Unsupported Cell Type. Double-Click to inspect/edit the content.

```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
```

```
df = pd.read_csv("/content/Train.csv")
df.head()
```

	ID	Datetime	Count
0	0	25-08-2012 00:00	8
1	1	25-08-2012 01:00	2
2	2	25-08-2012 02:00	6
3	3	25-08-2012 03:00	2
4	4	25-08-2012 04:00	2

```
## Cleaning up the data
df.columns=["ID","DateTime","Count"]
del df["ID"]
df.head()
```

	DateTime	Count
0	25-08-2012 00:00	8

```
df.DateTime = pd.to_datetime(df.DateTime,format='%d-%m-%Y %H:%M')
df.index = df.DateTime
df = df.resample('D').mean()
```

```
# ## Drop last 2 rows
# df.drop(106,axis=0,inplace=True)
# df.drop(105,axis=0,inplace=True)
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 762 entries, 2012-08-25 to 2014-09-25
Freq: D
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   Count   762 non-null    float64
dtypes: float64(1)
memory usage: 11.9 KB
```

```
# # Convert DateTime into Datetime
# df['DateTime']=pd.to_datetime(df['DateTime'])
# df.info()
```

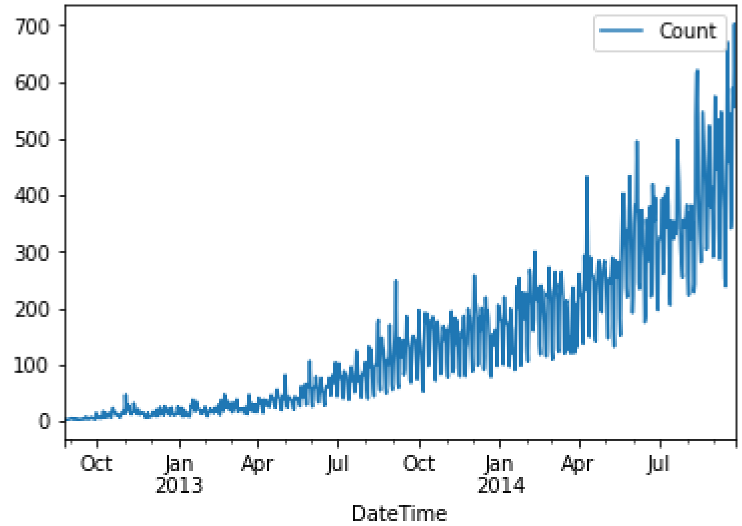
```
# df.set_index('DateTime',inplace=True)
# df.head()
```

```
df.describe()
```

	Count
count	762.000000
mean	138.958115
std	135.911437
min	2.416667
25%	24.250000
50%	99.125000
75%	215.958333
max	702.333333

```
df.plot()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f78feb583d0>
```



Moving Average

This method removes the underlying trend in the time series also known as Detrending

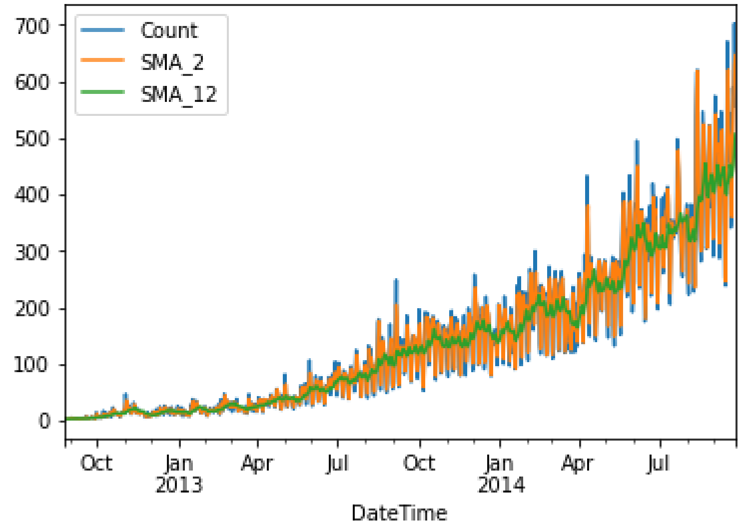
```
# SMA over a period of 2 and 12 DateTime
#min_period = min value to start calculation

df['SMA_2'] = df.Count.rolling(2, min_periods=1).mean()
df['SMA_12'] = df.Count.rolling(12, min_periods=1).mean()
df.head(20)
```

