## CLEAN AND TEST DATA

↳ 13 cells hidden

## Testing For Stationarity

```
[32] from statsmodels.tsa.stattools import adfuller
```

```
[33] test_result=adfuller(df['Rate'])
```

```
[34] #Ho: It is non stationary
     #H1: It is stationary

     def adfuller_test(Rate):
         result=adfuller(Rate)
         labels = ['ADF Test Statistic','p-value','#Lags Used','Number of Observations Used']
         for value,label in zip(result,labels):
             print(label+' : '+str(value) )
         if result[1] <= 0.05:
             print("strong evidence against the null hypothesis(Ho), reject the null hypothesis.Data has no unit root and is stationary")
         else:
             print("weak evidence against null hypothesis, time series has a unit root, indicating it is non-stationary ")
```

```
[35] adfuller_test(df['Rate'])
```

```
ADF Test Statistic : -2.680476503083977
p-value : 0.07747804548411097
#Lags Used : 1
Number of Observations Used : 151
weak evidence against null hypothesis, time series has a unit root, indicating it is non-stationary
```

## DIFFERENCING

```
[63] df['Rates First Difference'] = df['Rate'] - df['Rate'].shift(1)
```

```
[64] df['Rate'].shift(1)
```

```
Month
2010-11-01       NaN
2010-12-01   16.2225
2011-01-01   16.7800
2011-02-01   17.7850
2011-03-01   15.7350
              ...
2023-03-01   12.6825
2023-04-01   12.1180
2023-05-01   12.1350
2023-06-01   11.8500
2023-07-01   13.9400
Name: Rate, Length: 153, dtype: float64
```

```
[69] df['Rates First Difference'] = df['Rate'] - df['Rate'].shift(4)  ##Quarterly  shift for 4 months
```

```
[70] df.head(14)
```

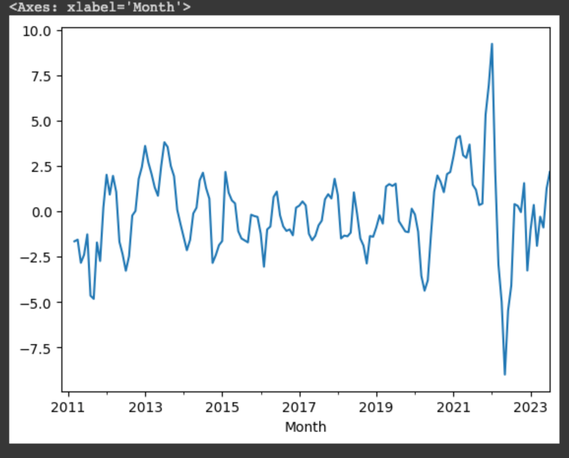
| Month | Rate | Rates First Difference |
|---|---|---|
| 2010-11-01 | 16.2225 | NaN |
| 2010-12-01 | 16.7800 | NaN |
| 2011-01-01 | 17.7850 | NaN |
| 2011-02-01 | 15.7350 | NaN |
| 2011-03-01 | 14.5700 | -1.6525 |
| 2011-04-01 | 15.2200 | -1.5600 |
| 2011-05-01 | 14.9475 | -2.8375 |
| 2011-06-01 | 13.3425 | -2.3925 |
| 2011-07-01 | 13.3020 | -1.2680 |
| 2011-08-01 | 10.5725 | -4.6475 |
| 2011-09-01 | 10.1240 | -4.8235 |
| 2011-10-01 | 11.6275 | -1.7150 |
| 2011-11-01 | 10.5650 | -2.7370 |
| 2011-12-01 | 10.7780 | 0.2055 |

```
[71] ## Again test dickey fuller test
     adfuller_test(df['Rates First Difference'].dropna())
```

```
ADF Test Statistic : -3.1023362174934275
p-value : 0.026380780322677662
#Lags Used : 12
Number of Observations Used : 136
strong evidence against the null hypothesis(Ho), reject the null hypothesis.Data has no unit root and is stationary
```

```
[72] df['Rates First Difference'].plot()
```

