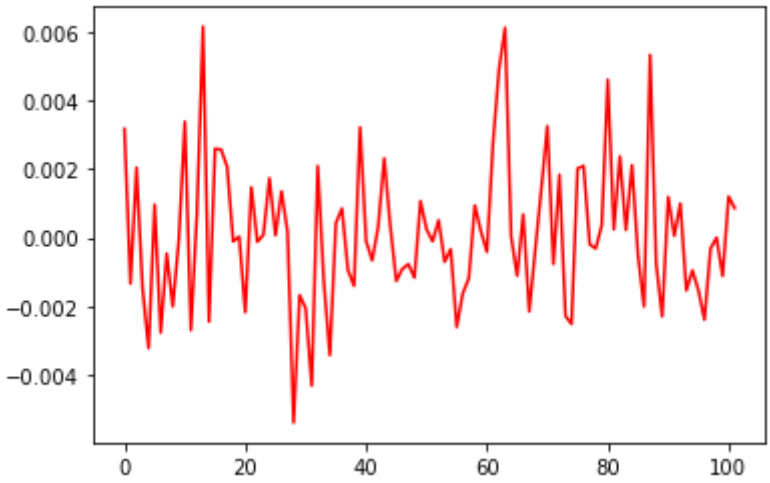
Volatality

Here we are finding volatality by taking difference between close and open prices

