Final Research

December 10, 2018

1 Forecasting Web Traffic

In [1]:
```
# Importing necessary packages
import pandas as pd
import numpy as np

import seaborn as sns
import scipy.stats as ss
import pylab as pl
from statsmodels.tsa.arima_model import ARMAResults
import statsmodels.api as sm
import statsmodels.graphics.tsaplots as tsa
from statsmodels.graphics import utils
from statsmodels.tsa.stattools import acf, pacf, acovf
import statsmodels.formula.api as smf
import statsmodels.tsa.api as smt
from statsmodels.tsa.ar_model import AR

import matplotlib.pyplot as plt
import matplotlib as mpl
from IPython.display import HTML, display
import tabulate
from arch import arch_model
```

In [2]:
```
# Import .csv files
# Facebook Wikipedia page
sampledata = pd.read_csv("C:/Users/Diana/Documents/University of Waterloo/" + \
                         "4th Year/ECON 423/Final Project/Facebook_Sample.csv")

sampledatasort=sampledata.sort_values(["Facebook"])
print(sampledatasort)
```

```
           Date  Facebook
40    8/10/2015        17
48    8/18/2015        17
71    9/10/2015        17
57    8/27/2015        18
127   11/5/2015        18
```

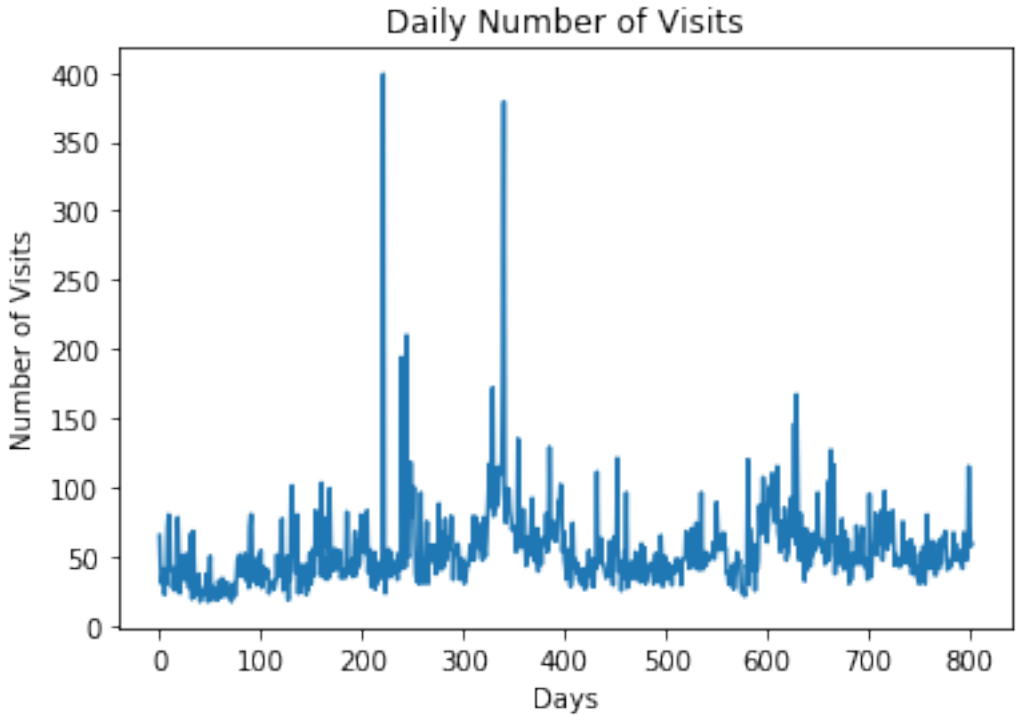
51	8/21/2015	18
47	8/17/2015	18
32	8/2/2015	19
52	8/22/2015	20
55	8/25/2015	20
61	8/31/2015	20
578	1/29/2017	21
54	8/24/2015	21
65	9/4/2015	21
35	8/5/2015	21
68	9/7/2015	21
74	9/13/2015	21
72	9/11/2015	22
60	8/30/2015	22
38	8/8/2015	22
41	8/11/2015	22
5	7/6/2015	22
75	9/14/2015	22
56	8/26/2015	22
145	11/23/2015	22
45	8/15/2015	22
42	8/12/2015	22
575	1/26/2017	23
44	8/14/2015	23
137	11/15/2015	23
..	...	...
660	4/21/2017	104
609	3/1/2017	104
327	5/23/2016	106
596	2/16/2017	107
333	5/29/2016	109
605	2/25/2017	110
337	6/2/2016	110
432	9/5/2016	111
331	5/27/2016	114
240	2/26/2016	114
610	3/2/2017	115
336	6/1/2016	115
799	9/7/2017	115
666	4/27/2017	116
338	6/3/2016	116
326	5/22/2016	117
248	3/5/2016	118
581	2/1/2017	120
452	9/25/2016	121
663	4/24/2017	127
385	7/20/2016	129
354	6/19/2016	135

```
627    3/19/2017        146
629    3/21/2017        167
329    5/25/2016        172
339     6/4/2016        186
239    2/25/2016        194
244     3/1/2016        210
340     6/5/2016        379
221     2/7/2016        399

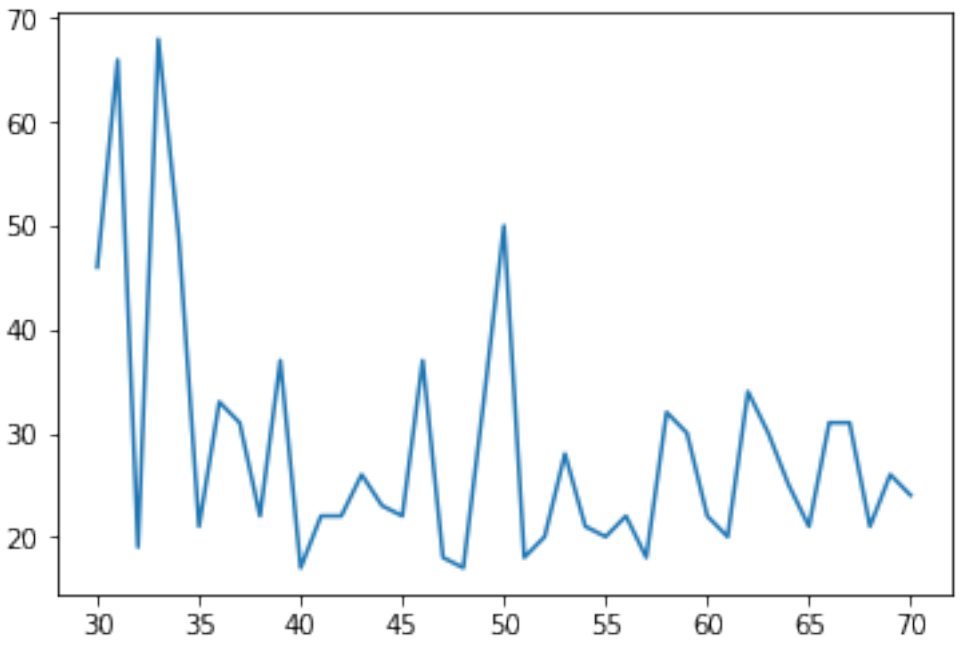
[803 rows x 2 columns]
```

1.1 Basic Data

```
In [3]: plt.plot(sampledata["Facebook"])
        plt.title("Daily Number of Visits")
        plt.xlabel("Days")
        plt.ylabel("Number of Visits")
        plt.show()
```




```
In [4]: plt.plot(sampledata["Facebook"][30:71])
        plt.show()
```



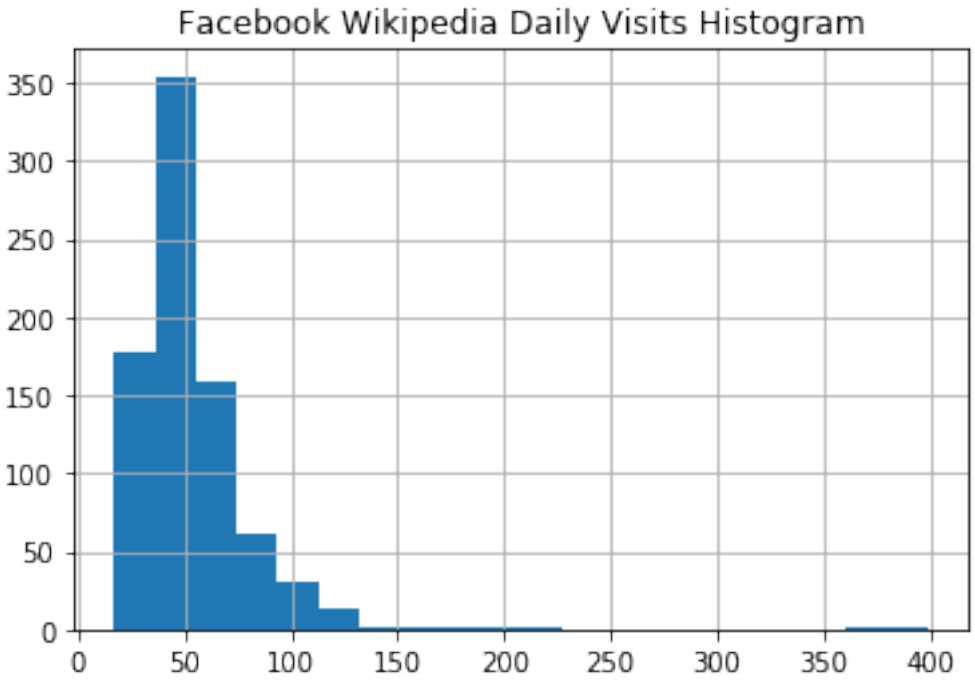
Mention stuff in units and say that the actual units are not disclosed by the publisher of the code.

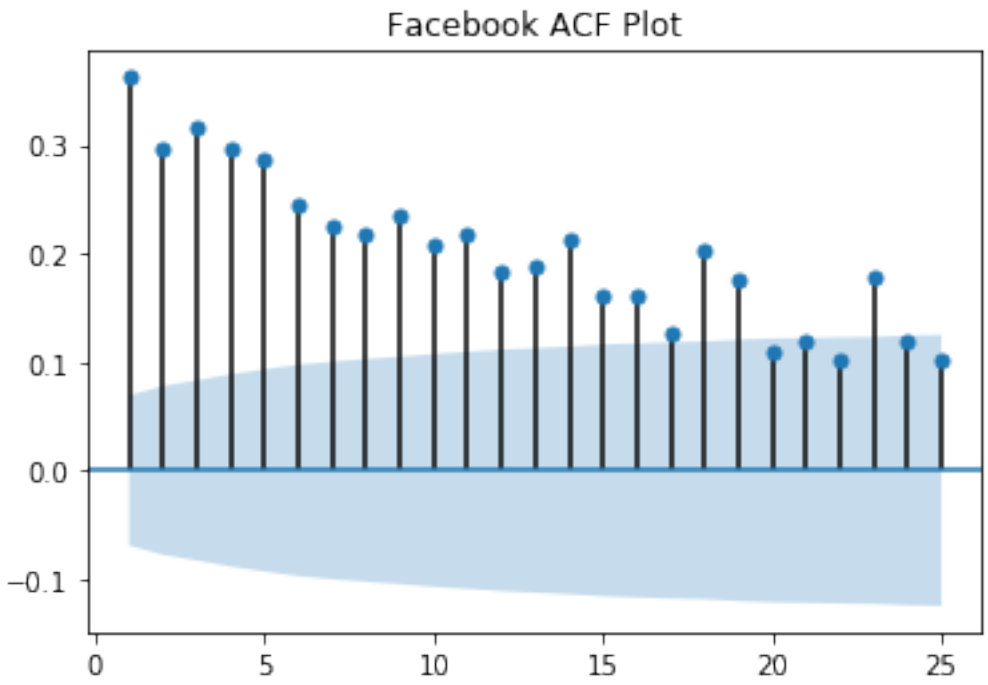
There is a weekly trend.

```
In [5]: def basic(df,column, histitle,title,titlelist):
            # histogram
            df.hist(column=column, bins=20)
            pl.title(histitle)
            # ACF plot
            data_acfplot = tsa.plot_acf(x=df[column], ax=None,
                                        lags=25, alpha=.05, use_vlines=True,
                                        unbiased=False,fft=False, title=title,
                                        zero=False, vlines_kwargs=None)
            mean_data=np.mean(df[column])
            var_data=np.var(df[column])
            skew_data=df[column].skew(skipna=True)
            kurtosis_data=df[column].kurtosis()
            print(titlelist)
            print("Mean: " + str(mean_data))
            print("Variance: " + str(var_data))
            print("Skewness(scipy): " + str(skew_data))
            print("Kurtosis: " + str(kurtosis_data))
            print("")

In [6]: basic(sampledata,"Facebook", "Facebook Wikipedia Daily Visits Histogram",
              "Facebook ACF Plot","---Facebook Daily Visits---")
```

```
---Facebook Daily Visits---
Mean: 53.612702366127024
Variance: 820.3991910782885
Skewness(scipy): 5.00691203231403
Kurtosis: 48.63380282083746
```





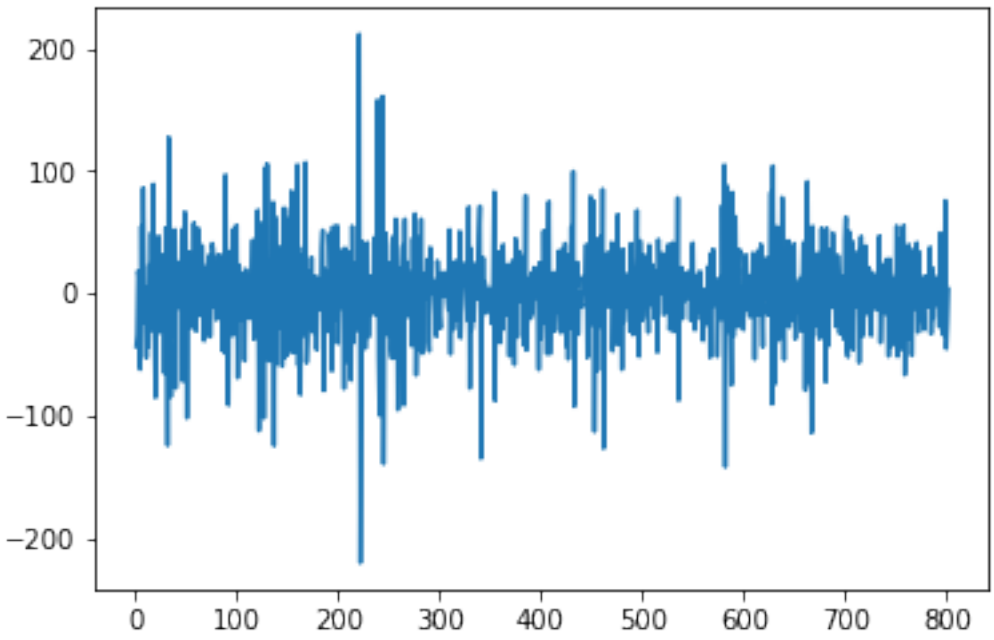
1.2 Change Data

```
In [7]: sampledata["FBChange"] = 100*(np.log(sampledata["Facebook"]) - \
                                     np.log(sampledata["Facebook"].shift(1)))
        sampledata = sampledata.iloc[1:]
        print(len(sampledata["FBChange"]))
```

```
802
```

```
In [8]: plt.plot(sampledata["FBChange"])
```

```
Out[8]: [<matplotlib.lines.Line2D at 0x27b0c6be588>]
```




```
In [9]: for i in range(1,5):
            for j in range(1,5):
                garch = arch_model(sampledata["FBChange"], p=i, q=j)
                garch_resid = garch.fit(disp='off')
                print(garch_resid.summary())
```

```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                      -0.000
Mean Model:             Constant Mean   Adj. R-squared:                 -0.000
Vol Model:                      GARCH   Log-Likelihood:               -4063.77
Distribution:                  Normal   AIC:                           8135.54
Method:            Maximum Likelihood   BIC:                           8154.29
                                        No. Observations:                  802
Date:                Mon, Dec 10 2018   Df Residuals:                      798
Time:                        02:44:17   Df Model:                            4
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3932      1.020      0.386      0.700 [ -1.606,  2.392]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
omega        688.9091    150.450      4.579  4.672e-06 [3.940e+02,9.838e+02]
```

```
alpha[1]       0.3840  7.056e-02      5.443  5.245e-08     [  0.246,  0.522]
beta[1]        0.2263  9.425e-02      2.401  1.635e-02   [4.157e-02,  0.411]
================================================================================

Covariance estimator: robust
                     Constant Mean - GARCH Model Results
================================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.76
Distribution:                  Normal   AIC:                            8137.52
Method:            Maximum Likelihood   BIC:                            8160.96
                                        No. Observations:                   802
Date:                Mon, Dec 10 2018   Df Residuals:                       797
Time:                        02:44:17   Df Model:                             5
                              Mean Model
================================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
--------------------------------------------------------------------------------
mu             0.3971      1.021      0.389      0.697 [ -1.604,  2.398]
                           Volatility Model
================================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
--------------------------------------------------------------------------------
omega        688.6609    148.924      4.624  3.760e-06 [3.968e+02,9.805e+02]
alpha[1]       0.3855  7.093e-02      5.434  5.503e-08     [  0.246,  0.524]
beta[1]        0.2105      0.254      0.829      0.407     [ -0.287,  0.708]
beta[2]        0.0142      0.213  6.672e-02      0.947     [ -0.403,  0.432]
================================================================================

Covariance estimator: robust
                     Constant Mean - GARCH Model Results
================================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.76
Distribution:                  Normal   AIC:                            8139.52
Method:            Maximum Likelihood   BIC:                            8167.65
                                        No. Observations:                   802
Date:                Mon, Dec 10 2018   Df Residuals:                       796
Time:                        02:44:17   Df Model:                             6
                              Mean Model
================================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
--------------------------------------------------------------------------------
mu             0.3971      1.019      0.390      0.697 [ -1.601,  2.395]
                           Volatility Model
================================================================================
```

```
                 coef    std err          t      P>|t|      95.0% Conf. Int.
-----------------------------------------------------------------------------
omega        688.6269    206.419      3.336  8.497e-04 [2.841e+02,1.093e+03]
alpha[1]       0.3855  8.230e-02      4.684  2.814e-06     [  0.224,  0.547]
beta[1]        0.2106      0.265      0.796      0.426     [ -0.308,  0.729]
beta[2]        0.0141      0.227  6.218e-02      0.950     [ -0.431,  0.459]
beta[3]    2.1866e-14      0.103  2.130e-13      1.000     [ -0.201,  0.201]
=============================================================================

Covariance estimator: robust
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.74
Distribution:                  Normal   AIC:                            8141.48
Method:            Maximum Likelihood   BIC:                            8174.29
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        795
Time:                        02:44:18   Df Model:                              7
                            Mean Model
=============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
-----------------------------------------------------------------------------
mu             0.4041      1.020      0.396      0.692 [ -1.595,  2.403]
                          Volatility Model
=============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
-----------------------------------------------------------------------------
omega        676.4021    216.182      3.129  1.755e-03 [2.527e+02,1.100e+03]
alpha[1]       0.3838  9.634e-02      3.984  6.775e-05     [  0.195,  0.573]
beta[1]        0.2177      0.297      0.734      0.463     [ -0.364,  0.799]
beta[2]    7.4322e-03      0.228  3.255e-02      0.974     [ -0.440,  0.455]
beta[3]    2.3121e-14      0.220  1.049e-13      1.000     [ -0.432,  0.432]
beta[4]    8.1214e-03  7.043e-02      0.115      0.908     [ -0.130,  0.146]
=============================================================================

Covariance estimator: robust
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.77
Distribution:                  Normal   AIC:                            8137.54
Method:            Maximum Likelihood   BIC:                            8160.97
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        797
Time:                        02:44:18   Df Model:                              5
```

```
                             Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3930      1.019      0.386      0.700 [ -1.605,  2.391]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
omega        689.2563    245.728      2.805  5.032e-03 [2.076e+02,1.171e+03]
alpha[1]       0.3840  7.001e-02      5.485  4.129e-08     [  0.247,  0.521]
alpha[2]       0.0000      0.113      0.000      1.000     [ -0.221,  0.221]
beta[1]        0.2261      0.236      0.959      0.338     [ -0.236,  0.688]
============================================================================

Covariance estimator: robust
                  Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.65
Distribution:                  Normal   AIC:                            8139.30
Method:            Maximum Likelihood   BIC:                            8167.43
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        796
Time:                        02:44:18   Df Model:                              6
                             Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3958      1.023      0.387      0.699 [ -1.609,  2.401]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        808.5053    685.263      1.180      0.238 [-5.346e+02,2.152e+03]
alpha[1]       0.3865  7.041e-02      5.489  4.042e-08      [  0.248,  0.524]
alpha[2]       0.0714      0.384      0.186      0.853      [ -0.682,  0.825]
beta[1]    5.4312e-16      1.000  5.432e-16      1.000      [ -1.960,  1.960]
beta[2]        0.0839      0.232      0.362      0.717      [ -0.370,  0.538]
============================================================================

Covariance estimator: robust
                  Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.65
```

```
Distribution:                  Normal   AIC:                           8141.30
Method:            Maximum Likelihood   BIC:                           8174.11
                                        No. Observations:                  802
Date:                Mon, Dec 10 2018   Df Residuals:                      795
Time:                        02:44:18   Df Model:                            7
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3956      1.020      0.388      0.698 [ -1.603,  2.394]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        808.5539    665.980      1.214      0.225 [-4.967e+02,2.114e+03]
alpha[1]       0.3865  8.213e-02      4.706  2.525e-06      [  0.226,  0.547]
alpha[2]       0.0714      0.357      0.200      0.842      [ -0.629,  0.771]
beta[1]        0.0000      0.922      0.000      1.000      [ -1.807,  1.807]
beta[2]        0.0839      0.197      0.425      0.671      [ -0.303,  0.471]
beta[3]    1.1111e-13      0.126  8.804e-13      1.000      [ -0.247,  0.247]
============================================================================

Covariance estimator: robust
                Constant Mean - GARCH Model Results
============================================================================
Dep. Variable:               FBChange   R-squared:                      -0.000
Mean Model:             Constant Mean   Adj. R-squared:                 -0.000
Vol Model:                      GARCH   Log-Likelihood:               -4063.65
Distribution:                  Normal   AIC:                           8143.30
Method:            Maximum Likelihood   BIC:                           8180.80
                                        No. Observations:                  802
Date:                Mon, Dec 10 2018   Df Residuals:                      794
Time:                        02:44:18   Df Model:                            8
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3968      1.020      0.389      0.697 [ -1.603,  2.396]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        806.0572    544.122      1.481      0.139 [-2.604e+02,1.873e+03]
alpha[1]       0.3864  8.219e-02      4.701  2.588e-06      [  0.225,  0.547]
alpha[2]       0.0714      0.274      0.261      0.794      [ -0.466,  0.608]
beta[1]        0.0000      0.685      0.000      1.000      [ -1.343,  1.343]
beta[2]        0.0835      0.137      0.611      0.541      [ -0.185,  0.352]
beta[3]    1.3035e-13      0.127  1.023e-12      1.000      [ -0.250,  0.250]
```

```
beta[4]    1.8499e-03  3.449e-02  5.364e-02      0.957 [-6.575e-02,6.945e-02]
==============================================================================

Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.31
Distribution:                  Normal   AIC:                            8138.62
Method:            Maximum Likelihood   BIC:                            8166.75
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        796
Time:                        02:44:18   Df Model:                              6
                             Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3633      1.020      0.356      0.722 [ -1.635,  2.362]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        878.1694    801.306      1.096      0.273 [-6.924e+02,2.449e+03]
alpha[1]       0.3821  6.970e-02      5.481  4.223e-08      [  0.245,  0.519]
alpha[2]       0.0779      0.360      0.216      0.829      [ -0.628,  0.784]
alpha[3]       0.0433      0.104      0.417      0.676      [ -0.160,  0.247]
beta[1]        0.0000      0.917      0.000      1.000      [ -1.798,  1.798]
============================================================================

Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.31
Distribution:                  Normal   AIC:                            8140.62
Method:            Maximum Likelihood   BIC:                            8173.43
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        795
Time:                        02:44:18   Df Model:                              7
                             Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3634      1.046      0.347      0.728 [ -1.687,  2.413]
                          Volatility Model
============================================================================
```

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	878.1579	1190.113	0.738	0.461	[-1.454e+03,3.211e+03]
alpha[1]	0.3821	6.914e-02	5.526	3.270e-08	[0.247, 0.518]
alpha[2]	0.0779	0.402	0.194	0.846	[-0.709, 0.865]
alpha[3]	0.0433	0.599	7.232e-02	0.942	[-1.130, 1.216]
beta[1]	0.0000	1.286	0.000	1.000	[-2.521, 2.521]
beta[2]	1.5146e-15	1.805	8.391e-16	1.000	[-3.538, 3.538]

Covariance estimator: robust

Constant Mean - GARCH Model Results

Dep. Variable:	FBChange	R-squared:	-0.000
Mean Model:	Constant Mean	Adj. R-squared:	-0.000
Vol Model:	GARCH	Log-Likelihood:	-4063.31
Distribution:	Normal	AIC:	8142.62
Method:	Maximum Likelihood	BIC:	8180.12
		No. Observations:	802
Date:	Mon, Dec 10 2018	Df Residuals:	794
Time:	02:44:18	Df Model:	8

Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	0.3643	1.017	0.358	0.720	[-1.628, 2.357]

Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	878.3289	666.678	1.317	0.188	[-4.283e+02,2.185e+03]
alpha[1]	0.3819	8.442e-02	4.524	6.073e-06	[0.216, 0.547]
alpha[2]	0.0778	0.410	0.190	0.849	[-0.725, 0.881]
alpha[3]	0.0432	0.450	9.606e-02	0.923	[-0.839, 0.925]
beta[1]	3.8960e-13	1.318	2.956e-13	1.000	[-2.583, 2.583]
beta[2]	1.0220e-13	1.503	6.802e-14	1.000	[-2.945, 2.945]
beta[3]	7.9815e-14	0.198	4.027e-13	1.000	[-0.388, 0.388]

Covariance estimator: robust

Constant Mean - GARCH Model Results

Dep. Variable:	FBChange	R-squared:	-0.000
Mean Model:	Constant Mean	Adj. R-squared:	-0.000
Vol Model:	GARCH	Log-Likelihood:	-4063.30
Distribution:	Normal	AIC:	8144.60
Method:	Maximum Likelihood	BIC:	8186.79
		No. Observations:	802

```
Date:                Mon, Dec 10 2018   Df Residuals:                      793
Time:                        02:44:18   Df Model:                           9
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3683      1.013      0.363      0.716 [ -1.618,  2.355]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        868.4047    689.416      1.260      0.208 [-4.828e+02,2.220e+03]
alpha[1]       0.3816  8.277e-02      4.610  4.019e-06      [  0.219,  0.544]
alpha[2]       0.0777      0.229      0.339      0.735      [ -0.372,  0.527]
alpha[3]       0.0434      0.326      0.133      0.894      [ -0.596,  0.682]
beta[1]    3.7843e-13      0.603  6.279e-13      1.000      [ -1.181,  1.181]
beta[2]        0.0000      0.862      0.000      1.000      [ -1.689,  1.689]
beta[3]        0.0000      0.176      0.000      1.000      [ -0.346,  0.346]
beta[4]    6.0439e-03  5.408e-02      0.112      0.911   [-9.996e-02,  0.112]
============================================================================

Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.31
Distribution:                  Normal   AIC:                            8140.62
Method:            Maximum Likelihood   BIC:                            8173.43
                                        No. Observations:                    802
Date:                Mon, Dec 10 2018   Df Residuals:                        795
Time:                        02:44:18   Df Model:                              7
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3632      1.011      0.359      0.720 [ -1.619,  2.346]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        878.3928    600.517      1.463      0.144 [-2.986e+02,2.055e+03]
alpha[1]       0.3820  6.941e-02      5.504  3.709e-08      [  0.246,  0.518]
alpha[2]       0.0778      0.273      0.285      0.776      [ -0.458,  0.614]
alpha[3]       0.0433  5.449e-02      0.794      0.427   [-6.354e-02,  0.150]
alpha[4]   4.3973e-12  6.524e-02  6.740e-11      1.000      [ -0.128,  0.128]
beta[1]        0.0000      0.693      0.000      1.000      [ -1.357,  1.357]
============================================================================
```

```
Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.31
Distribution:                  Normal   AIC:                            8142.62
Method:            Maximum Likelihood   BIC:                            8180.12
                                        No. Observations:                   802
Date:                Mon, Dec 10 2018   Df Residuals:                       794
Time:                        02:44:18   Df Model:                             8
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3636      1.025      0.355      0.723 [ -1.645,  2.372]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
----------------------------------------------------------------------------
omega        878.3577    874.861      1.004      0.315 [-8.363e+02,2.593e+03]
alpha[1]       0.3820  6.922e-02      5.519  3.409e-08      [  0.246,  0.518]
alpha[2]       0.0779      0.370      0.211      0.833      [ -0.647,  0.803]
alpha[3]       0.0433      0.543  7.962e-02      0.937      [ -1.022,  1.108]
alpha[4]   1.1600e-11  6.748e-02  1.719e-10      1.000      [ -0.132,  0.132]
beta[1]        0.0000      1.298      0.000      1.000      [ -2.545,  2.545]
beta[2]        0.0000      1.776      0.000      1.000      [ -3.481,  3.481]
============================================================================

Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                       -0.000
Mean Model:             Constant Mean   Adj. R-squared:                  -0.000
Vol Model:                      GARCH   Log-Likelihood:                -4063.31
Distribution:                  Normal   AIC:                            8144.62
Method:            Maximum Likelihood   BIC:                            8186.81
                                        No. Observations:                   802
Date:                Mon, Dec 10 2018   Df Residuals:                       793
Time:                        02:44:18   Df Model:                             9
                            Mean Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.3636      1.016      0.358      0.721 [ -1.629,  2.356]
                          Volatility Model
============================================================================
```

```
                 coef    std err          t      P>|t|       95.0% Conf. Int.
-----------------------------------------------------------------------------
omega        878.0366    720.515      1.219      0.223 [-5.341e+02,2.290e+03]
alpha[1]       0.3821      0.149      2.572  1.011e-02    [9.091e-02,  0.673]
alpha[2]       0.0779      0.279      0.279      0.780      [ -0.470,  0.625]
alpha[3]       0.0434      0.391      0.111      0.912      [ -0.723,  0.810]
alpha[4]   3.3218e-12      0.184  1.806e-11      1.000      [ -0.361,  0.361]
beta[1]    3.4890e-15      0.824  4.233e-15      1.000      [ -1.616,  1.616]
beta[2]    2.6051e-14      1.126  2.314e-14      1.000      [ -2.207,  2.207]
beta[3]    1.8340e-14      0.510  3.598e-14      1.000      [ -0.999,  0.999]
=============================================================================

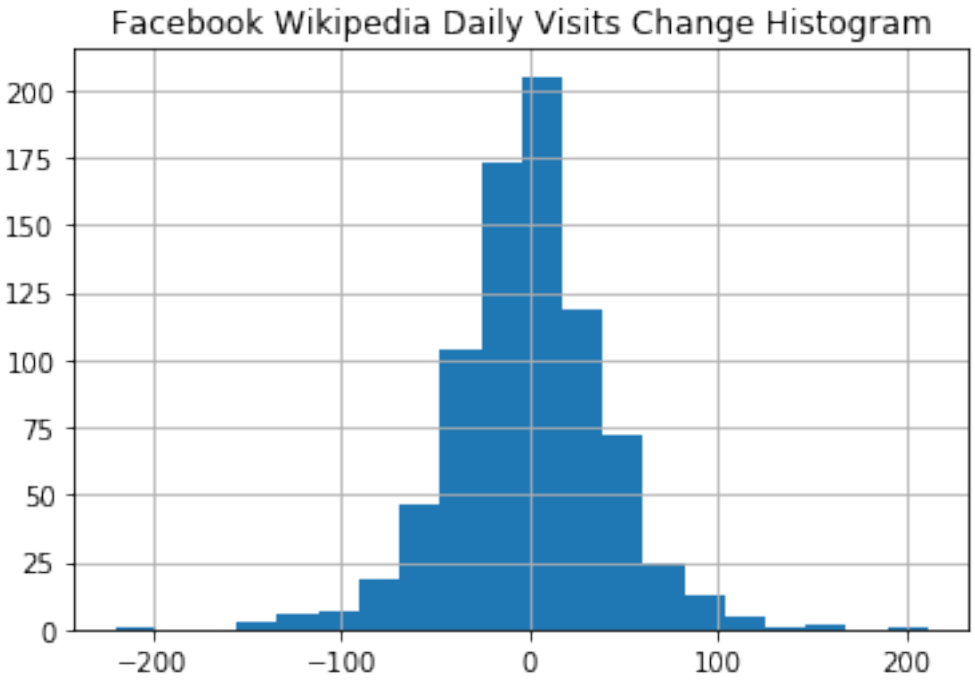
Covariance estimator: robust
                    Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:               FBChange   R-squared:                      -0.000
Mean Model:             Constant Mean   Adj. R-squared:                 -0.000
Vol Model:                      GARCH   Log-Likelihood:               -4063.30
Distribution:                  Normal   AIC:                           8146.60
Method:            Maximum Likelihood   BIC:                           8193.47
                                        No. Observations:                  802
Date:                Mon, Dec 10 2018   Df Residuals:                      792
Time:                        02:44:18   Df Model:                           10
                            Mean Model
=============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
-----------------------------------------------------------------------------
mu             0.3682      1.266      0.291      0.771 [ -2.113,  2.850]
                          Volatility Model
=============================================================================
                 coef    std err          t      P>|t|       95.0% Conf. Int.
-----------------------------------------------------------------------------
omega        868.6325   1025.415      0.847      0.397 [-1.141e+03,2.878e+03]
alpha[1]       0.3816      0.621      0.614      0.539      [ -0.836,  1.599]
alpha[2]       0.0776      0.747      0.104      0.917      [ -1.386,  1.541]
alpha[3]       0.0434      1.623  2.675e-02      0.979      [ -3.138,  3.225]
alpha[4]       0.0000      1.233      0.000      1.000      [ -2.416,  2.416]
beta[1]    6.8849e-11      2.888  2.384e-11      1.000      [ -5.660,  5.660]
beta[2]    3.8800e-12      4.802  8.080e-13      1.000      [ -9.412,  9.412]
beta[3]    6.0379e-13      3.240  1.864e-13      1.000      [ -6.350,  6.350]
beta[4]    5.9904e-03      0.235  2.551e-02      0.980      [ -0.454,  0.466]
=============================================================================

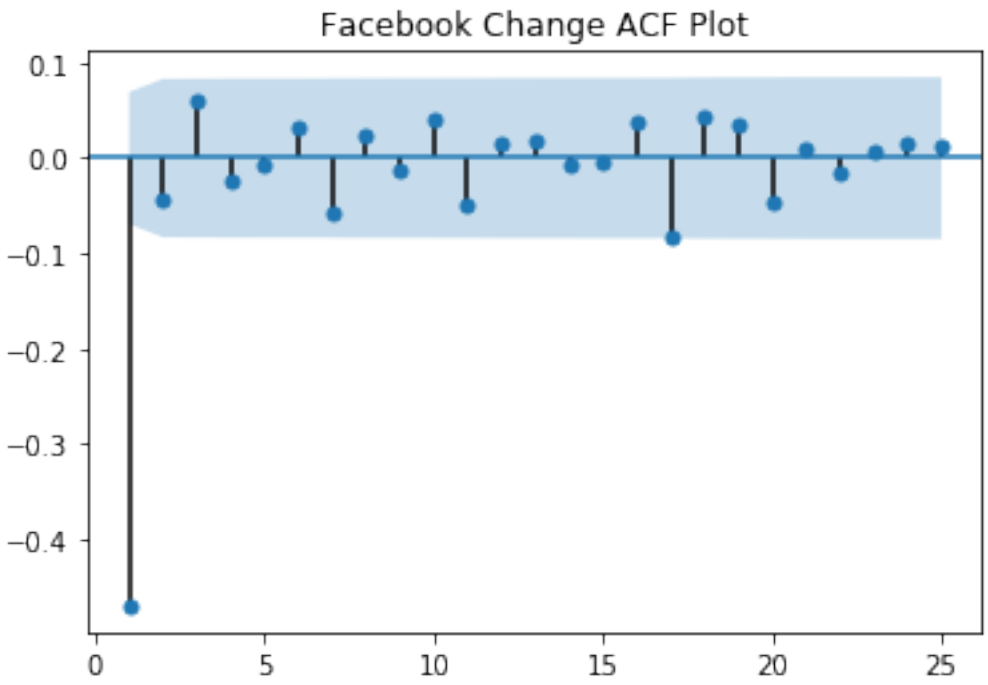
Covariance estimator: robust

In [10]: basic(sampledata, "FBChange", "Facebook Wikipedia Daily Visits Change Histogram","Face

---Facebook Daily Visits---
```

```
Mean: -0.01207603815335625
Variance: 1694.9150341390537
Skewness(scipy): -0.07505160617431292
Kurtosis: 2.6043402578909682
```





Not really autocorrelated. Meaning number of visits from yesterday's data doesn't determine the number of visits of today's data. Nothing too interesting with first differenced data.

1.3 Stationarity

```
In [11]: result=smt.adfuller(sampledata["Facebook"])
         print('ADF Statistic: %f' % result[0])
         print('p-value: %f' % result[1])
         print('Critical Values:')
         for key, value in result[4].items():
             print('\t%s: %.3f' % (key, value))

ADF Statistic: -6.964697
p-value: 0.000000
Critical Values:
        1%: -3.439
        5%: -2.865
        10%: -2.569
```

Data is stationary.

```
In [27]: result=smt.adfuller(sampledata["FBChange"])
         print('ADF Statistic: %f' % result[0])
         print('p-value: %s' % result[1])
         print('Critical Values:')
```

```
        for key, value in result[4].items():
            print('\t%s: %.3f' % (key, value))
```

```
ADF Statistic: -11.812116
p-value: 8.810406134104259e-22
Critical Values:
        1%: -3.439
        5%: -2.865
        10%: -2.569
```

Same with this one.

1.4 Model

```
In [13]: for i in range(0,11):
             for j in range(0,11):
                 model = smt.ARMA(sampledata["Facebook"], order=(i,j))
                 model_fit = model.fit(disp=0, method='mle', solver='nm')
                 print(model_fit.summary())
```

```
                              ARMA Model Results
==============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                     ARMA(0, 0)   Log Likelihood               -3829.036
Method:                           css   S.D. of innovations             28.658
Date:                Mon, 10 Dec 2018   AIC                           7662.071
Time:                        02:44:19   BIC                           7671.445
Sample:                             0   HQIC                          7665.672

==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         53.5985      1.012     52.966      0.000      51.615      55.582
==============================================================================
                              ARMA Model Results
==============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                     ARMA(0, 1)   Log Likelihood               -3788.302
Method:                           mle   S.D. of innovations             27.237
Date:                Mon, 10 Dec 2018   AIC                           7582.603
Time:                        02:44:19   BIC                           7596.665
Sample:                             0   HQIC                          7588.004

==============================================================================
                     coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const             53.5979      1.229     43.603      0.000      51.189      56.007
ma.L1.Facebook     0.2784      0.030      9.281      0.000       0.220       0.337
```

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	-3.5916	+0.0000j	3.5916	0.5000

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 2)	Log Likelihood	-3776.584
Method:	mle	S.D. of innovations	26.842
Date:	Mon, 10 Dec 2018	AIC	7561.169
Time:	02:44:19	BIC	7579.917
Sample:	0	HQIC	7568.370

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5949	1.356	39.528	0.000	50.937	56.252
ma.L1.Facebook	0.2769	0.036	7.771	0.000	0.207	0.347
ma.L2.Facebook	0.1544	0.032	4.872	0.000	0.092	0.216

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	-0.8969	-2.3820j	2.5452	-0.3073
MA.2	-0.8969	+2.3820j	2.5452	0.3073

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 3)	Log Likelihood	-3765.003
Method:	mle	S.D. of innovations	26.456
Date:	Mon, 10 Dec 2018	AIC	7540.006
Time:	02:44:19	BIC	7563.442
Sample:	0	HQIC	7549.008

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5814	1.472	36.410	0.000	50.697	56.466
ma.L1.Facebook	0.2614	0.036	7.199	0.000	0.190	0.333
ma.L2.Facebook	0.1572	0.032	4.854	0.000	0.094	0.221
ma.L3.Facebook	0.1579	0.033	4.845	0.000	0.094	0.222

Roots

	Real	Imaginary	Modulus	Frequency

MA.1	0.4477	-1.7743j	1.8299	-0.2107
MA.2	0.4477	+1.7743j	1.8299	0.2107
MA.3	-1.8910	-0.0000j	1.8910	-0.5000

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 4)	Log Likelihood	-3756.481
Method:	mle	S.D. of innovations	26.176
Date:	Mon, 10 Dec 2018	AIC	7524.963
Time:	02:44:19	BIC	7553.086
Sample:	0	HQIC	7535.765

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5907	1.577	33.983	0.000	50.500	56.682
ma.L1.Facebook	0.2408	0.036	6.687	0.000	0.170	0.311
ma.L2.Facebook	0.1469	0.036	4.028	0.000	0.075	0.218
ma.L3.Facebook	0.1770	0.033	5.437	0.000	0.113	0.241
ma.L4.Facebook	0.1434	0.034	4.192	0.000	0.076	0.210

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	0.7743	-1.3020j	1.5148	-0.1646
MA.2	0.7743	+1.3020j	1.5148	0.1646
MA.3	-1.3912	-1.0503j	1.7432	-0.3971
MA.4	-1.3912	+1.0503j	1.7432	0.3971

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 5)	Log Likelihood	-3747.465
Method:	mle	S.D. of innovations	25.882
Date:	Mon, 10 Dec 2018	AIC	7508.930
Time:	02:44:19	BIC	7541.740
Sample:	0	HQIC	7521.533

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5983	1.707	31.405	0.000	50.253	56.943
ma.L1.Facebook	0.2348	0.035	6.636	0.000	0.165	0.304
ma.L2.Facebook	0.1507	0.036	4.174	0.000	0.080	0.221
ma.L3.Facebook	0.1823	0.033	5.545	0.000	0.118	0.247
ma.L4.Facebook	0.1566	0.034	4.624	0.000	0.090	0.223
ma.L5.Facebook	0.1461	0.034	4.311	0.000	0.080	0.213

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	0.8879	-1.0253j	1.3563	-0.1364
MA.2	0.8879	+1.0253j	1.3563	0.1364
MA.3	-1.5206	-0.0000j	1.5206	-0.5000
MA.4	-0.6635	-1.4164j	1.5641	-0.3197
MA.5	-0.6635	+1.4164j	1.5641	0.3197

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 6)	Log Likelihood	-3743.951
Method:	mle	S.D. of innovations	25.768
Date:	Mon, 10 Dec 2018	AIC	7503.902
Time:	02:44:20	BIC	7541.399
Sample:	0	HQIC	7518.305

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5964	1.801	29.756	0.000	50.066	57.127
ma.L1.Facebook	0.2357	0.035	6.678	0.000	0.167	0.305
ma.L2.Facebook	0.1553	0.036	4.311	0.000	0.085	0.226
ma.L3.Facebook	0.1855	0.036	5.147	0.000	0.115	0.256
ma.L4.Facebook	0.1621	0.035	4.696	0.000	0.094	0.230
ma.L5.Facebook	0.1554	0.034	4.529	0.000	0.088	0.223
ma.L6.Facebook	0.0892	0.034	2.654	0.008	0.023	0.155

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	0.9362	-0.9061j	1.3029	-0.1224
MA.2	0.9362	+0.9061j	1.3029	0.1224
MA.3	-0.2848	-1.5182j	1.5447	-0.2795
MA.4	-0.2848	+1.5182j	1.5447	0.2795
MA.5	-1.5227	-0.6707j	1.6639	-0.4340
MA.6	-1.5227	+0.6707j	1.6639	0.4340

```
C:\Users\Diana\Anaconda3\lib\site-packages\statsmodels\base\model.py:508: ConvergenceWarning: M
  "Check mle_retvals", ConvergenceWarning)
```

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 7)	Log Likelihood	-3741.873
Method:	mle	S.D. of innovations	25.701
Date:	Mon, 10 Dec 2018	AIC	7501.746
Time:	02:44:21	BIC	7543.930
Sample:	0	HQIC	7517.950

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5920	1.876	28.570	0.000	49.915	57.268
ma.L1.Facebook	0.2359	0.035	6.666	0.000	0.167	0.305
ma.L2.Facebook	0.1549	0.036	4.259	0.000	0.084	0.226
ma.L3.Facebook	0.1890	0.036	5.182	0.000	0.117	0.260
ma.L4.Facebook	0.1634	0.035	4.671	0.000	0.095	0.232
ma.L5.Facebook	0.1589	0.034	4.658	0.000	0.092	0.226
ma.L6.Facebook	0.1026	0.035	2.951	0.003	0.034	0.171
ma.L7.Facebook	0.0668	0.033	2.037	0.042	0.003	0.131

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	0.9792	-0.8205j	1.2775	-0.1110
MA.2	0.9792	+0.8205j	1.2775	0.1110
MA.3	0.0812	-1.5394j	1.5416	-0.2416
MA.4	0.0812	+1.5394j	1.5416	0.2416
MA.5	-1.5011	-0.0000j	1.5011	-0.5000
MA.6	-1.0775	-1.1876j	1.6035	-0.3673
MA.7	-1.0775	+1.1876j	1.6035	0.3673

C:\Users\Diana\Anaconda3\lib\site-packages\statsmodels\base\model.py:508: ConvergenceWarning: M
  "Check mle_retvals", ConvergenceWarning)

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 8)	Log Likelihood	-3740.858
Method:	mle	S.D. of innovations	25.669
Date:	Mon, 10 Dec 2018	AIC	7501.717
Time:	02:44:23	BIC	7548.588
Sample:	0	HQIC	7519.720

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

const	53.5705	1.924	27.850	0.000	49.800	57.341
ma.L1.Facebook	0.2304	0.036	6.449	0.000	0.160	0.300
ma.L2.Facebook	0.1524	0.037	4.173	0.000	0.081	0.224
ma.L3.Facebook	0.1876	0.037	5.127	0.000	0.116	0.259
ma.L4.Facebook	0.1649	0.037	4.507	0.000	0.093	0.237
ma.L5.Facebook	0.1645	0.035	4.754	0.000	0.097	0.232
ma.L6.Facebook	0.1011	0.035	2.891	0.004	0.033	0.170
ma.L7.Facebook	0.0763	0.033	2.288	0.022	0.011	0.142
ma.L8.Facebook	0.0500	0.035	1.432	0.153	-0.018	0.119

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	1.0166	-0.7578j	1.2680	-0.1019
MA.2	1.0166	+0.7578j	1.2680	0.1019
MA.3	0.3880	-1.4624j	1.5130	-0.2087
MA.4	0.3880	+1.4624j	1.5130	0.2087
MA.5	-0.6836	-1.3311j	1.4963	-0.3255
MA.6	-0.6836	+1.3311j	1.4963	0.3255
MA.7	-1.4835	-0.4737j	1.5573	-0.4508
MA.8	-1.4835	+0.4737j	1.5573	0.4508

C:\Users\Diana\Anaconda3\lib\site-packages\statsmodels\base\model.py:508: ConvergenceWarning: M
  "Check mle_retvals", ConvergenceWarning)

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 9)	Log Likelihood	-3738.426
Method:	mle	S.D. of innovations	25.591
Date:	Mon, 10 Dec 2018	AIC	7498.853
Time:	02:44:24	BIC	7550.411
Sample:	0	HQIC	7518.657

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.6737	1.985	27.035	0.000	49.783	57.565
ma.L1.Facebook	0.2281	0.036	6.371	0.000	0.158	0.298
ma.L2.Facebook	0.1520	0.036	4.188	0.000	0.081	0.223
ma.L3.Facebook	0.1834	0.037	5.021	0.000	0.112	0.255
ma.L4.Facebook	0.1670	0.036	4.688	0.000	0.097	0.237
ma.L5.Facebook	0.1617	0.035	4.578	0.000	0.093	0.231
ma.L6.Facebook	0.1127	0.035	3.190	0.001	0.043	0.182
ma.L7.Facebook	0.0815	0.034	2.396	0.017	0.015	0.148

ma.L8.Facebook	0.0373	0.036	1.050	0.294	-0.032	0.107
ma.L9.Facebook	0.0792	0.034	2.363	0.018	0.014	0.145

Roots

	Real	Imaginary	Modulus	Frequency
MA.1	1.0653	-0.6726j	1.2599	-0.0896
MA.2	1.0653	+0.6726j	1.2599	0.0896
MA.3	0.6400	-1.2323j	1.3886	-0.1738
MA.4	0.6400	+1.2323j	1.3886	0.1738
MA.5	-1.2876	-0.0000j	1.2876	-0.5000
MA.6	-1.0283	-0.8458j	1.3314	-0.3905
MA.7	-1.0283	+0.8458j	1.3314	0.3905
MA.8	-0.2688	-1.3173j	1.3444	-0.2820
MA.9	-0.2688	+1.3173j	1.3444	0.2820

C:\Users\Diana\Anaconda3\lib\site-packages\statsmodels\base\model.py:508: ConvergenceWarning: I
  "Check mle_retvals", ConvergenceWarning)

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(0, 10)	Log Likelihood	-3738.726
Method:	mle	S.D. of innovations	25.601
Date:	Mon, 10 Dec 2018	AIC	7501.451
Time:	02:44:27	BIC	7557.697
Sample:	0	HQIC	7523.056

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.6545	1.980	27.093	0.000	49.773	57.536
ma.L1.Facebook	0.2202	0.036	6.120	0.000	0.150	0.291
ma.L2.Facebook	0.1430	0.037	3.863	0.000	0.070	0.216
ma.L3.Facebook	0.1855	0.037	5.048	0.000	0.113	0.258
ma.L4.Facebook	0.1645	0.035	4.683	0.000	0.096	0.233
ma.L5.Facebook	0.1612	0.037	4.337	0.000	0.088	0.234
ma.L6.Facebook	0.1140	0.035	3.258	0.001	0.045	0.183
ma.L7.Facebook	0.0556	0.035	1.592	0.112	-0.013	0.124
ma.L8.Facebook	0.0180	0.035	0.516	0.606	-0.050	0.086
ma.L9.Facebook	0.0780	0.034	2.298	0.022	0.011	0.145
ma.L10.Facebook	0.0568	0.036	1.559	0.119	-0.015	0.128

Roots

	Real	Imaginary	Modulus	Frequency

```
-----------------------------------------------------------------------------
MA.1            1.1156          -0.6130j            1.2729           -0.0800
MA.2            1.1156          +0.6130j            1.2729            0.0800
MA.3            0.7184          -1.0561j            1.2773           -0.1549
MA.4            0.7184          +1.0561j            1.2773            0.1549
MA.5           -0.1250          -1.2661j            1.2723           -0.2657
MA.6           -0.1250          +1.2661j            1.2723            0.2657
MA.7           -0.9340          -0.9858j            1.3581           -0.3707
MA.8           -0.9340          +0.9858j            1.3581            0.3707
MA.9           -1.4623          -0.3056j            1.4939           -0.4672
MA.10          -1.4623          +0.3056j            1.4939            0.4672
-----------------------------------------------------------------------------
                            ARMA Model Results
=============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                  ARMA(1, 0)   Log Likelihood               -3772.572
Method:                         mle   S.D. of innovations             26.707
Date:                Mon, 10 Dec 2018   AIC                          7551.144
Time:                        02:44:28   BIC                          7565.205
Sample:                             0   HQIC                         7556.545

==============================================================================
                    coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const            53.5941      1.478     36.271      0.000      50.698      56.490
ar.L1.Facebook    0.3622      0.033     11.015      0.000       0.298       0.427
                                    Roots
=============================================================================
                  Real          Imaginary           Modulus         Frequency
-----------------------------------------------------------------------------
AR.1            2.7608           +0.0000j            2.7608            0.0000
-----------------------------------------------------------------------------
                            ARMA Model Results
=============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                  ARMA(1, 1)   Log Likelihood               -3728.093
Method:                         mle   S.D. of innovations             25.260
Date:                Mon, 10 Dec 2018   AIC                          7464.185
Time:                        02:44:28   BIC                          7482.934
Sample:                             0   HQIC                         7471.387

==============================================================================
                    coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const            53.5391      3.731     14.351      0.000      46.227      60.851
ar.L1.Facebook    0.9479      0.018     52.605      0.000       0.913       0.983
ma.L1.Facebook   -0.7782      0.037    -21.076      0.000      -0.851      -0.706
                                    Roots
```

	Real	Imaginary	Modulus	Frequency
AR.1	1.0550	+0.0000j	1.0550	0.0000
MA.1	1.2851	+0.0000j	1.2851	0.0000

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(1, 2)	Log Likelihood	-3727.359
Method:	mle	S.D. of innovations	25.237
Date:	Mon, 10 Dec 2018	AIC	7464.717
Time:	02:44:28	BIC	7488.153
Sample:	0	HQIC	7473.719

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5260	3.909	13.692	0.000	45.864	61.188
ar.L1.Facebook	0.9554	0.017	56.326	0.000	0.922	0.989
ma.L1.Facebook	-0.7528	0.040	-18.843	0.000	-0.831	-0.675
ma.L2.Facebook	-0.0475	0.039	-1.215	0.225	-0.124	0.029

Roots

	Real	Imaginary	Modulus	Frequency
AR.1	1.0467	+0.0000j	1.0467	0.0000
MA.1	1.2325	+0.0000j	1.2325	0.0000
MA.2	-17.0977	+0.0000j	17.0977	0.5000

ARMA Model Results

Dep. Variable:	Facebook	No. Observations:	802
Model:	ARMA(1, 3)	Log Likelihood	-3726.939
Method:	mle	S.D. of innovations	25.223
Date:	Mon, 10 Dec 2018	AIC	7465.877
Time:	02:44:29	BIC	7494.000
Sample:	0	HQIC	7476.679

	coef	std err	z	P>|z|	[0.025	0.975]
const	53.5420	3.765	14.222	0.000	46.163	60.921
ar.L1.Facebook	0.9492	0.020	46.769	0.000	0.909	0.989
ma.L1.Facebook	-0.7469	0.041	-18.316	0.000	-0.827	-0.667
ma.L2.Facebook	-0.0688	0.045	-1.535	0.125	-0.157	0.019
ma.L3.Facebook	0.0344	0.038	0.916	0.360	-0.039	0.108

Roots

```
=============================================================================
                  Real          Imaginary           Modulus         Frequency
-----------------------------------------------------------------------------
AR.1            1.0535           +0.0000j            1.0535            0.0000
MA.1            1.2847           +0.0000j            1.2847            0.0000
MA.2           -4.4114           +0.0000j            4.4114            0.5000
MA.3            5.1233           +0.0000j            5.1233            0.0000
-----------------------------------------------------------------------------
                              ARMA Model Results
==============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                     ARMA(1, 4)   Log Likelihood               -3726.805
Method:                           mle   S.D. of innovations             25.219
Date:                Mon, 10 Dec 2018   AIC                          7467.610
Time:                        02:44:29   BIC                          7500.419
Sample:                             0   HQIC                         7480.212

==============================================================================
                    coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const             53.5313      3.845     13.923      0.000      45.995      61.067
ar.L1.Facebook     0.9529      0.020     47.334      0.000       0.913       0.992
ma.L1.Facebook    -0.7518      0.041    -18.311      0.000      -0.832      -0.671
ma.L2.Facebook    -0.0693      0.044     -1.573      0.116      -0.156       0.017
ma.L3.Facebook     0.0479      0.046      1.048      0.295      -0.042       0.138
ma.L4.Facebook    -0.0192      0.037     -0.517      0.605      -0.092       0.054
                                    Roots
=============================================================================
                  Real          Imaginary           Modulus         Frequency
-----------------------------------------------------------------------------
AR.1            1.0495           +0.0000j            1.0495            0.0000
MA.1            1.2485           -0.0000j            1.2485           -0.0000
MA.2           -2.9250           -0.0000j            2.9250           -0.5000
MA.3            2.0851           -3.1467j            3.7748           -0.1569
MA.4            2.0851           +3.1467j            3.7748            0.1569
-----------------------------------------------------------------------------


C:\Users\Diana\Anaconda3\lib\site-packages\statsmodels\base\model.py:508: ConvergenceWarning: M
  "Check mle_retvals", ConvergenceWarning)


                              ARMA Model Results
==============================================================================
Dep. Variable:               Facebook   No. Observations:                  802
Model:                     ARMA(1, 5)   Log Likelihood               -3726.674
Method:                           mle   S.D. of innovations             25.215
Date:                Mon, 10 Dec 2018   AIC                          7469.348
```

```
Time:                        02:44:30   BIC                            7506.845
Sample:                             0   HQIC                           7483.751

==============================================================================
                  coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const           53.5241      3.921     13.652      0.000      45.840      61.208
ar.L1.Facebook   0.9562      0.020     48.038      0.000       0.917       0.995
ma.L1.Facebook  -0.7564      0.041    -18.341      0.000      -0.837      -0.676
ma.L2.Facebook  -0.0698      0.044     -1.569      0.117      -0.157       0.017
ma.L3.Facebook   0.0494      0.046      1.068      0.286      -0.041       0.140
ma.L4.Facebook  -0.0066      0.045     -0.149      0.882      -0.094       0.081
ma.L5.Facebook  -0.0196      0.038     -0.511      0.609      -0.095       0.056
                                    Roots
==============================================================================
                 Real          Imaginary           Modulus         Frequency
------------------------------------------------------------------------------
AR.1            1.0458           +0.0000j            1.0458            0.0000
MA.1            1.2150           -0.0000j            1.2150           -0.0000
MA.2            1.5041           -1.8192j            2.3605           -0.1400
MA.3            1.5041           +1.8192j            2.3605            0.1400
MA.4           -2.2801           -1.5232j            2.7421           -0.4063
MA.5           -2.2801           +1.5232j            2.7421            0.4063
------------------------------------------------------------------------------
```

```
---------------------------------------------------------------------------

ValueError                                Traceback (most recent call last)

<ipython-input-13-48682322ec2a> in <module>()
      2     for j in range(0,11):
      3         model = smt.ARMA(sampledata["Facebook"], order=(i,j))
----> 4         model_fit = model.fit(disp=0, method='mle', solver='nm')
      5         print(model_fit.summary())


~\Anaconda3\lib\site-packages\statsmodels\tsa\arima_model.py in fit(self, start_params
944         else:  # estimate starting parameters
945             start_params = self._fit_start_params((k_ar, k_ma, k), method,
--> 946                                                   start_ar_lags)
947
948         if transparams:  # transform initial parameters to ensure invertibility


~\Anaconda3\lib\site-packages\statsmodels\tsa\arima_model.py in _fit_start_params(self
556     def _fit_start_params(self, order, method, start_ar_lags=None):
```

```
    557         if method != 'css-mle':  # use Hannan-Rissanen to get start params
--> 558             start_params = self._fit_start_params_hr(order, start_ar_lags)
    559         else:  # use CSS to get start params
    560             func = lambda params: -self.loglike_css(params)


~\Anaconda3\lib\site-packages\statsmodels\tsa\arima_model.py in _fit_start_params_hr(s
    539         if p and not np.all(np.abs(np.roots(np.r_[1, -start_params[k:k + p]]
    540                                            )) < 1):
--> 541             raise ValueError("The computed initial AR coefficients are not "
    542                              "stationary\nYou should induce stationarity, "
    543                              "choose a different model order, or you can\n"


    ValueError: The computed initial AR coefficients are not stationary
You should induce stationarity, choose a different model order, or you can
pass your own start_params.
```

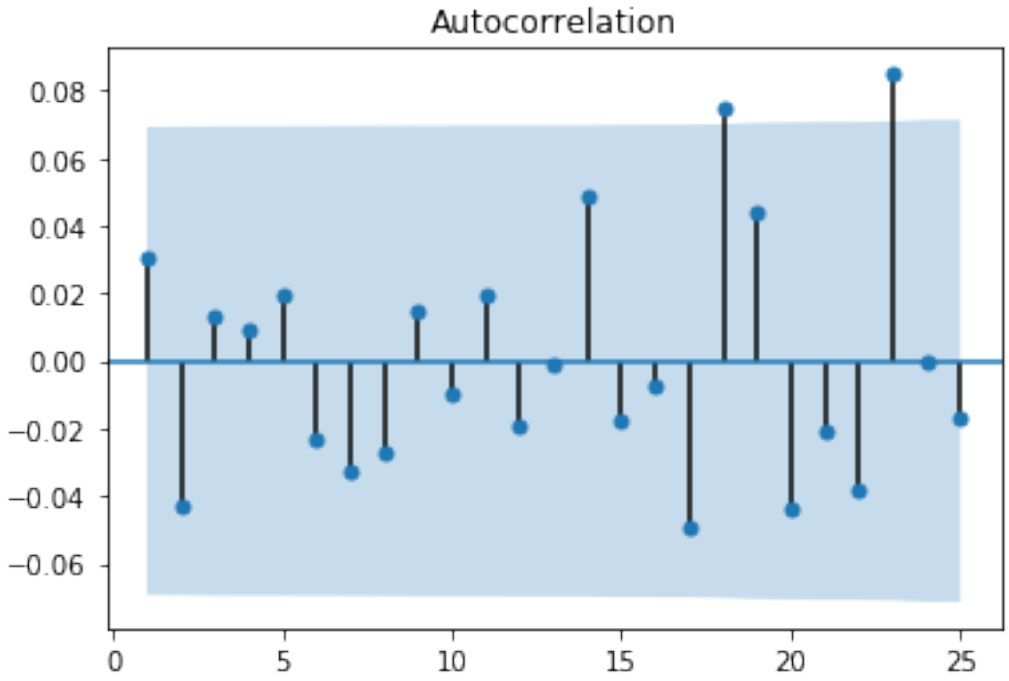
```
In [14]: model = smt.ARMA(sampledata["Facebook"], order=(1,1))
         model_fit = model.fit(disp=0, method='mle', solver='nm')
         print(model_fit.summary())

         data_acfplot = tsa.plot_acf(x=model_fit.resid, ax=None,
                                     lags=25, alpha=.05, use_vlines=True,
                                     unbiased=False,fft=False, zero=False,
                                     vlines_kwargs=None)
```

```
                              ARMA Model Results
==============================================================================
Dep. Variable:                Facebook   No. Observations:                  802
Model:                     ARMA(1, 1)   Log Likelihood               -3728.093
Method:                           mle   S.D. of innovations             25.260
Date:                Mon, 10 Dec 2018   AIC                           7464.185
Time:                        02:46:03   BIC                           7482.934
Sample:                             0   HQIC                          7471.387

==============================================================================
                    coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const             53.5391      3.731     14.351      0.000      46.227      60.851
ar.L1.Facebook     0.9479      0.018     52.605      0.000       0.913       0.983
ma.L1.Facebook    -0.7782      0.037    -21.076      0.000      -0.851      -0.706
                                    Roots
=============================================================================
                  Real          Imaginary           Modulus         Frequency
-----------------------------------------------------------------------------
AR.1            1.0550           +0.0000j            1.0550            0.0000
```

```
MA.1           1.2851          +0.0000j           1.2851            0.0000
-----------------------------------------------------------------------------
```



ARMA(1,1) is best and therefore tomorrow's data only depends on today's. Plot ACF on the residual to model check. The serila correlation is really low and no trend so it provides evidence that each reisdual is independent of each other.

series is adjusted to mean, the AR portion suggests that after significant spikes, the web traffic will slowly decrease overtime to the mean. You take the 95% of the first data and then 95% of that again. 95% comes from the coefficient. Can talk about how after the spike, the series goes down.

for MA with negative coefficient means that the previous day would have an opposite effect on the next day as seen in the jaggedness of the series.

```
In [15]: table = [["Model","AIC","BIC"],
                  ["ARMA(0,0)",7644.129,7653.498],
                  ["MA(1)",7565.164,7579.218],
                  ["MA(2)",7543.781,7562.781],
                  ["MA(3)",7522.786,7546.209],
                  ["MA(4)",7507.885,7535.993],
                  ["MA(5)",7492.126,7524.919],
                  ["AR(1)",7533.897,7547.951],
                  ["AR(2)",7506.299,7525.037],
                  ["AR(3)",7478.710,7502.133],
                  ["AR(4)",7466.529,7494.637],
                  ["AR(5)",7458.583,7491.375],
                  ["ARMA(1,1)",7447.300,7466.039],
```

```
                    ["ARMA(1,2)",7447.836,7471.259],
                    ["ARMA(1,3)",7449.007,7477.114],
                    ["ARMA(1,5)",7452.512,7489.989],
                    ["ARMA(2,1)",7447.964,7471.387],
                    ["ARMA(2,2)",7448.713,7476.821],
                    ["ARMA(2,5)",7454.635,7496.796],
                    ["ARMA(3,1)",7449.049,7477.157],
                    ["ARMA(3,5)",7456.112,7502.958],
                    ["ARMA(4,5)",7452.134,7503.665],
                    ["ARMA(5,5)",7453.500,7509.716]]
          display(HTML(tabulate.tabulate(table, tablefmt='html')))
```

```
<IPython.core.display.HTML object>
```

```
In [16]: facebookforecast = model_fit.forecast(steps=365)
         print(facebookforecast)
         plt.plot(facebookforecast[0])
         plt.title("Forecasted Daily Visits")
         plt.xlabel("Days")
         plt.ylabel("Daily Visits")
```

```
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```
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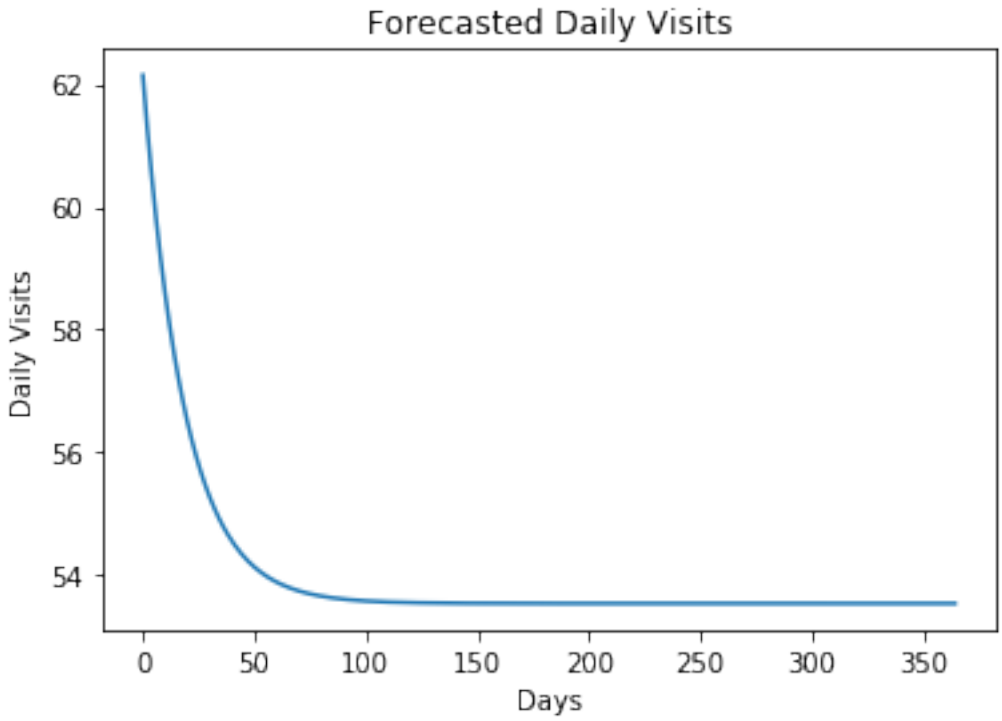
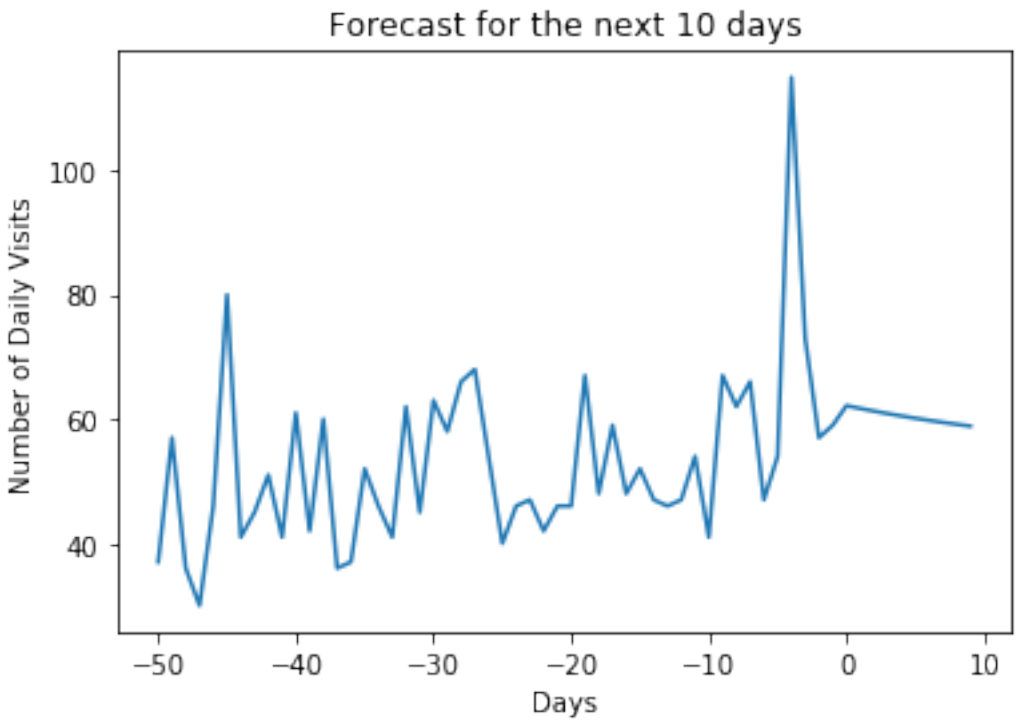
```

Out[16]: Text(0,0.5,'Daily Visits')



In [25]:
```
training_array = sampledata["Facebook"]
forecast, stderr, ci = model_fit.forecast(steps=10, alpha=0.1)
values_line = np.r_[training_array[-50:], forecast]
x_points = np.arange(-50, 10)
plt.plot(x_points, values_line)
# plt.fill_between(np.arange(10), ci[:,0], ci[:,1], alpha=0.3)
plt.title("Forecast for the next 10 days")
plt.xlabel("Days")
plt.ylabel("Number of Daily Visits")
plt.show()
```


Forecast for the next 10 days
Number of Daily Visits
100
80
60
40
−50
−40
−30
−20
−10
0
10
Days