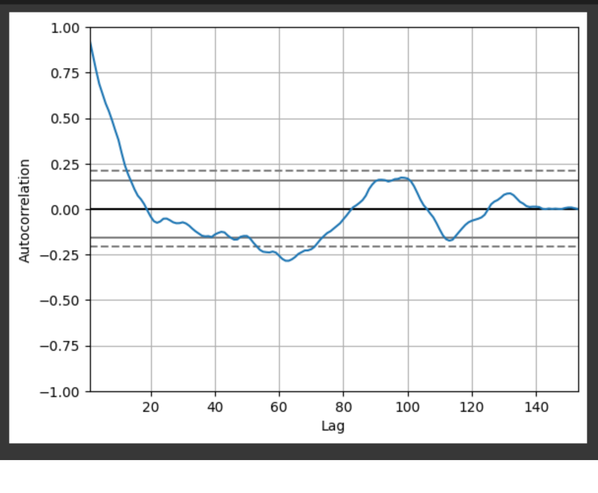
```
<Axes: xlabel='Month'>
```




## DETERMINING p (AR) ,d (diff), q (MA)

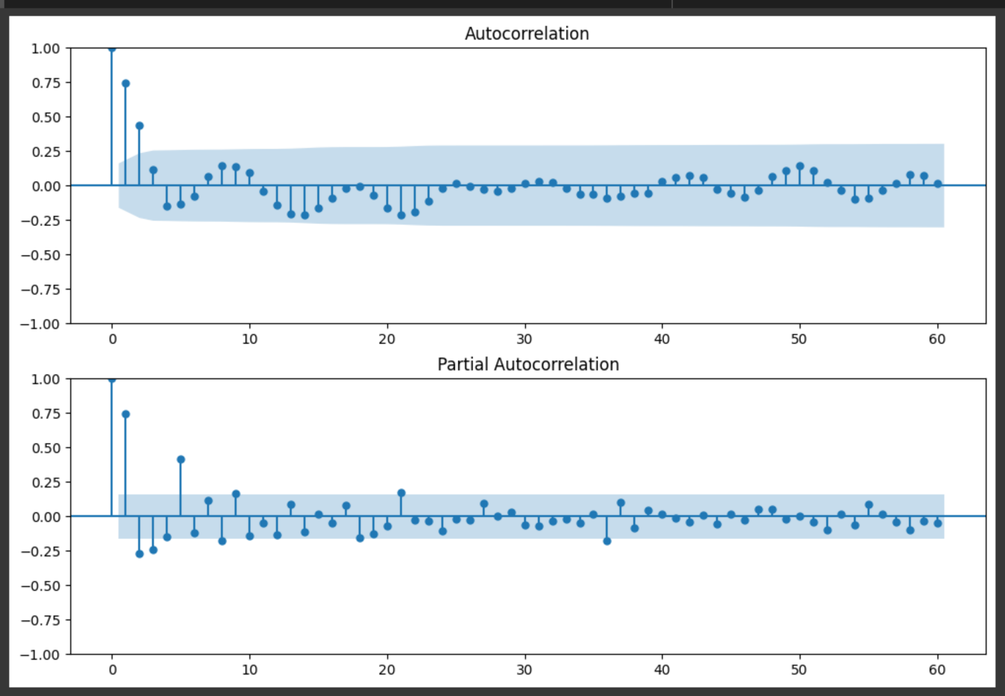
p- partial auto-correlation q- auto-correlation

```
[73] from pandas.plotting import autocorrelation_plot
     autocorrelation_plot(df['Rate'])
     plt.show()
```



```
[74] from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
     import statsmodels.api as sm
```

```
fig = plt.figure(figsize=(12,8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(df['Rates First Difference'].iloc[5:],lags=60,ax=ax1)
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(df['Rates First Difference'].iloc[5:],lags=60,ax=ax2)
```




## Building ARIMA

p=1, d=1, q=2 or 3

```
[76] # For non-seasonal data

     from statsmodels.tsa.arima.model import ARIMA
```

```
[118] model=ARIMA(df['Rate'],order=(1,1,2))
      model_fit=model.fit()
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
```

```
[119] model_fit.summary()
```

SARIMAX Results

| | | | |
|---|---|---|---|
| **Dep. Variable:** | Rate | **No. Observations:** | 153 |
| **Model:** | ARIMA(1, 1, 2) | **Log Likelihood** | -227.379 |
| **Date:** | Sun, 20 Aug 2023 | **AIC** | 462.759 |
| **Time:** | 22:35:13 | **BIC** | 474.854 |
| **Sample:** | 11-01-2010 - 07-01-2023 | **HQIC** | 467.672 |

**Covariance Type:** opg

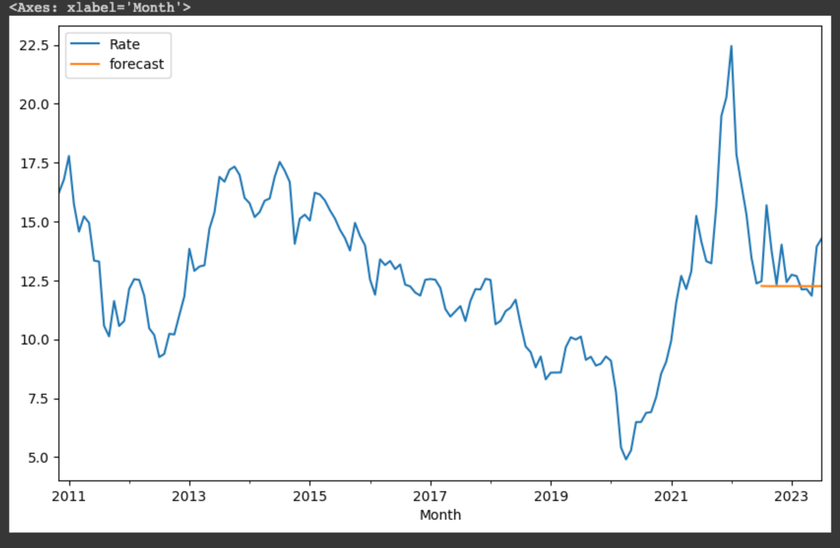
| | coef | std err | z | P>\|z\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **ar.L1** | 0.0469 | 8.846 | 0.005 | 0.996 | -17.292 | 17.385 |
| **ma.L1** | 0.0595 | 8.857 | 0.007 | 0.995 | -17.301 | 17.420 |
| **ma.L2** | 0.0018 | 0.954 | 0.002 | 0.998 | -1.869 | 1.872 |
| **sigma2** | 1.1663 | 0.102 | 11.387 | 0.000 | 0.966 | 1.367 |

| | | | |
|---|---|---|---|
| **Ljung-Box (L1) (Q):** | 0.00 | **Jarque-Bera (JB):** | 56.65 |
| **Prob(Q):** | 1.00 | **Prob(JB):** | 0.00 |
| **Heteroskedasticity (H):** | 2.03 | **Skew:** | -0.27 |
| **Prob(H) (two-sided):** | 0.01 | **Kurtosis:** | 5.94 |

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

```
[131] df['forecast']=model_fit.predict(start=140,end=153,dynamic=True)
      df[['Rate','forecast']].plot(figsize=(10,6))
```

```
<Axes: xlabel='Month'>
```



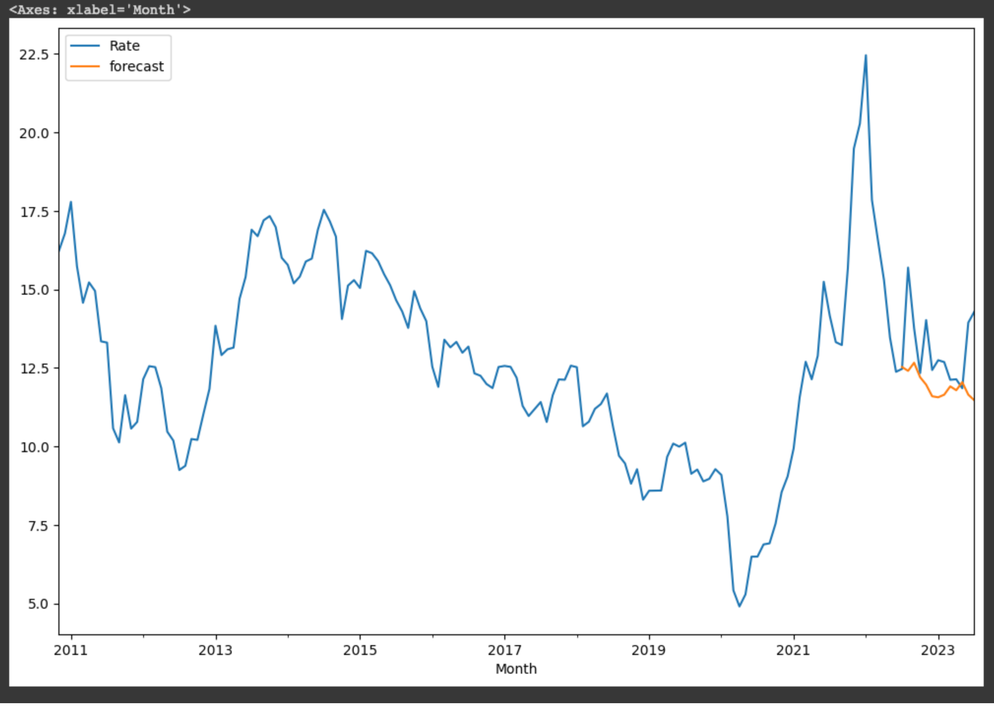

```
[121] import statsmodels.api as sm
```

```
[122] model=sm.tsa.statespace.SARIMAX(df['Rate'],order=(1, 1, 2),seasonal_order=(1,1,2,4))
      results=model.fit()
```

```
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
/usr/local/lib/python3.10/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: No frequency information was provided, so inferred frequency MS will be used.
  self._init_dates(dates, freq)
/usr/local/lib/python3.10/dist-packages/statsmodels/base/model.py:607: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
```

```
[130] df['forecast']=results.predict(start=140,end=153,dynamic=True)
      df[['Rate','forecast']].plot(figsize=(12,8))
```

```
<Axes: xlabel='Month'>
```



```
[132] from pandas.tseries.offsets import DateOffset
      future_dates=[df.index[-1]+ DateOffset(months=x)for x in range(0,24)]
```

```
[133] future_datest_df=pd.DataFrame(index=future_dates[1:],columns=df.columns)
```

```
[134] future_datest_df.tail()
```

| | Rate | Rates First Difference | forecast |
|---|---|---|---|
| 2025-02-01 | NaN | NaN | NaN |
| 2025-03-01 | NaN | NaN | NaN |
| 2025-04-01 | NaN | NaN | NaN |
| 2025-05-01 | NaN | NaN | NaN |
| 2025-06-01 | NaN | NaN | NaN |

```
[135] future_df=pd.concat([df,future_datest_df])
```

## Quaterly FORECAST

```
[136] future_df['forecast'] = results.predict(start = 152, end = 175, dynamic= True)
      future_df[['Rate', 'forecast']].plot(figsize=(12, 8))
```

```
<Axes: >
```