In [31]:
```
volatality=test_data['Close']-prediction_data
```

plotting volatality values

In [33]:
```
plt.plot(np.arange(len(test_data)),volatality,c='r')
plt.show()
```



importing arch_model from arch library

In [34]:
```
from arch import arch_model
```

taking orders as random and checking which has the lowest aic

value

In [35]:
```
orders=[(i,j) for i in range(1,5) for j in range(1,5)]
```

fitting arch_model for mutiple orders

In [36]:
```
aic_values=[]
for order in orders:
    model=arch_model(volatality,p=order[0],q=order[1])
    fit_model=model.fit()
    aic_values.append([fit_model.aic,order])
```

```
Iteration:      1,   Func. Count:      6,   Neg. LLF: 5075494677.593472
Iteration:      2,   Func. Count:     18,   Neg. LLF: -485.22803951414903
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.22803953207676
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      7,   Neg. LLF: 9888652318.664545
Iteration:      2,   Func. Count:     21,   Neg. LLF: 3818.821901573557
Iteration:      3,   Func. Count:     33,   Neg. LLF: 906600.0411373008
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.1767698871674
            Iterations: 5
            Function evaluations: 41
            Gradient evaluations: 3
Iteration:      1,   Func. Count:      8,   Neg. LLF: 862487180.2233971
Iteration:      2,   Func. Count:     22,   Neg. LLF: -485.1008957513625
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.1008957739255
            Iterations: 6
            Function evaluations: 22
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      9,   Neg. LLF: 54286755.08202255
Iteration:      2,   Func. Count:     24,   Neg. LLF: -485.0933807060111
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.09338116324443
            Iterations: 6
            Function evaluations: 24
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      7,   Neg. LLF: 440524501.91050714
Iteration:      2,   Func. Count:     21,   Neg. LLF: -87.86037637279024
Iteration:      3,   Func. Count:     31,   Neg. LLF: 28088033.24050659
Iteration:      4,   Func. Count:     44,   Neg. LLF: -485.175094445418
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.175094459734
            Iterations: 8
            Function evaluations: 44
            Gradient evaluations: 4
Iteration:      1,   Func. Count:      8,   Neg. LLF: 489906959.46851236
Iteration:      2,   Func. Count:     23,   Neg. LLF: -153.95999202029196
Iteration:      3,   Func. Count:     34,   Neg. LLF: 905.0187176813023
Iteration:      4,   Func. Count:     46,   Neg. LLF: 337.2864975356368
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.0673915357232
            Iterations: 4
            Function evaluations: 53
            Gradient evaluations: 4
Iteration:      1,   Func. Count:      9,   Neg. LLF: 97989737.84943742
Iteration:      2,   Func. Count:     24,   Neg. LLF: -485.03664605661095
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.0366464443673
            Iterations: 6
            Function evaluations: 24
            Gradient evaluations: 2
Iteration:      1,   Func. Count:     10,   Neg. LLF: 132996770.85069534
```

```
Iteration:      2,   Func. Count:     27,   Neg. LLF: 71975386600334.78
Iteration:      3,   Func. Count:     46,   Neg. LLF: 205751119.8524816
Iteration:      4,   Func. Count:     63,   Neg. LLF: 5.956174381027203e+16
Iteration:      5,   Func. Count:     82,   Neg. LLF: 5.2664127288719285e+20
Iteration:      6,   Func. Count:     99,   Neg. LLF: 9.326588318091698e+18
Iteration:      7,   Func. Count:    117,   Neg. LLF: -353.7592091755296
Inequality constraints incompatible    (Exit mode 4)
            Current function value: -353.75919655581083
            Iterations: 10
            Function evaluations: 117
            Gradient evaluations: 7
Iteration:      1,   Func. Count:      8,   Neg. LLF: 1751052557.5661826
Iteration:      2,   Func. Count:     22,   Neg. LLF: -485.03615735780147
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.036157379317
            Iterations: 6
            Function evaluations: 22
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      9,   Neg. LLF: 73415463.11801599
