ddb2bevaf

March 15, 2025

[27]:

```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import statsmodels.api as sm
from scipy import stats
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.graphics.api import qqplot
from warnings import simplefilter
```

[28]:

```
plt.style.use('Solarize_Light2')
simplefilter('ignore')
```

[29]:

```
print(sm.datasets.sunspots.NOTE)
```

```
::

    Number of Observations - 309 (Annual 1700 - 2008)
    Number of Variables - 1
    Variable name definitions::

        SUNACTIVITY - Number of sunspots for each year

    The data file contains a 'YEAR' variable that is not returned by load.
```

[30]:

```
dta = sm.datasets.sunspots.load_pandas().data
```

[31]:

```
dta
```

[31]:

```
       YEAR  SUNACTIVITY
0    1700.0          5.0
1    1701.0         11.0
2    1702.0         16.0
3    1703.0         23.0
4    1704.0         36.0
..      …            …
304  2004.0         40.4
305  2005.0         29.8
```

```
306  2006.0          15.2
307  2007.0           7.5
308  2008.0           2.9

[309 rows x 2 columns]
```

[32]:

```
dta.index = pd.Index(sm.tsa.datetools.dates_from_range("1700", "2008"))
dta.index.freq = dta.index.inferred_freq
del dta["YEAR"]
```

[33]:

```
dta
```

[33]:

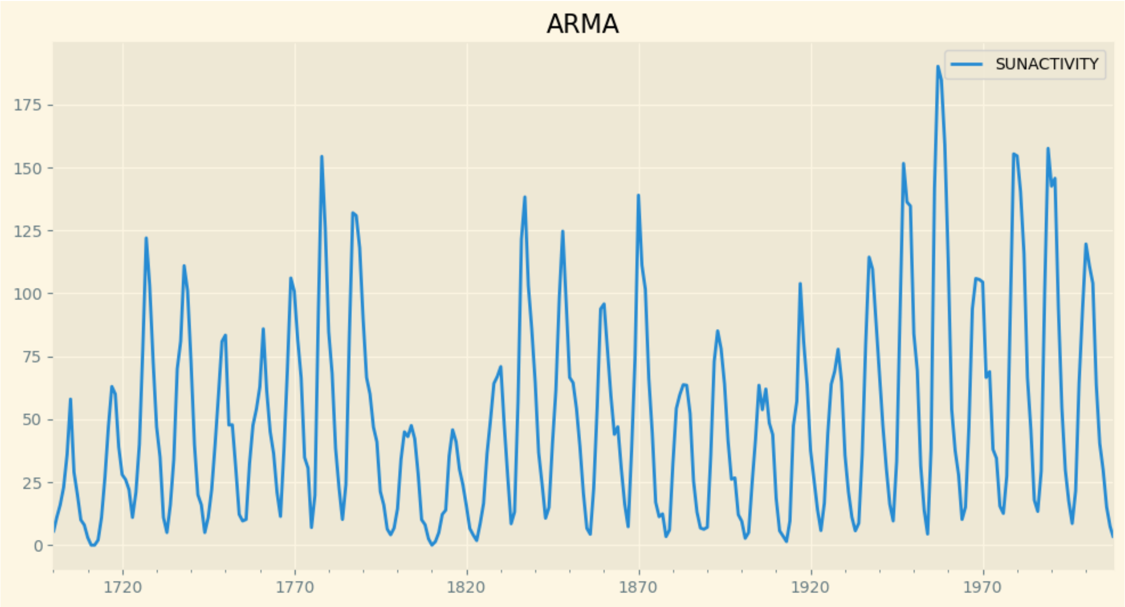
```
            SUNACTIVITY
1700-12-31          5.0
1701-12-31         11.0
1702-12-31         16.0
1703-12-31         23.0
1704-12-31         36.0
…                   …
2004-12-31         40.4
2005-12-31         29.8
2006-12-31         15.2
2007-12-31          7.5
2008-12-31          2.9

[309 rows x 1 columns]
```

[34]:

```
dta.plot(figsize=(12, 6),title = 'ARMA')
```

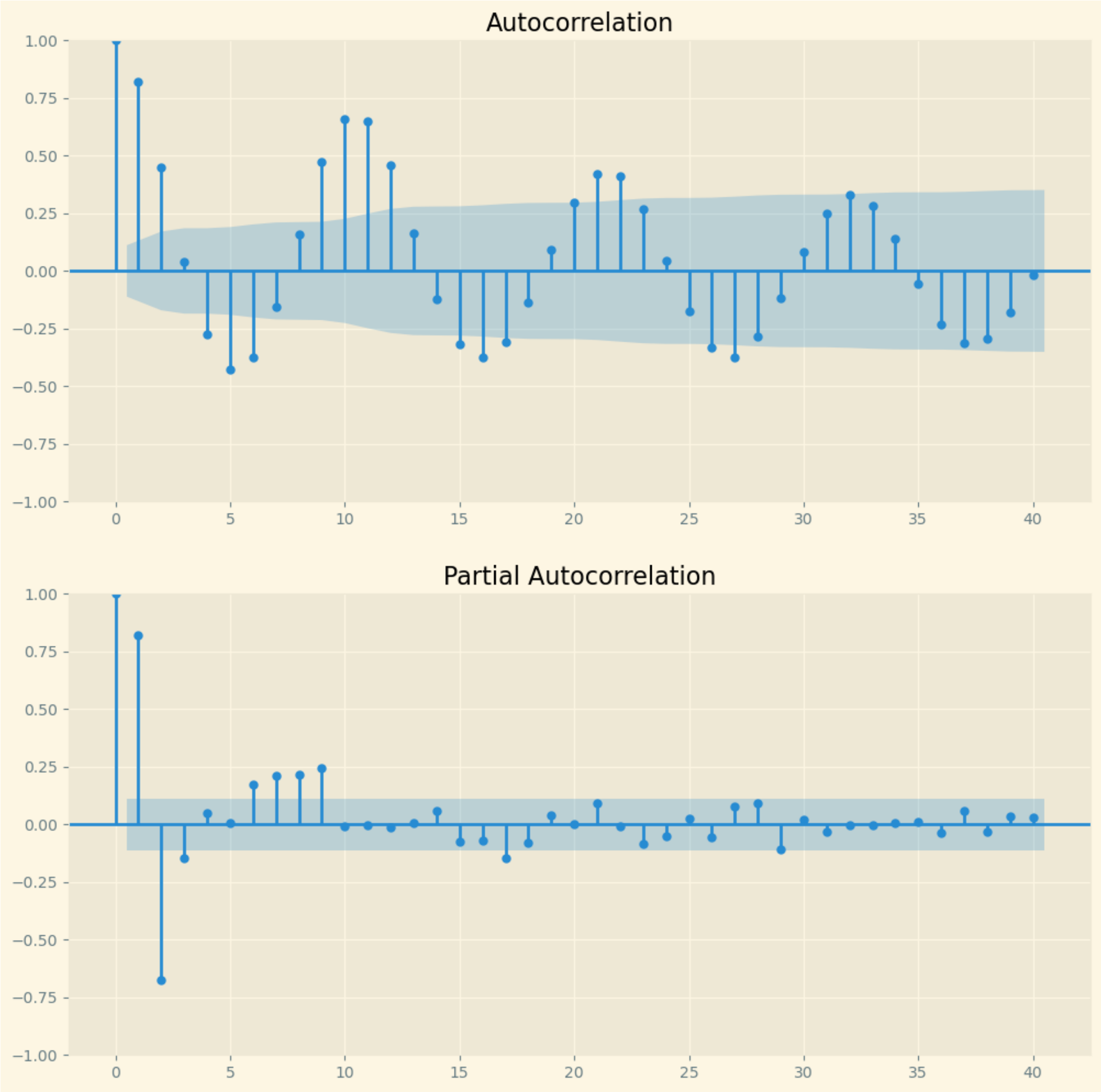
[34]:

```
<Axes: title={'center': 'ARMA'}>
```



[35]:

```
fig = plt.figure(figsize =(12,12))
ax1 = fig.add_subplot(211)
fig = sm.graphics.tsa.plot_acf(dta.values.squeeze(),lags=40, ax=ax1)
ax2 = fig.add_subplot(212)
fig = sm.graphics.tsa.plot_pacf(dta,lags=40,ax=ax2)
```



[36]:

```
arma_mod20 = ARIMA(dta, order=(2, 0, 0)).fit()
print(arma_mod20.params)
```

```
const       49.746198
ar.L1        1.390633
ar.L2      -0.688573
sigma2    274.727182
dtype: float64
```

[37]:

```
arma_mod30 = ARIMA(dta, order=(3, 0, 0)).fit()
print(arma_mod20.aic, arma_mod20.bic, arma_mod20.hqic)
```

```
2622.637093301418 2637.570458409009 2628.607481146664
```

[38]:

```
print(arma_mod30.params)
```

```
const      49.751911
ar.L1       1.300818
ar.L2      -0.508102
ar.L3      -0.129644
sigma2    270.101139
dtype: float64
```

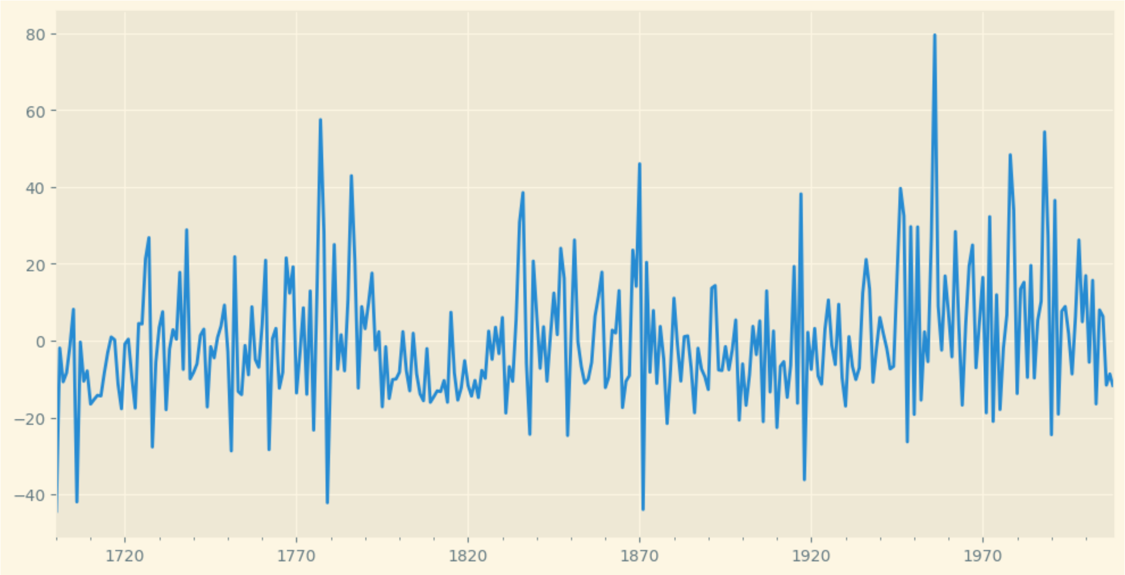
[39]:

```
print(arma_mod30.aic, arma_mod30.bic, arma_mod30.hqic)
```

```
2619.4036292456613 2638.07033563015 2626.8666140522187
```

[61]:

```
fig = plt.figure(figsize=(12,6))
ax = fig.add_subplot(111)
ax = arma_mod30.resid.plot(ax=ax)
```



[62]:

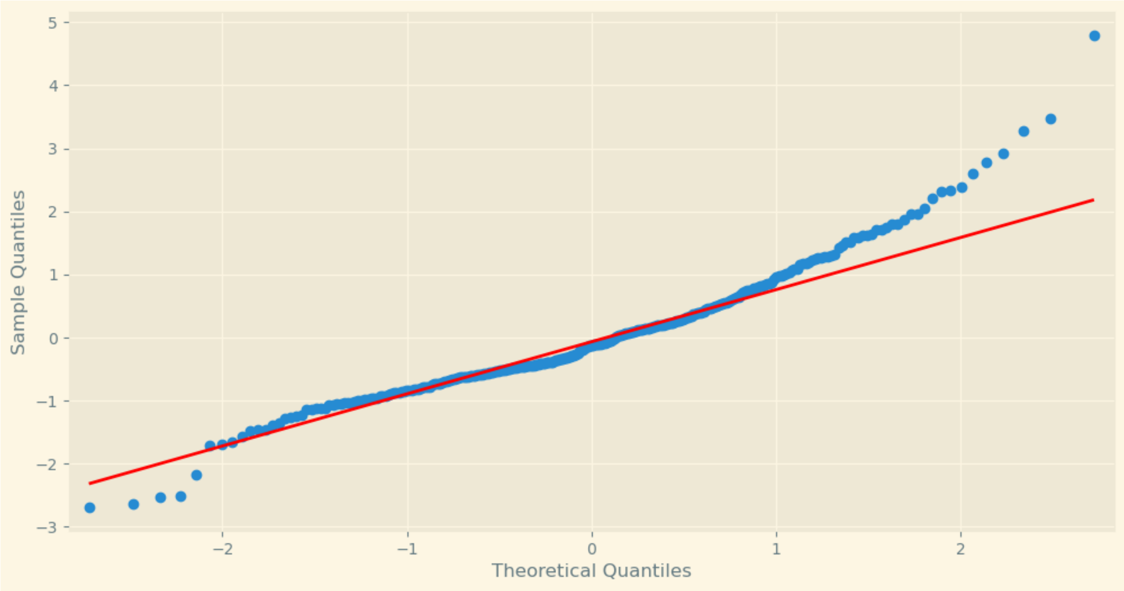
```
resid = arma_mod30.resid
```

[63]:

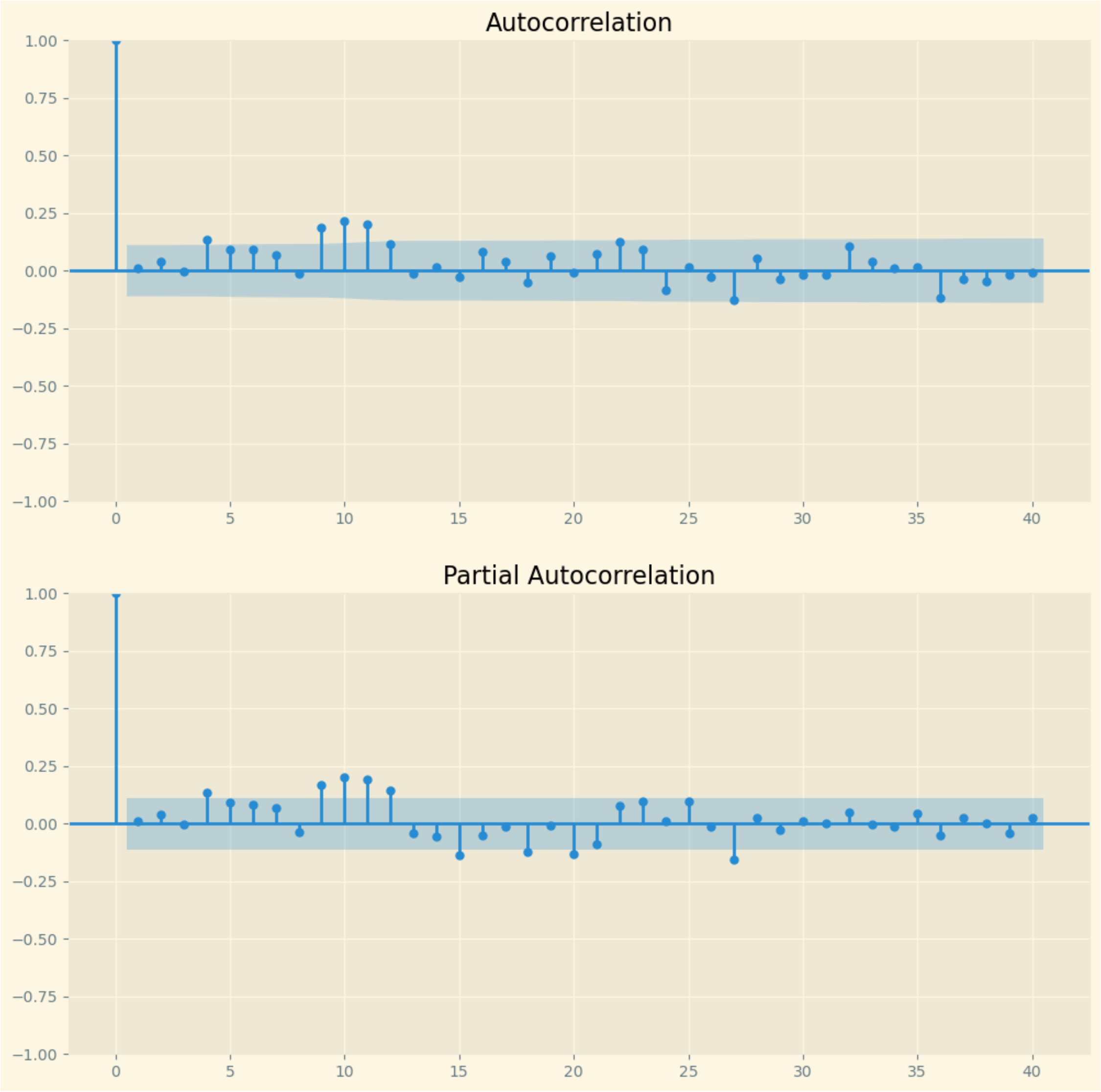
```
stats.normaltest(resid)
```

```
[63]: NormaltestResult(statistic=49.84393220546791, pvalue=1.5015079756277692e-11)
```

```
[64]: fig = plt.figure(figsize=(12, 6))
      ax = fig.add_subplot(111)
      fig = qqplot(resid, line="q", ax=ax, fit=True)
```



```
[66]: fig = plt.figure(figsize=(12, 12))
      ax1 = fig.add_subplot(211)
      fig = sm.graphics.tsa.plot_acf(resid.values.squeeze(), lags=40, ax=ax1)
      ax2 = fig.add_subplot(212)
      fig = sm.graphics.tsa.plot_pacf(resid, lags=40, ax=ax2)
```



```
[67]: r,q,p = sm.tsa.acf(resid.values.squeeze(), fft=True, qstat =True)
      data = np.c_[np.arange(1,25),r[1:],q,p]
```

```
[68]: table = pd.DataFrame(data, columns=["lag","AC", "Q", "Prob(>Q)"])
      print(table.set_index("lag"))
```

```
            AC          Q      Prob(>Q)
lag
1.0   0.009170   0.026239  8.713184e-01
2.0   0.041793   0.572982  7.508939e-01
3.0  -0.001338   0.573544  9.024612e-01
4.0   0.136086   6.408642  1.706385e-01
5.0   0.092465   9.111351  1.047043e-01
```

```
6.0   0.091947  11.792661  6.675737e-02
7.0   0.068747  13.296552  6.520425e-02
8.0  -0.015022  13.368601  9.978086e-02
9.0   0.187590  24.641072  3.394963e-03
10.0  0.213715  39.320758  2.230588e-05
11.0  0.201079  52.359565  2.346490e-07
12.0  0.117180  56.802479  8.580351e-08
13.0 -0.014057  56.866630  1.895209e-07
14.0  0.015398  56.943864  4.000370e-07
15.0 -0.024969  57.147642  7.746546e-07
16.0  0.080916  59.295052  6.876728e-07
17.0  0.041138  59.852008  1.111674e-06
18.0 -0.052022  60.745723  1.549418e-06
19.0  0.062496  62.040010  1.832778e-06
20.0 -0.010303  62.075305  3.383285e-06
21.0  0.074453  63.924941  3.195540e-06
22.0  0.124954  69.152954  8.984238e-07
23.0  0.093162  72.069214  5.803579e-07
24.0 -0.082152  74.344911  4.716006e-07
```

[69]:

```python
predict_sunspots = arma_mod30.predict("1990", "2012", dynamic=True)
print(predict_sunspots)
```

```
1990-12-31    167.048337
1991-12-31    140.995022
1992-12-31     94.862115
1993-12-31     46.864439
1994-12-31     11.246106
1995-12-31     -4.718265
1996-12-31     -1.164628
1997-12-31     16.187246
1998-12-31     39.022948
1999-12-31     59.450799
2000-12-31     72.171269
2001-12-31     75.378329
2002-12-31     70.438480
2003-12-31     60.733987
2004-12-31     50.204383
2005-12-31     42.078584
2006-12-31     38.116648
2007-12-31     38.456730
2008-12-31     41.965644
2009-12-31     46.870948
2010-12-31     51.424877
2011-12-31     54.401403
2012-12-31     55.323515
Freq: YE-DEC, Name: predicted_mean, dtype: float64
```

[70]:

```python
def mean_forecast_err(y, yhat):
    return y.sub(yhat).mean()
```

[71]:

```python
mean_forecast_err(dta.SUNACTIVITY, predict_sunspots)
```

[71]:

```
5.634832989728748
```

[ ]:

```python

```