```
!pip3 install pmdarima
```

```
Requirement already satisfied: pmdarima in /usr/local/lib/python3.7/dist-packages (1
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.7/dist-package
Requirement already satisfied: Cython<0.29.18,>=0.29 in /usr/local/lib/python3.7/dist
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages (fro
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/python3
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: statsmodels!=0.12.0,>=0.11 in /usr/local/lib/python3.7
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: patsy>=0.5 in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.7/dis
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from pa
```

```
# Import package
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import warnings
from statsmodels.tsa.api import SimpleExpSmoothing
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
from datetime import datetime
from statsmodels.tsa.arima_model import ARIMA
from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
```

```
warnings.simplefilter('ignore')
```

```
data = pd.read_csv('Dataset3_nasdaq_1985_2014.csv',names = ['nasdaq_1985_2014'])
```

Applying KPSS and ADF test

1. ADF test

```
#define function for ADF test
from statsmodels.tsa.stattools import adfuller

def adf_test(atr):
    #Perform Dickey-Fuller test:
    timeseries = data[atr].dropna()
    print ('Results of Dickey-Fuller Test for ',atr,'\n')
    dftest = adfuller(timeseries, autolag='AIC')
    dfoutput = pd.Series(dftest[0:4], index=['Test Statistic','p-value','#Lags Used','Numb
    for key,value in dftest[4].items():
       dfoutput['Critical Value (%s)'%key] = value
```

```
        dfoutput['Critical Value (%s)'%key] = value
    print(dfoutput)

#apply adf test on the series
adf_test('nasdaq_1985_2014')
```

```
Results of Dickey-Fuller Test for  nasdaq_1985_2014

Test Statistic                  -2.381102
p-value                          0.147141
#Lags Used                      35.000000
Number of Observations Used   7240.000000
Critical Value (1%)             -3.431254
Critical Value (5%)             -2.861939
Critical Value (10%)            -2.566983
dtype: float64
```

2. KPSS test

```
#define function for kpss test
from statsmodels.tsa.stattools import kpss
#define KPSS
def kpss_test(atr):
    timeseries = data[atr].dropna()
    print ('Results of KPSS Test for ',atr)
    kpsstest = kpss(timeseries, regression='c')
    kpss_output = pd.Series(kpsstest[0:3], index=['Test Statistic','p-value','Lags Used'])
    for key,value in kpsstest[3].items():
        kpss_output['Critical Value (%s)'%key] = value
    print (kpss_output)
kpss_test('nasdaq_1985_2014')
```

```
Results of KPSS Test for  nasdaq_1985_2014
Test Statistic           12.143812
p-value                   0.010000
Lags Used                36.000000
Critical Value (10%)      0.347000
Critical Value (5%)       0.463000
Critical Value (2.5%)     0.574000
Critical Value (1%)       0.739000
dtype: float64
```

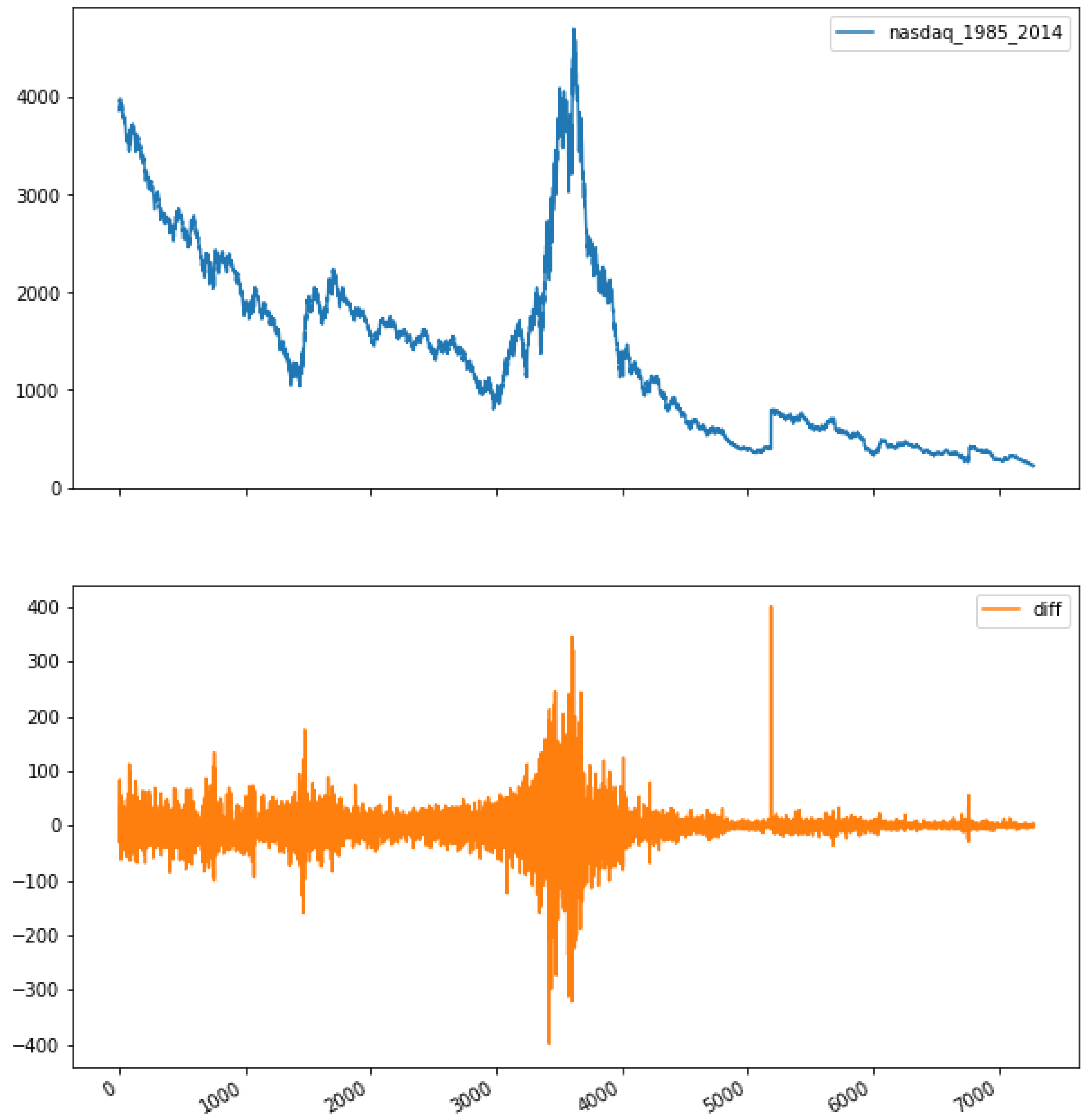
For ADF test, we can see that the p-value is more than 0.05. Thus, from ADF test, we can say that the dataset is non-stationary.

For KPSS test, Test Statistic is more than Critical Value, thus we reject the null hypothesis. Thus, from KPSS test, we can say that the dataset is non-stationary.

Since, both tests conclude that the series is stationary, therefore, the dataset is concluded as Non-Stationary.

Making dataset stationary with differencing

```
# Differencing
data['diff'] = data['nasdaq_1985_2014'].diff(periods=1)

data.plot(subplots=True, figsize=(10,12))
plt.show()
```



Applying Exponential Smoothening

```
#List of least mse and mae
mseses=[]
msedes=[]
msetes=[]
maeses=[]
```

```
maeses=[]
maedes=[]
maetes=[]
```

Single Exponential Smoothing

```
#Defining Single Exponential Smoothing function ses
def ses(arr,alpha):
    arr1 = [arr[0]]
    for i in range(1, len(arr)):
        arr1.append(alpha * arr[i-1] + (1 - alpha) * arr1[i-1])
    return arr1


#Defining Mean of Squared Error Function mse
def mse(arr1,arr2):
  arr3=[0]
  for i, j in zip(arr1, arr2):
    arr3.append(i-j)
  Sum=0
  for i in arr3:
    sqr=i**2
    Sum+=sqr
  mse=Sum/(len(arr2)-1)
  return mse


#Function to make list of demand with interval 'n'
def dem_n(arr,n):
  arr1=[arr[0]]
  for i in range(1,len(arr)):
    if i%n==0:
      arr1.append(arr[i])
  return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
```

```
print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)

     Mean of Square Errors for alpha = 0.2 is:  2472.741440084606
     Mean of Square Errors for alpha = 0.5 is:  1336.440186179414
     Mean of Square Errors for alpha = 0.8 is:  1117.7909898783196


#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8 is: ",mae3)

     Mean Absolute Errors for alpha = 0.2 is:  28.000982741860746
     Mean Absolute Errors for alpha = 0.5 is:  19.850599625184778
     Mean Absolute Errors for alpha = 0.8 is:  17.774120514236166


#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
```

```
alpha:  0.8
```

Double Exponential Smoothing


```
#Defining Double Exponential Smoothing function des
def des(arr,alpha,beta):
  a=[arr[0]]
  l=len(arr)
  b=[(arr[l-1]-arr[0])/(l-1)]
  arr1 = [arr[0]]
  arr1.append(a[0]+b[0])
  for i in range(1,len(arr)-1):
      a.append(alpha * arr[i] + (1 - alpha) * (a[i-1]+b[i-1]))
      b.append(beta * (a[i]-a[i-1]) + (1 - beta) * (b[i-1]))
      arr1.append(a[i]+b[i])
  return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  2536.946969983234
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  1610.849168270192
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  1730.2882602330976
```

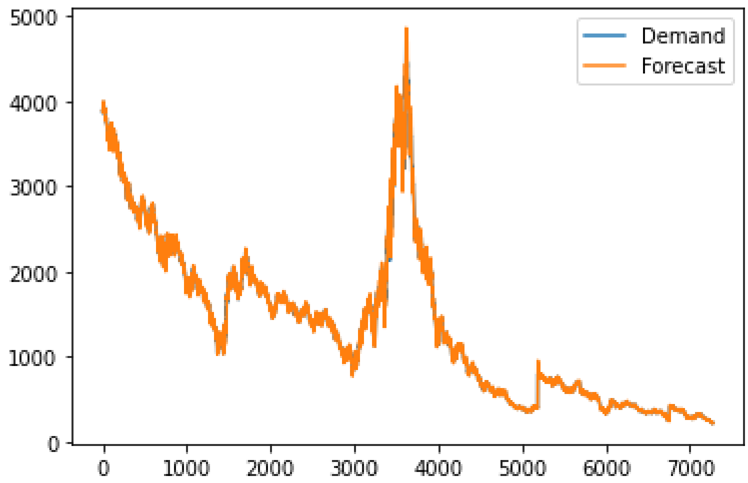
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3 is: ",mae1)
```

```
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3 is:  27.818256325155097
Mean Absolute Errors for alpha = 0.5,beta= 0.6 is:  21.526120724184242
Mean Absolute Errors for alpha = 0.8,beta= 0.9 is:  21.86028543903852
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
```

```
alpha:  0.5
beta:  0.6
```



Triple Exponential Smoothing

```
#Defining initial trend
def initial_trend(arr, slen):
    Sum = 0
    for i in range(slen):
        Sum += float(arr[i+slen] - arr[i]) / slen
    return Sum / slen
```

```
#Defining initial seasonal
def initial_seasonal(arr, slen):
    arr1 = {}
    s_avg = []
    m = int(len(arr)/slen)
    for j in range(m):
        s_avg.append(sum(arr[slen*j:slen*j+slen])/float(slen))
    for i in range(slen):
        Sum = 0
        for j in range(m):
            Sum += arr[slen*j+i]-s_avg[j]
        arr1[i] = Sum/m
    return arr1


#Defining Triple Exponential Smoothing function tes with interval 'n'
def tes(arr, slen, alpha, beta, gamma, n):
    arr1 = []
    seasonals = initial_seasonal(arr, slen)
    for i in range(len(arr)+n):
        if i == 0:
            smooth = arr[0]
            trend = initial_trend(arr, slen)
            arr1.append(arr[0])
            continue
        if i >= len(arr):
            m = i - len(arr) + 1
            arr1.append((smooth + m*trend) + seasonals[i%slen])
        else:
            val = arr[i]
            lsmooth, smooth = smooth, alpha*(val-seasonals[i%slen]) + (1-alpha)*(smooth+tr
            trend = beta * (smooth-lsmooth) + (1-beta)*trend
            seasonals[i%slen] = gamma*(val-smooth) + (1-gamma)*seasonals[i%slen]
            arr1.append(smooth+trend+seasonals[i%slen])
    return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here
```

```
forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  324.98461283387843
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  159.5560160348016
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  584.5190867801982
```

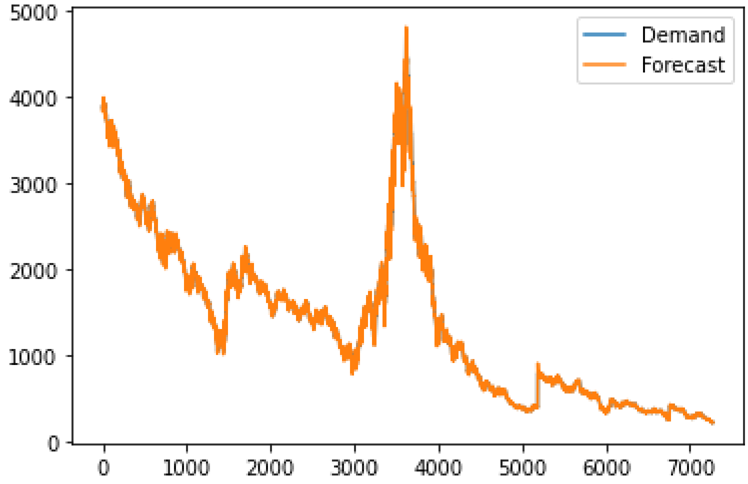
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  9.812028958449401
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  7.130769745696372
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  12.927075494158293
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
```

```
print("gamma: ",gamma3)
df3.plot(style=['-','-'])
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```



For 1 Unit

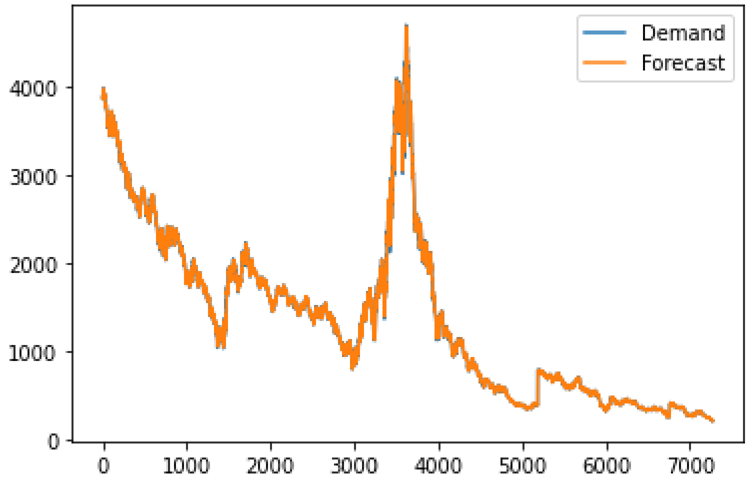
Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  2472.741440084606
Mean of Square Errors for alpha = 0.5 is:  1336.440186179414
Mean of Square Errors for alpha = 0.8 is:  1117.7909898783196
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)
```

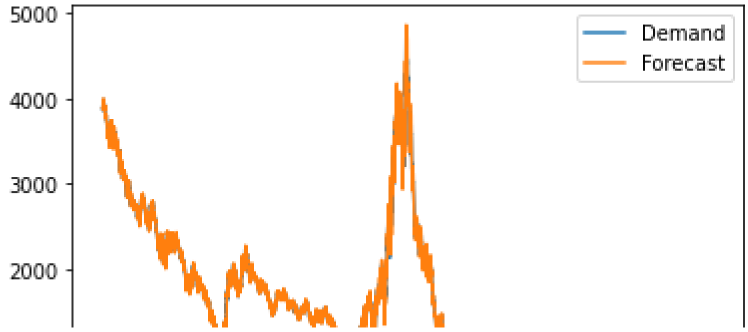
```
#Forecasting
alpha1=0.2
```

```
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  2536.946969983234
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  1610.849168270192
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  1730.2882602330976
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

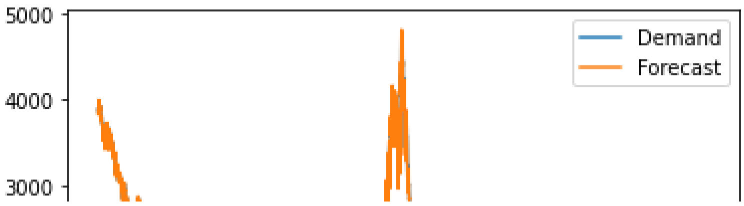
```
    Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  324.98461283387843
    Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  159.5560160348016
    Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  584.5190867801982
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
    Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  9.812028958449401
    Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  7.130769745696372
    Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  12.927075494158293
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 2 Unit

Single Exponential Smoothing

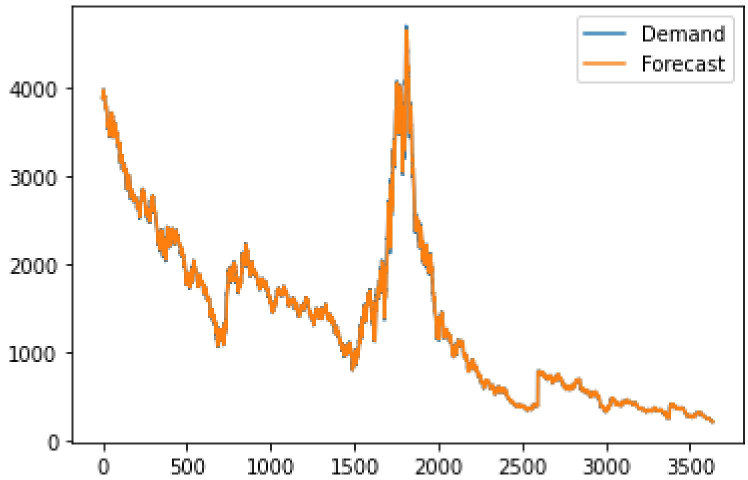
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  4853.103732434068
Mean of Square Errors for alpha = 0.5 is:  2458.2670288633058
Mean of Square Errors for alpha = 0.8 is:  2061.186342147135
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}
```

```
df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

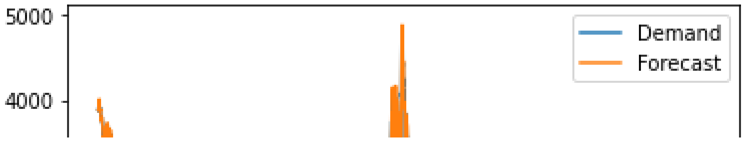
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
```

```
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  4470.512808464085
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  2844.2289410307126
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  3182.6378222035564
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  594.8463666539786
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  297.6694292157872
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  1072.0211757567604
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  13.574281218977394
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  9.916028550010301
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  18.06301492152557
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```

```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 4 Unit

Single Exponential Smoothing

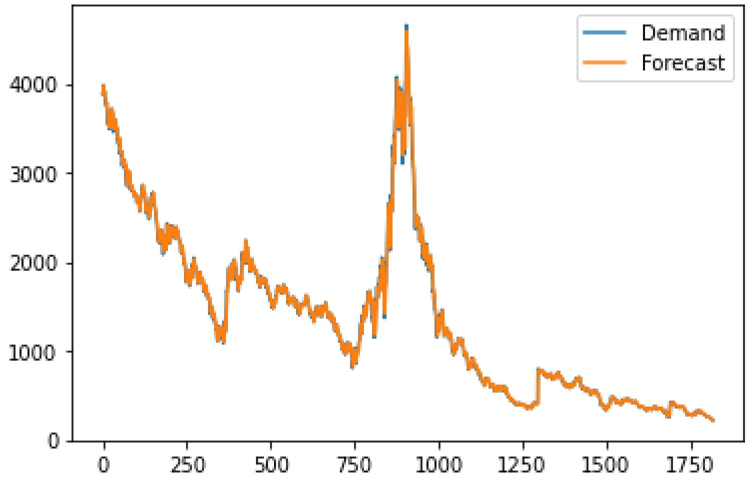
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  10016.916979346734
Mean of Square Errors for alpha = 0.5 is:  4511.036145599884
Mean of Square Errors for alpha = 0.8 is:  3560.3736671460274
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
```

```
    print('alpha: ',alpha1)
    df1.plot(style=['-','-'])
    mseses.append(mse1)
  elif mse2<=mse1 and mse2<=mse3:
    print('alpha: ',alpha2)
    df2.plot(style=['-','-'])
    mseses.append(mse2)
  else:
    print('alpha: ',alpha3)
    df3.plot(style=['-','-'])
    mseses.append(mse3)
```

```
alpha:  0.8
```




```
  #Storing least mae values
  if mae1<=mae2 and mae1<=mae3:
    maeses.append(mae1)
  elif mae2<=mae1 and mae2<=mae3:
    maeses.append(mae2)
  else:
    maeses.append(mae3)
```

Double Exponential Smoothing

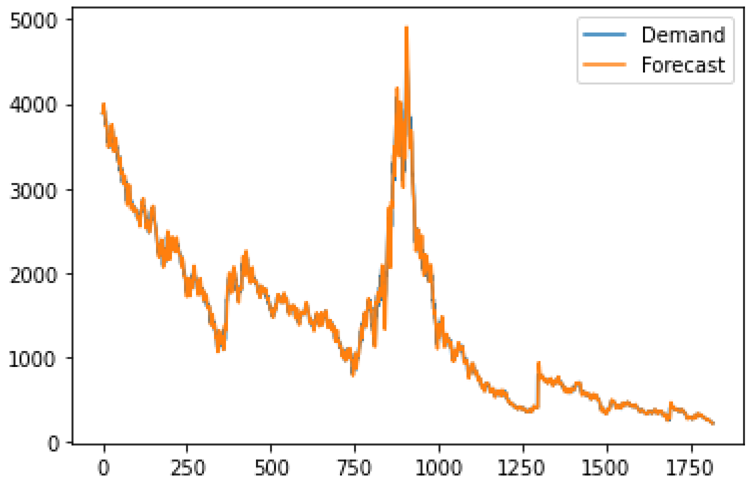
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)
```

```
#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  9032.16360528243
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  4731.670089222
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  5163.114656800682
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```



```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  1105.38559951607
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  601.9928399245516
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  1879.0043718837271
```

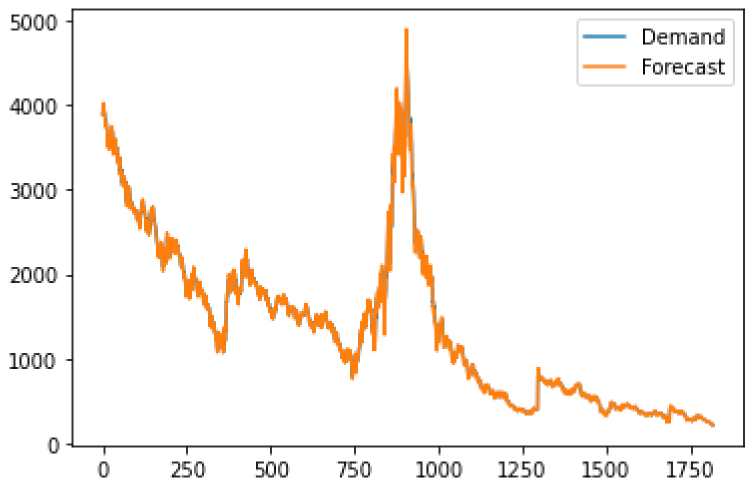
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
```

```
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  19.20878869799074
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  14.281490895883545
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  24.85511351923015
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
```

```
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 8 Unit

Single Exponential Smoothing

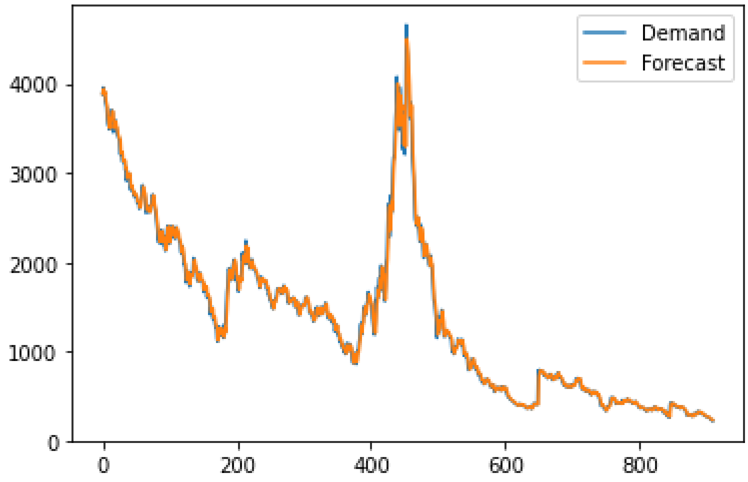
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  22001.115413497686
Mean of Square Errors for alpha = 0.5 is:  9496.632863043103
Mean of Square Errors for alpha = 0.8 is:  7285.948785941906
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
```

```
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

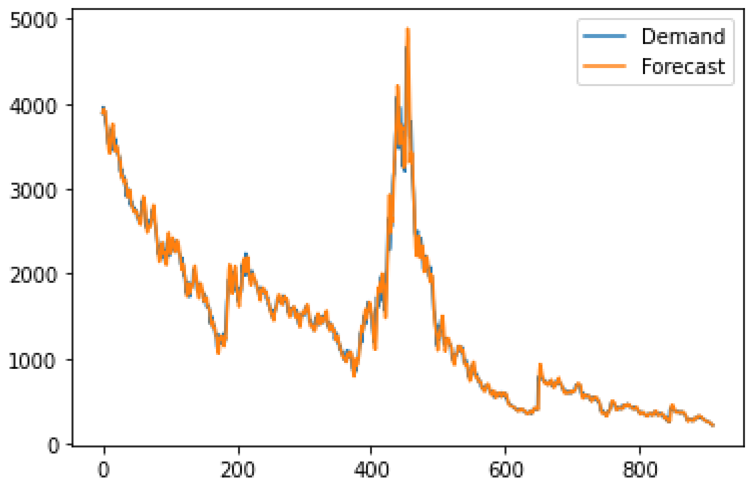
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)
```

```
print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  18784.37734055738
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  9918.183439676426
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  10292.573461734017
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
```

```
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

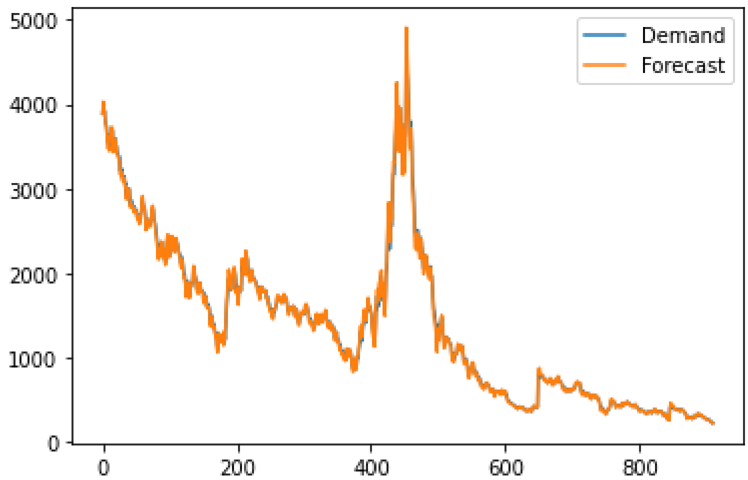
```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  2411.5017852362967
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  1315.0437876670146
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  3885.604997022788
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  28.816348734870992
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  21.113458801196593
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  35.508952118471896
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 12 Unit

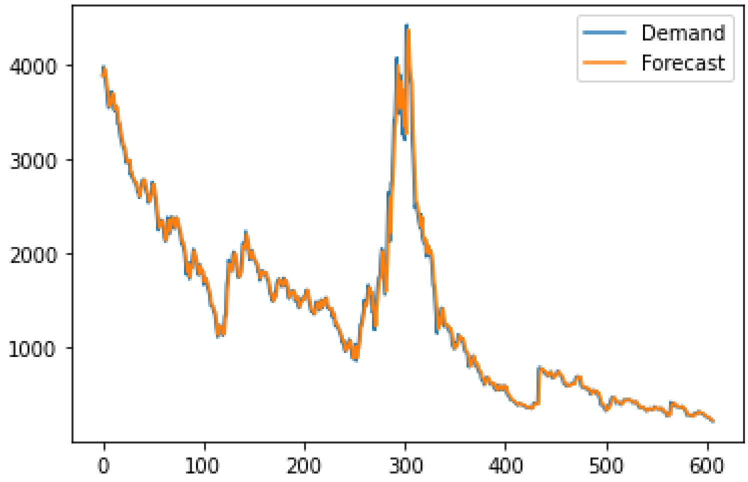
Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  36554.707547896985
Mean of Square Errors for alpha = 0.5 is:  15334.264016352563
Mean of Square Errors for alpha = 0.8 is:  11696.207437428884
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

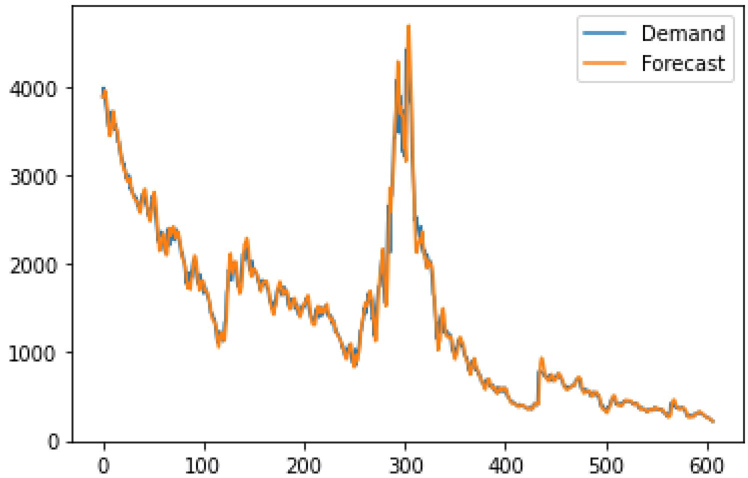
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  27677.866788889336
```

```
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  15523.773209021978
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  16105.13520294062
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
     Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  4009.291152396081
     Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  2162.61293598704
     Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  6217.613679652851
```

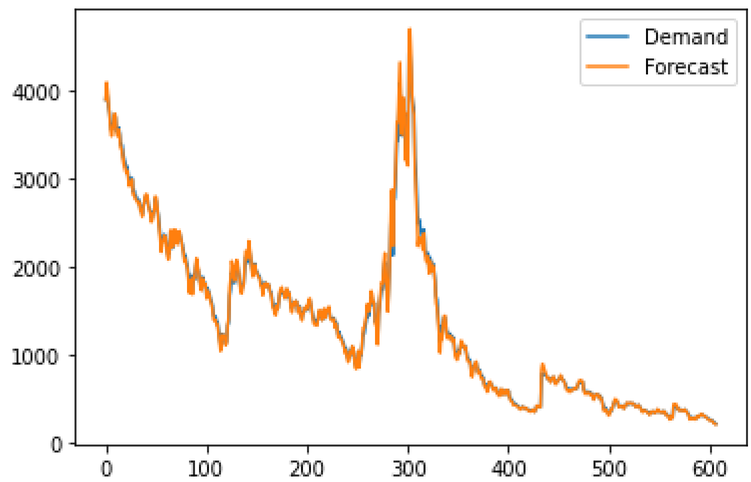
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
     Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  37.25633299856909
     Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  27.860130011503685
     Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  45.02798320799283
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}
```

```
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```



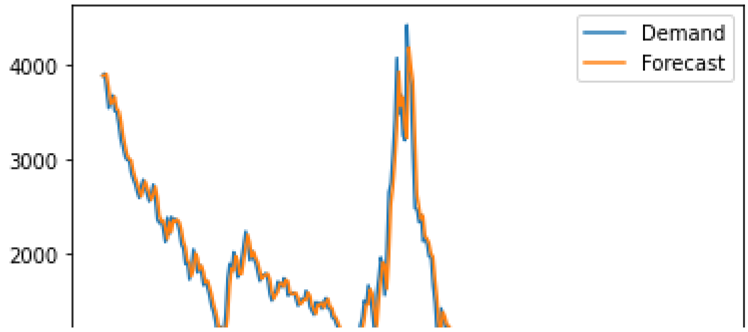

```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 24 Interval

Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)

     Mean of Square Errors for alpha = 0.2 is:  81646.70511270332
     Mean of Square Errors for alpha = 0.5 is:  33991.33138341908
     Mean of Square Errors for alpha = 0.8 is:  25484.935350911685


#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

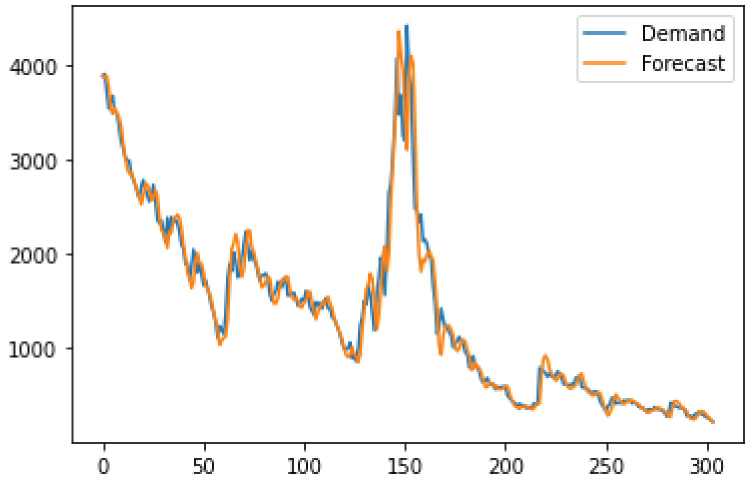
```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  67629.46120193429
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  34800.05663995416
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  34922.28877471786
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
```

```
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```



Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.nasdaq_1985_2014,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9
```

```
gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  8382.365317435291
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  4817.319971579469
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  13690.609282051906
```

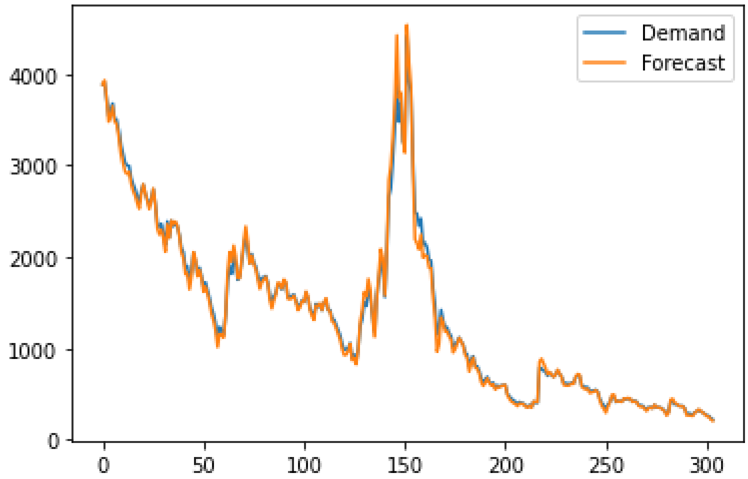
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  54.238860420695346
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  42.58463728481874
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  67.30157256856023
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
```

```
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

Least MSE and MAE values are

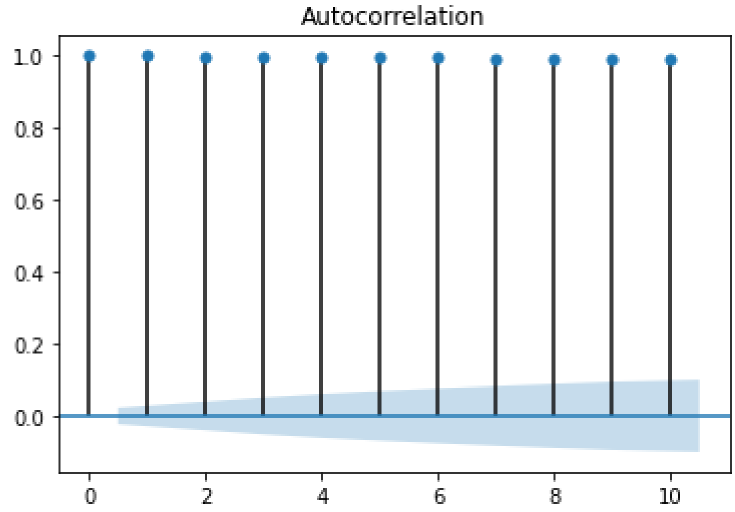
```
print("Least MSE ses")
print(mseses)
print("Least MSE des")
print(msedes)
print("Least MSE tes")
print(msetes)


print("Least MAE ses")
print(maeses)
print("Least MAE des")
print(maedes)
print("Least MAE tes")
print(maetes)
```

```
Least MSE ses
[1117.7909898783196, 2061.186342147135, 3560.3736671460274, 7285.948785941906, 11696
Least MSE des
[1610.849168270192, 2844.2289410307126, 4731.670089222, 9918.183439676426, 15523.773
Least MSE tes
[159.5560160348016, 297.6694292157872, 601.9928399245516, 1315.0437876670146, 2162.6
Least MAE ses
[7.130769745696372, 7.130769745696372, 9.916028550010301, 14.281490895883545, 21.113
Least MAE des
[7.130769745696372, 7.130769745696372, 9.916028550010301, 14.281490895883545, 21.113
Least MAE tes
[7.130769745696372, 9.916028550010301, 14.281490895883545, 21.113458801196593, 27.86
```

Applying ACF and PACF

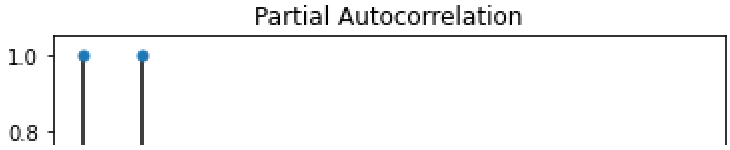
```
#Plotting ACF
plot_acf(data.nasdaq_1985_2014,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(data.nasdaq_1985_2014,lags=10)
plt.show
```

```
&lt;function matplotlib.pyplot.show&gt;
```



Applying AR, MA, ARIMA Models

```
#AR

#fit model
model=ARIMA(data['nasdaq_1985_2014'], order=(1,0,0))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastAR'] = model_fit.predict()
data[['nasdaq_1985_2014','forecastAR']].plot()
```

```
                                 ARMA Model Results
     ==============================================================================
     Dep. Variable:       nasdaq_1985_2014   No. Observations:                 7276
```

```
mse=mean_squared_error(data.nasdaq_1985_2014,data.forecastAR.dropna())
print("MSE for AR is:",mse)
```

```
     MSE for AR is: 2345.0059510285555
```

```
mae=mean_absolute_error(data.nasdaq_1985_2014,data.forecastAR.dropna())
print("MAE for AR is:",mae)
```

```
     MAE for AR is: 17.872702594616264
                                         Roots
```

```
#MA

#fit model
model=ARIMA(data['nasdaq_1985_2014'].dropna(), order=(0,0,1))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastMA'] = model_fit.predict()
data[['nasdaq_1985_2014','forecastMA']].plot()
```

```
                              ARMA Model Results
==============================================================================
Dep. Variable:       nasdaq_1985_2014   No. Observations:                 7276
Model:                     ARMA(0, 1)   Log Likelihood              -55311.023
Method:                       css-mle   S.D. of innovations            484.294
Date:                Mon, 01 Mar 2021   AIC                         110628.046
```

```
mse=mean_squared_error(data.nasdaq_1985_2014,data.forecastMA.dropna())
print("MSE for MA is:",mse)
```

```
MSE for MA is: 235534.93345216895
------------------------------------------------------------------------------------
```

```
mae=mean_absolute_error(data.nasdaq_1985_2014,data.forecastMA.dropna())
print("MAE for MA is:",mae)
```

```
MAE for MA is: 392.66799044674684
```

```
#ARIMA

#fit model
model=ARIMA(data['diff'].dropna(), order=(1,1,1))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastARIMA'] = model_fit.predict()
data[['diff','forecastARIMA']].plot()
```

```
                              ARIMA Model Results
==============================================================================
Dep. Variable:                 D.diff   No. Observations:                 7274
Model:                 ARIMA(1, 1, 1)   Log Likelihood              -35797.946
Method:                       css-mle   S.D. of innovations             33.176
Date:                Mon, 01 Mar 2021   AIC                          71603.892
Time:                        05:20:18   BIC                          71631.461
Sample:                             1   HQIC                         71613.374

================================================================================
                  coef    std err          z      P>|z|      [0.025      0.975]
```

```
mse=mean_squared_error(data.nasdaq_1985_2014[0:-2],data.forecastARIMA.dropna())
print("MSE for MA is:",mse)
```

```
MSE for MA is: 2790845.8382340004
```

```
mae=mean_absolute_error(data.nasdaq_1985_2014[0:-2],data.forecastARIMA.dropna())
print("MAE for MA is:",mae)
```

```
MAE for MA is: 1376.2490735730798
```

Applying Auto ARIMA

```
import pmdarima as pm
model = pm.auto_arima(data.iloc[:,0], start_p=1, start_q=1,test='adf',max_p=3, max_q=3,m=1
print(model.summary())
```

```
Performing stepwise search to minimize aic
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=71573.519, Time=2.28 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=71626.005, Time=0.17 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=71602.481, Time=0.22 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=71598.884, Time=0.67 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=71625.676, Time=0.11 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=71573.861, Time=4.34 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=71573.643, Time=3.13 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=71574.051, Time=2.33 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=71575.909, Time=0.71 sec
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=71575.157, Time=4.78 sec
 ARIMA(1,1,1)(0,0,0)[0]             : AIC=71573.985, Time=0.87 sec

Best model:  ARIMA(1,1,1)(0,0,0)[0] intercept
Total fit time: 19.657 seconds
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                 7276
Model:               SARIMAX(1, 1, 1)   Log Likelihood              -35782.760
Date:                Mon, 01 Mar 2021   AIC                          71573.519
Time:                        05:20:38   BIC                          71601.088
Sample:                             0   HQIC                         71583.001
                               - 7276
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
```

```
------------------------------------------------------------------------------
intercept     -0.2041      0.131     -1.552      0.121      -0.462       0.054
ar.L1          0.5947      0.030     19.738      0.000       0.536       0.654
ma.L1         -0.6657      0.028    -23.530      0.000      -0.721      -0.610
sigma2      1096.2903      5.118    214.201      0.000    1086.259    1106.322
===================================================================================
Ljung-Box (L1) (Q):                   0.26   Jarque-Bera (JB):            167022.66
Prob(Q):                              0.61   Prob(JB):                         0.00
Heteroskedasticity (H):               0.15   Skew:                             0.19
Prob(H) (two-sided):                  0.00   Kurtosis:                        26.47
===================================================================================

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

Best model: ARIMA(1,1,1)(0,0,0)[0]

Final Result

Dataset 3													
Is Dataset Stationery	No												
If yes, why, and if not, why not	For ADF test, we can see that the p-value is more than 0.05. Thus, from ADF test, we can say that the dataset is non-stationary. For KPSS test, Test Statistic is more than Critical Value, thus we reject the null hypothesis. Thus, from KPSS test, we can say that the dataset is non-stationary. Thus,Non-Stationary.												
If differencing was done, how many times it was done?	One												
		Prediction FOR ->											
		MSE						MAE					
		1 UNIT	2 UNIT	4 UNIT	8 UNIT	12 UNIT	24 UNIT	1 UNIT	2 UNIT	4 UNIT	8 UNIT	12 UNIT	24 UNIT
Single Exponential Smoothing	alpha(0.8)	1101.34	2057.2	3712.016908.17		9829.77	20926.61	17.53	24.75	24.75	47.57	57.46	85.08
Double and triple Exponential Smoothing	alpha(0.5), beta(0,6)	3511.46	3309.81	3309.81	3309.81	3309.81	3309.81	19.53	19.53	19.063	19.063	19.063	19.063
Triple Exponential Smoothing	alpha(0.5), beta(0.6), gamma(0.7)	2221696.164	2233127.16	2242310.11	2248883.71	2269030.61	2274708.93	1151	1155.25	1159.09	1161.65	1166.282	1168.38
Only AR	AR(1)	1874.12						17.82					
Only MA	MA(1)	235534.916						392.66					
ARIMA	ARIMA(1,1,1)	2788888.74						1375.85					
SARIMA (if the data has seasonality)	season(?)												