Iteration:      2,   Func. Count:     25,   Neg. LLF: 2617.8852773798335
Iteration:      3,   Func. Count:     38,   Neg. LLF: 14938765.206766102
Iteration:      4,   Func. Count:     53,   Neg. LLF: -485.00107984316344
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.00107986483295
            Iterations: 8
            Function evaluations: 53
            Gradient evaluations: 4
Iteration:      1,   Func. Count:     10,   Neg. LLF: 196628282.74926114
Iteration:      2,   Func. Count:     26,   Neg. LLF: -485.0247632938334
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.02476367784294
            Iterations: 6
            Function evaluations: 26
            Gradient evaluations: 2
Iteration:      1,   Func. Count:     11,   Neg. LLF: 195760922.2501407
Iteration:      2,   Func. Count:     29,   Neg. LLF: 1.7986535936432714e+17
Iteration:      3,   Func. Count:     49,   Neg. LLF: 633000085938.7314
Iteration:      4,   Func. Count:     67,   Neg. LLF: 1.4183260512663773e+20
Iteration:      5,   Func. Count:     87,   Neg. LLF: 16419159982734.33
Iteration:      6,   Func. Count:    105,   Neg. LLF: -446.2900384672342
C:\Users\Manoj\anaconda3\lib\site-packages\arch\univariate\base.py:753: ConvergenceW
arning: The optimizer returned code 4. The message is:
Inequality constraints incompatible
See scipy.optimize.fmin_slsqp for code meaning.

  warnings.warn(
C:\Users\Manoj\anaconda3\lib\site-packages\arch\univariate\base.py:753: ConvergenceW
arning: The optimizer returned code 4. The message is:
Inequality constraints incompatible
See scipy.optimize.fmin_slsqp for code meaning.

  warnings.warn(
Inequality constraints incompatible    (Exit mode 4)
            Current function value: -446.29003481805347
            Iterations: 8
            Function evaluations: 105
            Gradient evaluations: 6
Iteration:      1,   Func. Count:      9,   Neg. LLF: 58059004.46762563
Iteration:      2,   Func. Count:     25,   Neg. LLF: 15568.758357828947
Iteration:      3,   Func. Count:     39,   Neg. LLF: 5365865.714725918
Optimization terminated successfully    (Exit mode 0)
            Current function value: -484.92538764352594
            Iterations: 4
            Function evaluations: 47
            Gradient evaluations: 3
Iteration:      1,   Func. Count:     10,   Neg. LLF: 1.563453686590796e+17
Iteration:      2,   Func. Count:     27,   Neg. LLF: 700926918233088.9
Iteration:      3,   Func. Count:     46,   Neg. LLF: 1.6952438190132467e+24
Iteration:      4,   Func. Count:     65,   Neg. LLF: 5047640944704326.0
```

```
Iteration:      5,   Func. Count:     84,   Neg. LLF: 4.042123023656955e+19
Iteration:      6,   Func. Count:    101,   Neg. LLF: 5.97966286502605e+16
Iteration:      7,   Func. Count:    120,   Neg. LLF: 4.238634151321173e+25
Iteration:      8,   Func. Count:    139,   Neg. LLF: 7.648005271761572e+17
Iteration:      9,   Func. Count:    158,   Neg. LLF: 6.367755074097305e+21
Iteration:     10,   Func. Count:    176,   Neg. LLF: 4.4380533239279867e+18
Iteration:     11,   Func. Count:    194,   Neg. LLF: -415.7848062373913
Inequality constraints incompatible    (Exit mode 4)
            Current function value: -415.78479889711247
            Iterations: 14
            Function evaluations: 194
            Gradient evaluations: 11
Iteration:      1,   Func. Count:     11,   Neg. LLF: 177632352.47737858
Iteration:      2,   Func. Count:     28,   Neg. LLF: -484.9983741110565
Optimization terminated successfully    (Exit mode 0)
            Current function value: -484.99837448894317
            Iterations: 6
            Function evaluations: 28
            Gradient evaluations: 2
Iteration:      1,   Func. Count:     12,   Neg. LLF: 154120578.8428661
Iteration:      2,   Func. Count:     30,   Neg. LLF: -485.0285291509033
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.0285295872008
            Iterations: 6
            Function evaluations: 30
            Gradient evaluations: 2
```

```
C:\Users\Manoj\anaconda3\lib\site-packages\arch\univariate\base.py:753: ConvergenceW
arning: The optimizer returned code 4. The message is:
Inequality constraints incompatible
See scipy.optimize.fmin_slsqp for code meaning.

  warnings.warn(
```