	Count	SMA_2	SMA_12
DateTime			
2012-08-25	3.166667	3.166667	3.166667
2012-08-26	3.666667	3.416667	3.416667
2012-08-27	2.583333	3.125000	3.138889
2012-08-28	2.416667	2.500000	2.958333
2012-08-29	2.500000	2.458333	2.866667

```
df.plot()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f78fcab2c50>
```




```
df['CMA']= df.Count.expanding(min_periods=1).mean()  # cummulative moving average the cumulative moving average considers all of the
df.head(15)
```

DateTime	Count	SMA_2	SMA_12	CMA
2012-08-25	3.166667	3.166667	3.166667	3.166667
2012-08-26	3.666667	3.416667	3.416667	3.416667
2012-08-27	2.583333	3.125000	3.138889	3.138889
2012-08-28	2.416667	2.500000	2.958333	2.958333
2012-08-29	2.500000	2.458333	2.866667	2.866667
2012-08-30	3.083333	2.791667	2.902778	2.902778
2012-08-31	3.250000	3.166667	2.952381	2.952381
2012-09-01	4.666667	3.958333	3.166667	3.166667
2012-09-02	4.916667	4.791667	3.361111	3.361111
2012-09-03	4.500000	4.708333	3.475000	3.475000
2012-09-04	2.750000	3.625000	3.409091	3.409091
2012-09-05	4.333333	3.541667	3.486111	3.486111
2012-09-06	4.166667	4.250000	3.569444	3.538462

```
df.plot()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f78fc96a810>
```

Exponential Moving Average

[ ] ↳ *3 cells hidden*

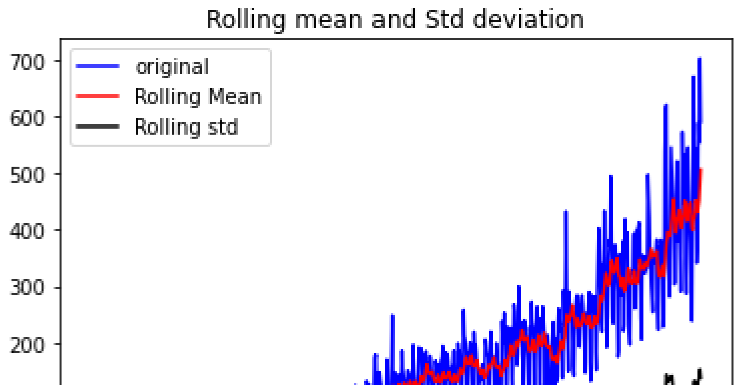
Check for Stationarity

Two common methods to check for stationarity are Visualization and the Augmented Dickey-Fuller (ADF) Test. Python makes both approaches easy:

```
# Rolling Statistics or Visualization

rolmean = df.Count.rolling(window=12).mean()
rolstd = df.Count.rolling(window=12).std()


orig = plt.plot(df.Count,color='blue',label='original')
mean = plt.plot(rolmean,color='red',label='Rolling Mean')
std = plt.plot(rolstd,color='black',label='Rolling std')
plt.legend()
plt.title('Rolling mean and Std deviation')
plt.show()
```




```
### Testing For Stationarity using Dickey-fuller test

from statsmodels.tsa.stattools import adfuller


test_result=adfuller(df['Count'])
test_result  # 'ADF Test Statistic','p-value','#Lags Used','Number of Observations Used'
```

```
(2.9863509590138064,
 1.0,
 20,
 741,
 {'1%': -3.4392057325732104,
  '10%': -2.5688512291811225,
  '5%': -2.8654483492874236},
 7212.068059584323)
```

```
#Ho: It is not stationary
#H1: It is stationary

def adfuller_test(sales):
    result=adfuller(sales)
    #print(result)
    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 is stationary")
    else:
        print("weak evidence against null hypothesis, indicating it is non-stationary ")

adfuller_test(df['Count'])
```

```
ADF Test Statistic : 2.9863509590138064
p-value : 1.0
Lags Used : 20
Number of Observations Used : 741
weak evidence against null hypothesis, indicating it is non-stationary
```

Converting Non- stationary into stationary

Detrending

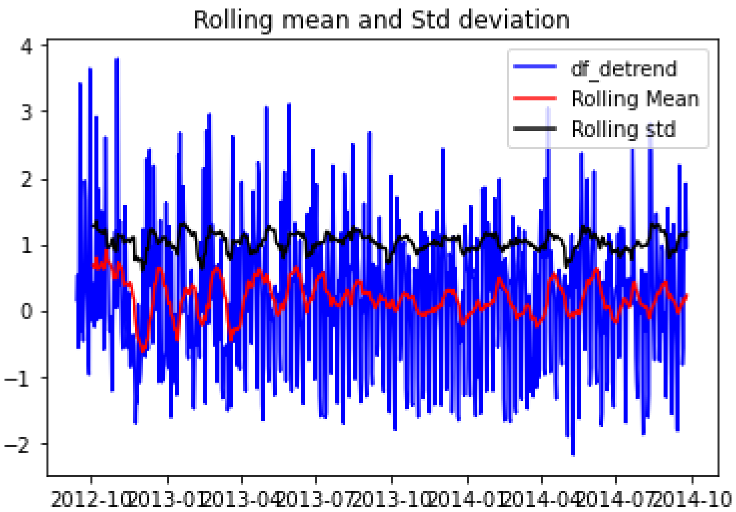
This method removes the underlying trend in the time series:

```
# Detrending
df_detrend =  (df['Count'] - df['Count'].rolling(window=21).mean())/df['Count'].rolling(window=21).std()


# Rolling Statistics or Visualization

rolmean = df_detrend.rolling(window=21).mean()
rolstd = df_detrend.rolling(window=21).std()

orig = plt.plot(df_detrend,color='blue',label='df_detrend')
mean = plt.plot(rolmean,color='red',label='Rolling Mean')
std = plt.plot(rolstd,color='black',label='Rolling std')
plt.legend()
plt.title('Rolling mean and Std deviation')
plt.show()
```

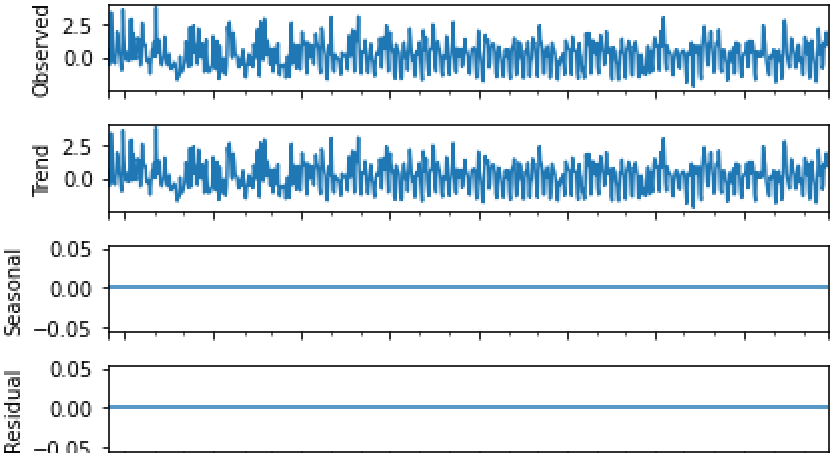



```
df_detrend = df_detrend.dropna()
```

```
#ad fuller test
adfuller_test(df_detrend.dropna())
```

```
ADF Test Statistic : -6.858601721956719
p-value : 1.6241878203855412e-09
Lags Used : 20
Number of Observations Used : 721
strong evidence against the null hypothesis(Ho), reject the null hypothesis. Data is stationary
```

```
from statsmodels.tsa.seasonal import seasonal_decompose
decompose_result = seasonal_decompose(df_detrend,model='additive',freq=1)
decompose_result.plot()
plt.show()
```




```
n_df = df_detrend

converted = pd.DataFrame()

converted['converted_count'] = df_detrend

# from statsmodels.tsa.ar_model import AutoReg

converted['converted_count']=df['Count']-df['Count'].shift(1)
## Again test dickey fuller test
test_result=adfuller(converted['converted_count'].dropna())
test_result
```

```
(-7.869743724780802,
 5.022165724692337e-12,
 20,
 721,
 {'1%': -3.4394522667904153,
  '10%': -2.568909106765338,
  '5%': -2.8655569894909805},
 7036.700334387224)
```

```
converted['converted_count']=df['Count']-df['Count'].shift(21)
## Again test dickey fuller test
test_result=adfuller(converted['converted_count'].dropna())
test_result
```

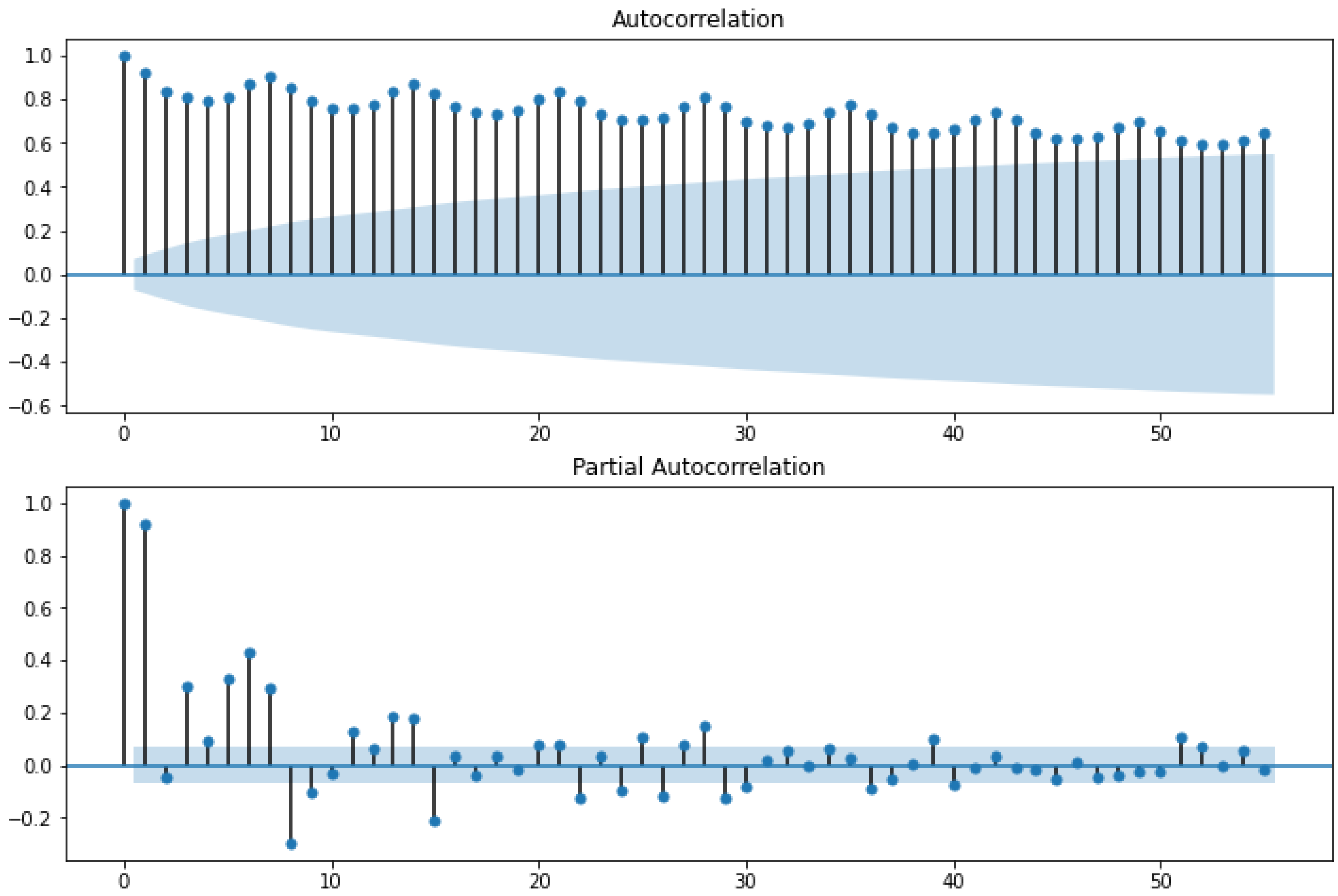
```
(-9.481491805173777,
 3.8620327288466455e-16,
 20,
 720,
 {'1%': -3.439464954327953,
  '10%': -2.5689120852623457,
  '5%': -2.8655625802683473},
 7169.7144851612675)
```

```
DateTime
2012-08-25      3.166667
2012-08-26      3.666667
2012-08-27      2.583333
2012-08-28      2.416667
2012-08-29      2.500000
                  ...
2014-09-21    379.250000
2014-09-22    588.166667
2014-09-23    554.333333
2014-09-24    702.333333
2014-09-25    589.666667
Freq: D, Name: Count, Length: 762, dtype: float64
```

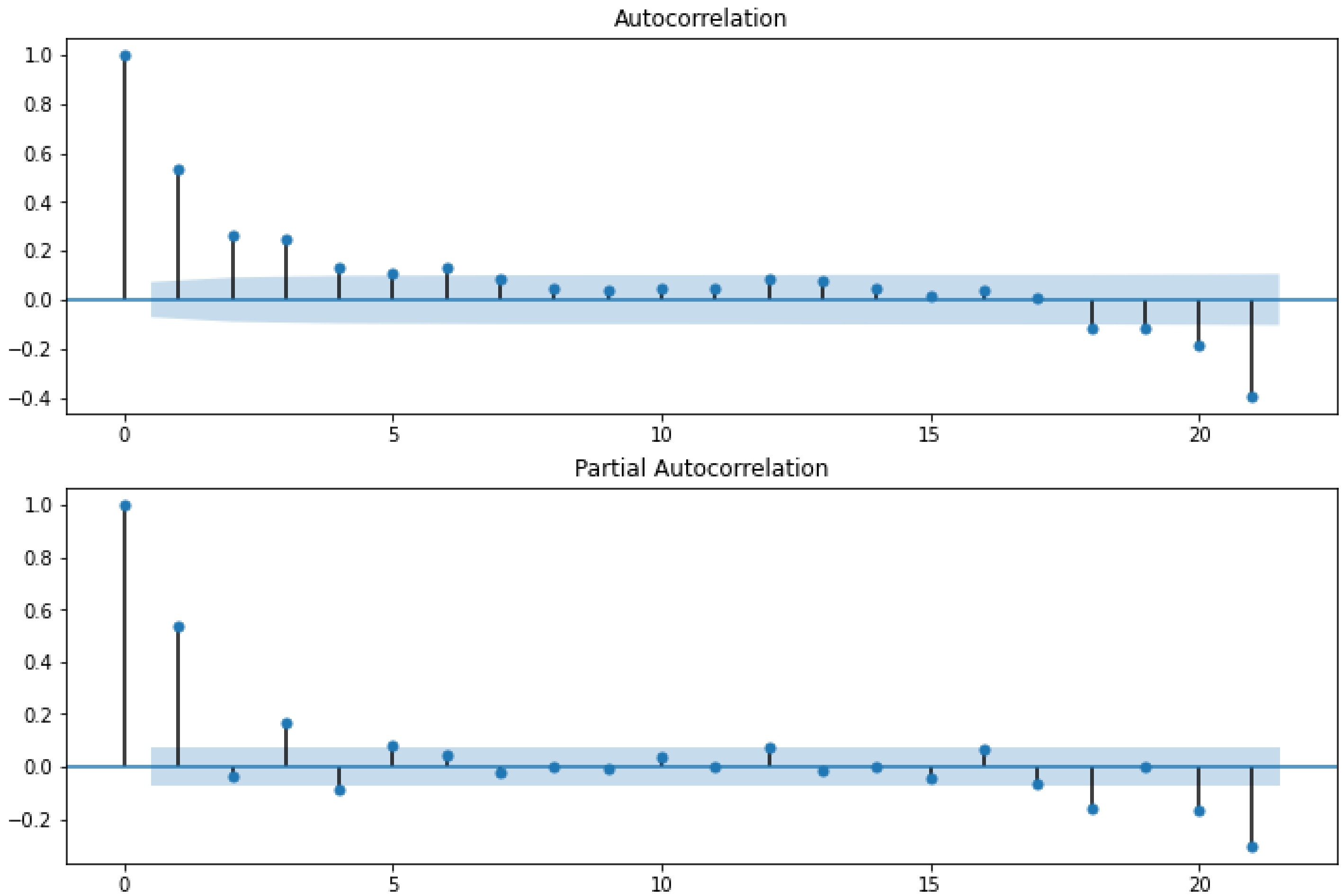
```
import statsmodels.api as sm
```

```
%matplotlib inline
fig = plt.figure(figsize=(12,8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(df['Count'], lags=55, ax=ax1)
```

```
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(df['Count'], lags=55, ax=ax2)
```




```
%matplotlib inline
fig = plt.figure(figsize=(12,8))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(converted['converted_count'].dropna(), lags=21, ax=ax1)
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(converted['converted_count'].dropna(), lags=21, ax=ax2)
```




```
from statsmodels.tsa.arima_model import ARMA
# fit model
ARMAmodel = ARMA(df['Count'], order=(1, 1))
ARmodel_fit = ARMAmodel.fit(disp=False)
```

```
df['Count'].count()
```

```
762
```

```
actuals = df['Count'][749:763]
```

```
actuals
```

```
DateTime
2014-09-13    253.333333
2014-09-14    238.166667
2014-09-15    445.333333
2014-09-16    670.000000
2014-09-17    569.833333
2014-09-18    458.333333
2014-09-19    543.083333
2014-09-20    341.083333
2014-09-21    379.250000
2014-09-22    588.166667
2014-09-23    554.333333
2014-09-24    702.333333
2014-09-25    589.666667
Freq: D, Name: Count, dtype: float64
```

```
ypredicted = ARmodel_fit.predict(750,762)  # end point included
print(ypredicted)
```

```
2014-09-14    239.031502
2014-09-15    230.901013
2014-09-16    434.640107
2014-09-17    643.347121
2014-09-18    533.043302
2014-09-19    429.993243
2014-09-20    519.084823
2014-09-21    315.752144
2014-09-22    364.912357
2014-09-23    567.068787
2014-09-24    522.228165
2014-09-25    670.027630
2014-09-26    550.966952
Freq: D, dtype: float64
```

```
from sklearn.metrics import mean_absolute_error
mae = mean_absolute_error(actuals, ypredicted)
```

```
print('MAE: %f' % mae)
#print(ARmodel_fit.aic)
```

```
MAE: 23.993809
```

```
import itertools
i = j = range(0, 7)
ij = itertools.product(i,j)
for parameters in ij:
    try:
        mod = ARMA(df['Count'],order=parameters)
        results = mod.fit()
        ypredicted = results.predict(750,762)  # end point included
        mae = mean_absolute_error(actuals, ypredicted)
        print('ARMA{} - MAE:{}'.format(parameters, mae))
        #print('ARMA{} - AIC:{}'.format(parameters, results.aic))
    except:
        continue
```

```
ARMA(0, 0) - MAE:348.1893212867622
ARMA(0, 1) - MAE:185.19680811759886
ARMA(1, 0) - MAE:23.241765447862583
ARMA(1, 1) - MAE:23.993809429479125
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no bse
  'available', HessianInversionWarning)
ARMA(1, 2) - MAE:73.41028372281995
ARMA(1, 3) - MAE:70.42411559356346
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no bse
  'available', HessianInversionWarning)
ARMA(1, 4) - MAE:85.94018480793235
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/kalmanf/kalmanfilter.py:221: RuntimeWarning: overflow encountered in squ
  Z_mat, R_mat, T_mat)
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: overflow encountered in exp
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: invalid value encountered in true_divid
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: overflow encountered in exp
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: invalid value encountered in true_divid
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
```

```
ARMA(1, 5) - MAE:90.0948267021097
ARMA(1, 6) - MAE:84.28812911156312
ARMA(2, 0) - MAE:23.512621313096666
ARMA(2, 1) - MAE:64.91906974103894
ARMA(2, 2) - MAE:71.18613272452762
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:651: RuntimeWarning: divide by zero encountered in arctanh
  invarcoefs = 2*np.arctanh(params)
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no bse
  'available', HessianInversionWarning)
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:512: ConvergenceWarning: Maximum Likelihood optimization faile
  "Check mle_retvals", ConvergenceWarning)
ARMA(2, 4) - MAE:85.64056957820587
ARMA(2, 5) - MAE:89.5869433129625
ARMA(2, 6) - MAE:76.90897615286934
ARMA(3, 0) - MAE:41.25107417522671
ARMA(3, 1) - MAE:79.14527114934191
ARMA(3, 2) - MAE:83.3511688311627
ARMA(4, 0) - MAE:41.67867406755878
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:512: ConvergenceWarning: Maximum Likelihood optimization faile
  "Check mle_retvals", ConvergenceWarning)
ARMA(4, 1) - MAE:81.15622076486316
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no bse
  'available', HessianInversionWarning)
ARMA(4, 2) - MAE:82.43789364373518
ARMA(4, 3) - MAE:87.59775837360436
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:649: RuntimeWarning: invalid value encountered in double_sca
  (1-a**2)
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:651: RuntimeWarning: divide by zero encountered in arctanh
  invarcoefs = 2*np.arctanh(params)
ARMA(5, 0) - MAE:64.31037666309341
ARMA(5, 1) - MAE:92.68158471295337
ARMA(6, 0) - MAE:83.385117119368
```

```
ARMAmodel = ARMA(df['Count'], order=(1, 0))
ARmodel_fit = ARMAmodel.fit()
```

```
ypredicted = ARmodel_fit.predict(750,762)  # end point included
print(ypredicted)
mae = mean_absolute_error(actuals, ypredicted)
print('MAE: %f' % mae)
print(ARmodel_fit.aic)
```

```
2014-09-14    245.949290
2014-09-15    231.811256
2014-09-16    424.927481
2014-09-17    634.356822
2014-09-18    540.983651
2014-09-19    437.045796
2014-09-20    516.047888
2014-09-21    327.747916
2014-09-22    363.326046
2014-09-23    558.073583
2014-09-24    526.534891
2014-09-25    664.497246
2014-09-26    559.471850
Freq: D, dtype: float64
MAE: 23.241765
8169.4641126953575
```

We now calculate the Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (BIC), and Hannan-Quinn Information Criterion (HQIC). Our goalis to choose a model that minimizes (AIC, BIC, HQIC).

```
# make prediction
ypredicted = ARmodel_fit.predict(len(converted), len(converted)+12)
print(ypredicted)
```

```
DateTime
2014-09-06    506.182336
2014-09-07    326.582694
2014-09-08    276.866530
2014-09-09    406.905371
2014-09-10    518.766740
2014-09-11    460.039522
2014-09-12    405.196378
```

```
2014-09-13    359.752697
2014-09-14    245.949290
2014-09-15    231.811256
2014-09-16    424.927481
2014-09-17    634.356822
2014-09-18    540.983651
Freq: D, dtype: float64
```

```
import itertools
i = j = range(0, 10)
ij = itertools.product(i,j)
for parameters in ij:
    try:
        mod = ARMA(converted['converted_count'].dropna(),order=parameters)
        results = mod.fit()
        ypredicted = results.predict(720,732)  # end point included
        mae = mean_absolute_error(actuals, ypredicted)
        print('ARMA{} - MAE:{}'.format(parameters, mae))
        #print('ARMA{} - AIC:{}'.format(parameters, results.aic))
    except:
        continue
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: invalid value encountered in true_di
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: invalid value encountered in true_di
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
ARMA(7, 0) - MAE:472.6422915802113
ARMA(7, 1) - MAE:472.524452998291
ARMA(7, 2) - MAE:472.2177724053481
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
ARMA(7, 3) - MAE:470.87677006302096
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: overflow encountered in exp
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
```

```
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: invalid value encountered in true_di
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: overflow encountered in exp
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: invalid value encountered in true_di
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
ARMA(7, 4) - MAE:473.0221880579472
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: overflow encountered in exp
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:668: RuntimeWarning: invalid value encountered in true_di
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: overflow encountered in exp
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:669: RuntimeWarning: invalid value encountered in true_di
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:512: ConvergenceWarning: Maximum Likelihood optimization fa
  "Check mle_retvals", ConvergenceWarning)
ARMA(7, 5) - MAE:473.36824741774575
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:695: RuntimeWarning: invalid value encountered in log
  invmacoefs = -np.log((1-macoefs)/(1+macoefs))
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:512: ConvergenceWarning: Maximum Likelihood optimization fa
  "Check mle_retvals", ConvergenceWarning)
ARMA(7, 7) - MAE:472.5283162890333
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
ARMA(7, 8) - MAE:476.04251701419605
ARMA(8, 0) - MAE:472.6281138018138
ARMA(8, 1) - MAE:472.43148186434814
ARMA(8, 2) - MAE:472.1964006274497
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
ARMA(8, 3) - MAE:472.6627483735989
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
ARMA(8, 4) - MAE:471.50641854789126
/usr/local/lib/python3.7/dist-packages/statsmodels/tsa/tsatools.py:695: RuntimeWarning: invalid value encountered in log
  invmacoefs = -np.log((1-macoefs)/(1+macoefs))
```

```
  invmacoefs = -np.log((1-macoefs)/(1+macoefs))
ARMA(8, 6) - MAE:474.8265328152412
/usr/local/lib/python3.7/dist-packages/statsmodels/base/model.py:492: HessianInversionWarning: Inverting hessian failed, no
  'available', HessianInversionWarning)
ARMA(8, 8) - MAE:471.3401632748894
```