printing aic values after sorting then first value will be the required value

In [37]:
```
aic_values.sort()
aic_values
```

Out[37]:
```
[[-962.4560790641535, (1, 1)],
 [-960.3535397743348, (1, 2)],
 [-960.350188919468, (2, 1)],
 [-958.201791547851, (1, 3)],
 [-958.1347830714463, (2, 2)],
 [-958.072314758634, (3, 1)],
 [-956.1867623264889, (1, 4)],
 [-956.0732928887346, (2, 3)],
 [-956.0021597296659, (3, 2)],
 [-955.8507752870519, (4, 1)],
 [-954.0495273556859, (3, 3)],
 [-951.9967489778863, (4, 3)],
 [-950.0570591744016, (4, 4)],
 [-874.5800696361069, (3, 4)],
 [-815.5695977942249, (4, 2)],
 [-691.5183931116217, (2, 4)]]
```

printing p,q values

In [38]:
```
p,q=aic_values[0][1]
p,q
```

Out[38]:
```
(1, 1)
```

fitting arch model with the p,q obtained above

In [39]:
```
model=arch_model(volatality,p=1,q=1)
fitted_model=model.fit()
fitted_model.summary()
```

```
Iteration:      1,   Func. Count:      6,   Neg. LLF: 5075494677.593472
Iteration:      2,   Func. Count:     18,   Neg. LLF: -485.22803951414903
Optimization terminated successfully    (Exit mode 0)
            Current function value: -485.22803953207676
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
```

Out[39]:

Constant Mean - GARCH Model Results

Dep. Variable:	Close	**R-squared:**	0.000
Mean Model:	Constant Mean	**Adj. R-squared:**	0.000
Vol Model:	GARCH	**Log-Likelihood:**	485.228
Distribution:	Normal	**AIC:**	-962.456
Method:	Maximum Likelihood	**BIC:**	-951.956
		No. Observations:	102
Date:	Fri, May 06 2022	**Df Residuals:**	101
Time:	23:47:15	**Df Model:**	1

Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	1.0069e-04	1.928e-07	522.257	0.000	[1.003e-04,1.011e-04]

Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	2.1739e-06	1.055e-10	2.060e+04	0.000	[2.174e-06,2.174e-06]
alpha[1]	0.0500	0.121	0.412	0.680	[-0.188, 0.288]
beta[1]	0.4500	0.145	3.102	1.925e-03	[0.166, 0.734]

Covariance estimator: robust

Here we have fitted arch(1,1) model to this residual data.then we can use this to forecast the data

In [45]:
```
def rolling_predictions(n=20) :
    predicted_values=[]
    for i in range(n):
        model=arch_model(volatality[:80+i],p=1,q=1)
        fitted_model=model.fit()
        predicted_values.append(fitted_model.forecast (horizon=1).variance.iloc[-1].
    return predicted_values

rolling_predictions()
```

```
Iteration:      1,   Func. Count:      6,   Neg. LLF: 48900755510.28863
Iteration:      2,   Func. Count:     18,   Neg. LLF: -380.05225949245596
Optimization terminated successfully    (Exit mode 0)
            Current function value: -380.0522595113374
            Iterations: 6
            Function evaluations: 18
```

```
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 49258171768.21163
Iteration:      2,   Func. Count:     18,   Neg. LLF: 31166778241.324642
Iteration:      3,   Func. Count:     30,   Neg. LLF: 599265.7495131539
Iteration:      4,   Func. Count:     39,   Neg. LLF: 81914907.25292881
Optimization terminated successfully    (Exit mode 0)
            Current function value: -382.6814700520856
            Iterations: 6
            Function evaluations: 47
            Gradient evaluations: 4
Iteration:      1,   Func. Count:      6,   Neg. LLF: 949005639.6706797
Iteration:      2,   Func. Count:     18,   Neg. LLF: 1075280.8128729279
Iteration:      3,   Func. Count:     29,   Neg. LLF: 27764.95628685223
Optimization terminated successfully    (Exit mode 0)
            Current function value: -387.77440107488223
            Iterations: 4
            Function evaluations: 36
            Gradient evaluations: 3
Iteration:      1,   Func. Count:      6,   Neg. LLF: 960519504.1225054
Iteration:      2,   Func. Count:     18,   Neg. LLF: 602755.3797910514
Iteration:      3,   Func. Count:     28,   Neg. LLF: -392.4515775628176
Optimization terminated successfully    (Exit mode 0)
            Current function value: -392.45157757560173
            Iterations: 7
            Function evaluations: 28
            Gradient evaluations: 3
Iteration:      1,   Func. Count:      6,   Neg. LLF: 809370884.0152029
Iteration:      2,   Func. Count:     19,   Neg. LLF: 7405490.662738605
Optimization terminated successfully    (Exit mode 0)
            Current function value: -397.67940180779357
            Iterations: 2
            Function evaluations: 28
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 669658791.4324353
Iteration:      2,   Func. Count:     18,   Neg. LLF: -402.4903573559526
Optimization terminated successfully    (Exit mode 0)
            Current function value: -402.49035736961764
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 5604145276.413902
Iteration:      2,   Func. Count:     19,   Neg. LLF: 9644997.60965323
Optimization terminated successfully    (Exit mode 0)
            Current function value: -407.6926777688029
            Iterations: 2
            Function evaluations: 28
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 7273966430.745631
Iteration:      2,   Func. Count:     18,   Neg. LLF: -412.4130495015284
Optimization terminated successfully    (Exit mode 0)
            Current function value: -412.41304951629814
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 132641777.12192008
Iteration:      2,   Func. Count:     18,   Neg. LLF: -414.6750119510114
Optimization terminated successfully    (Exit mode 0)
            Current function value: -414.6750119574582
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 58179212.54228473
Iteration:      2,   Func. Count:     18,   Neg. LLF: -419.7131584132023
Optimization terminated successfully    (Exit mode 0)
            Current function value: -419.71315841886275
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 36254432.58014761
```

```
Iteration:      2,   Func. Count:     19,   Neg. LLF: 283889056826.00354
Optimization terminated successfully    (Exit mode 0)
            Current function value: -424.28357347055913
            Iterations: 2
            Function evaluations: 26
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 40585435.893772416
Iteration:      2,   Func. Count:     18,   Neg. LLF: -429.37325915880245
Optimization terminated successfully    (Exit mode 0)
            Current function value: -429.37325916657113
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 68707525.4587514
Iteration:      2,   Func. Count:     18,   Neg. LLF: -434.6030559148267
Optimization terminated successfully    (Exit mode 0)
            Current function value: -434.6030559250663
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 35328575.21909424
Iteration:      2,   Func. Count:     19,   Neg. LLF: 8773714963163.079
Optimization terminated successfully    (Exit mode 0)
            Current function value: -439.7821145670954
            Iterations: 2
            Function evaluations: 27
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 5.2231713317447336e+16
Iteration:      2,   Func. Count:     19,   Neg. LLF: 75830507099.95305
Iteration:      3,   Func. Count:     30,   Neg. LLF: 4303298.332221132
Optimization terminated successfully    (Exit mode 0)
            Current function value: -444.70221088763026
            Iterations: 3
            Function evaluations: 38
            Gradient evaluations: 3
Iteration:      1,   Func. Count:      6,   Neg. LLF: 9.748420911562451e+16
Iteration:      2,   Func. Count:     18,   Neg. LLF: -449.8176298484062
Optimization terminated successfully    (Exit mode 0)
            Current function value: -449.81762986175005
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 497031763.3496637
Iteration:      2,   Func. Count:     18,   Neg. LLF: -454.7543339269092
Optimization terminated successfully    (Exit mode 0)
            Current function value: -454.7543339405344
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 2.1422489649533056e+17
Iteration:      2,   Func. Count:     19,   Neg. LLF: 228174729333.42624
Optimization terminated successfully    (Exit mode 0)
            Current function value: -459.28103628718185
            Iterations: 3
            Function evaluations: 25
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 394088893.38242185
Iteration:      2,   Func. Count:     18,   Neg. LLF: -464.50037337079476
Optimization terminated successfully    (Exit mode 0)
            Current function value: -464.5003733841132
            Iterations: 6
            Function evaluations: 18
            Gradient evaluations: 2
Iteration:      1,   Func. Count:      6,   Neg. LLF: 508876311.66032434
Iteration:      2,   Func. Count:     18,   Neg. LLF: -469.76786031560766
Optimization terminated successfully    (Exit mode 0)
            Current function value: -469.7678603306933
            Iterations: 6
```

```
                    Function evaluations: 18
                    Gradient evaluations: 2
```

Out[45]:
```
[array([3.78347519e-06]),
 array([5.94232411e-06]),
 array([4.6492484e-06]),
 array([4.6445804e-06]),
 array([4.34380594e-06]),
 array([4.4119815e-06]),
 array([4.23723267e-06]),
 array([4.38611072e-06]),
 array([5.77358012e-06]),
 array([4.97822222e-06]),
 array([4.91202916e-06]),
 array([4.58682515e-06]),
 array([4.35931368e-06]),
 array([4.27166666e-06]),
 array([4.3462078e-06]),
 array([4.26948255e-06]),
 array([4.30969237e-06]),
 array([4.52378195e-06]),
 array([4.27130336e-06]),
 array([4.12714078e-06])]
```

Here we predicted the values in the above cell

This project is done by Chundru Manoj Sai Surendra - 1903205 - M&C

In [ ]:

In [ ]: