

```
1 from dateutil.parser import parse
2 import matplotlib as mpl
3 import matplotlib.pyplot as plt
4 import seaborn as sns
5 import numpy as np
6 import pandas as pd
7 plt.rcParams.update({'figure.figsize': (10, 7), 'figure.dpi': 120})
8
9 # Import as Dataframe
10 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'])
11 df.head()
```

↗

	date	value
0	1991-07-01	3.526591
1	1991-08-01	3.180891
2	1991-09-01	3.252221
3	1991-10-01	3.611003
4	1991-11-01	3.565869

```
1 ser = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'], index_col='date')
2 ser.head()
```

	value
date	
1991-07-01	3.526591
1991-08-01	3.180891
1991-09-01	3.252221
1991-10-01	3.611003
1991-11-01	3.565869

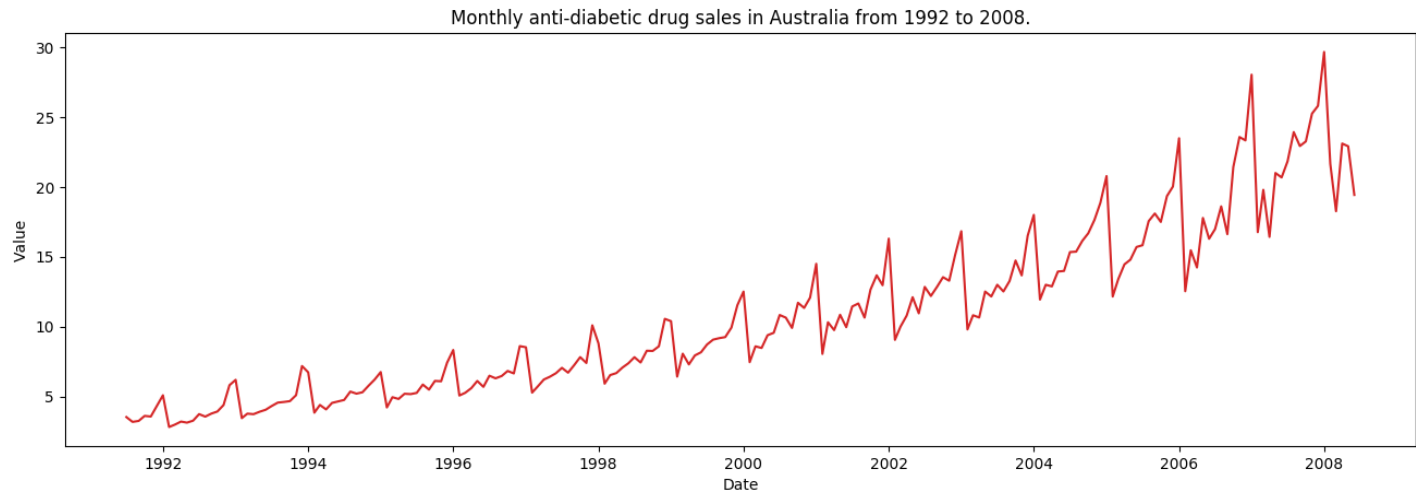
```
1 # dataset source: https://github.com/rouseguy
2 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/MarketArrivals.csv')
3 df = df.loc[df.market=='MUMBAI', :]
4 df.head()
```

	market	month	year	quantity	priceMin	priceMax	priceMod	state	city	date
6654	MUMBAI	January	2004	267100	719	971	849	MS	MUMBAI	January-2004
6655	MUMBAI	January	2005	275845	261	513	387	MS	MUMBAI	January-2005
6656	MUMBAI	January	2006	228000	315	488	402	MS	MUMBAI	January-2006
6657	MUMBAI	January	2007	205200	866	1136	997	MS	MUMBAI	January-2007
6658	MUMBAI	January	2008	267550	348	550	448	MS	MUMBAI	January-2008

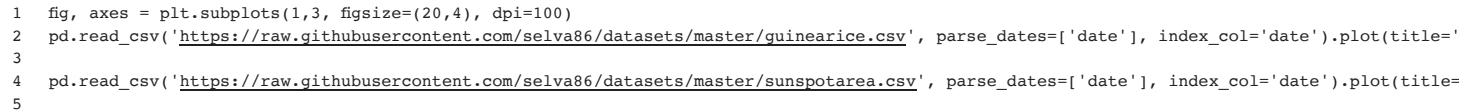
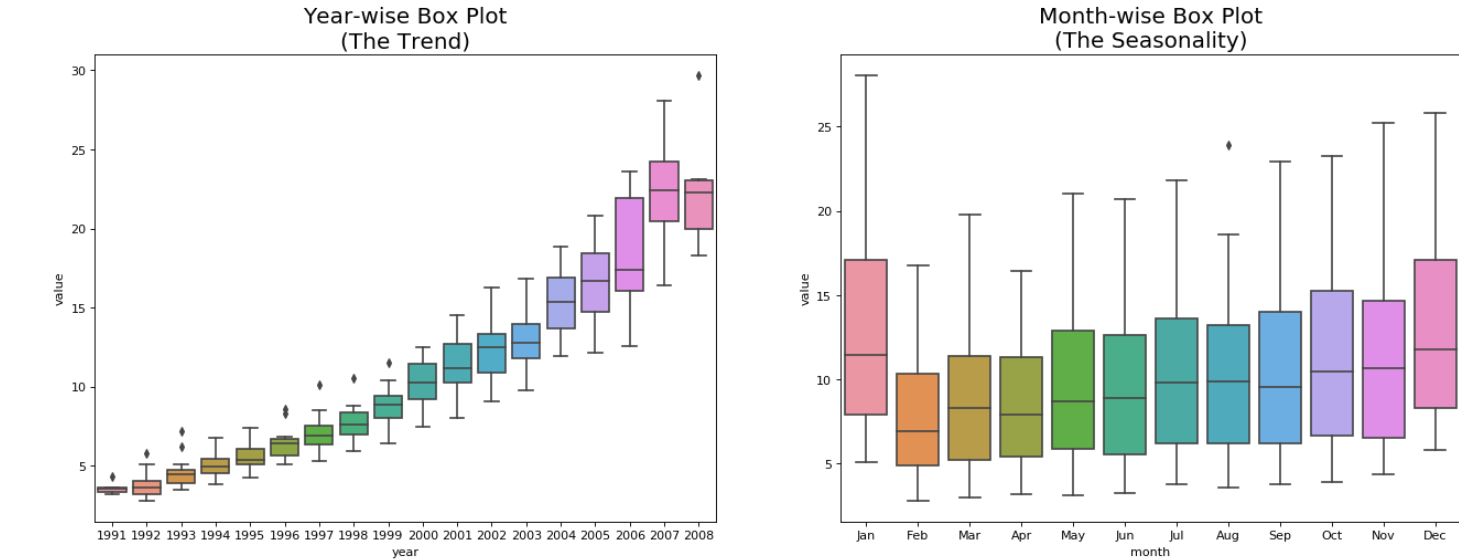
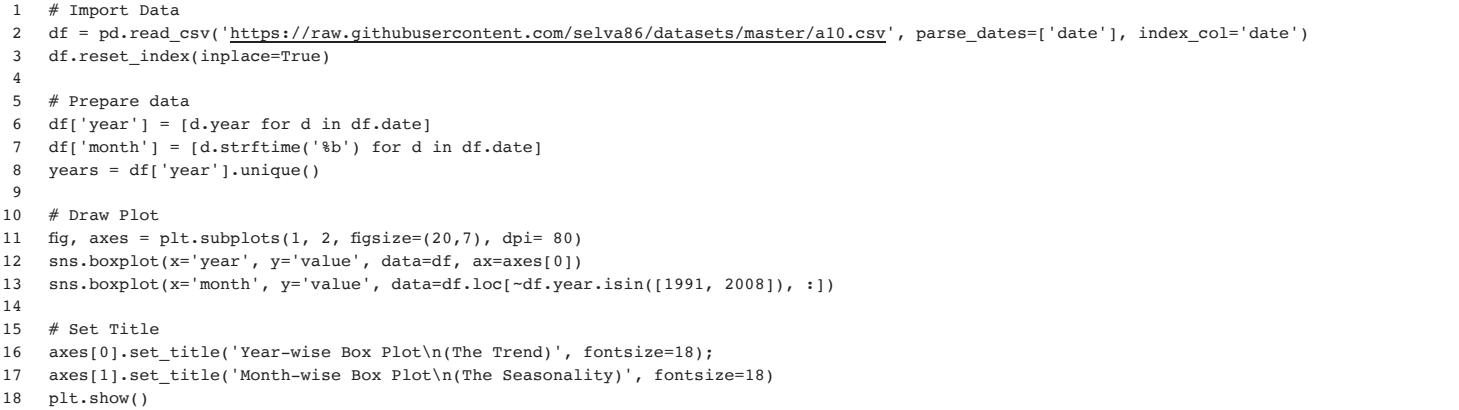
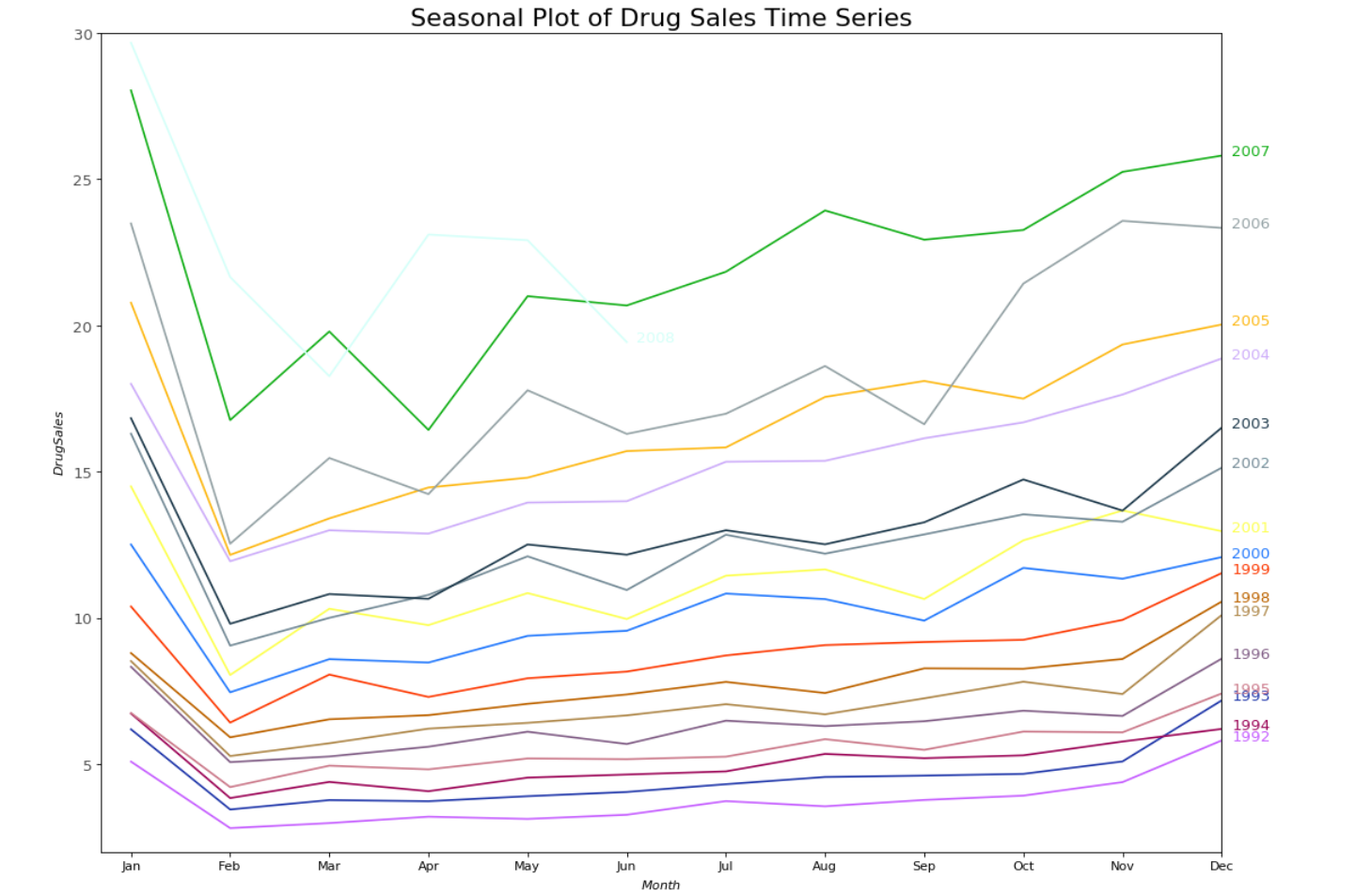
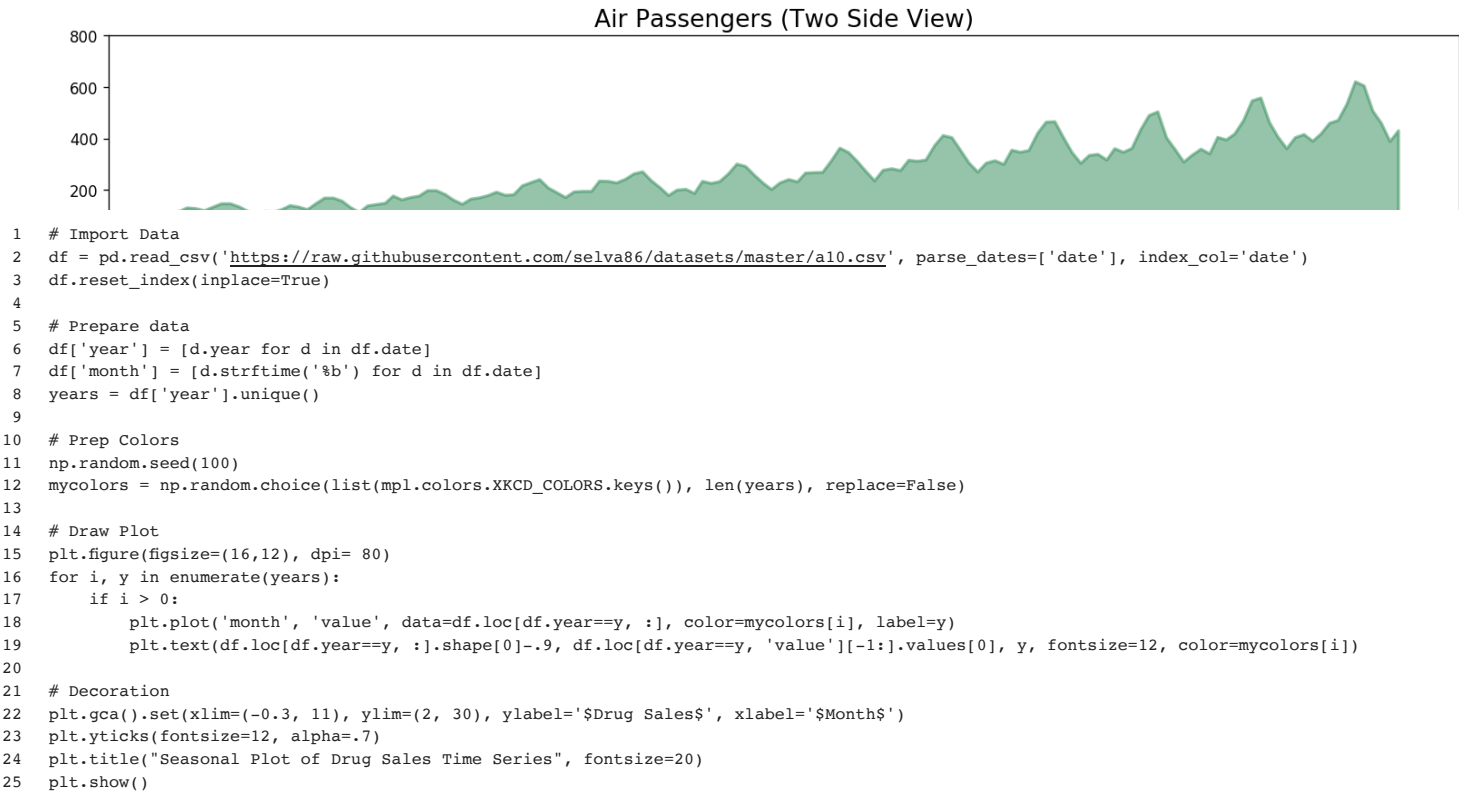
```
1 # Time series data source: fpp pacakge in R.
2 import matplotlib.pyplot as plt
3 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'], index_col='date')
4
5 # Draw Plot
6 def plot_df(df, x, y, title="", xlabel='Date', ylabel='Value', dpi=100):
7     plt.figure(figsize=(16,5), dpi=dpi)
8     plt.plot(x, y, color='tab:red')
9     plt.gca().set(title=title, xlabel=xlabel, ylabel=ylabel)
10    plt.show()
11
12 plot_df(df, x=df.index, y=df.value, title='Monthly anti-diabetic drug sales in Australia from 1992 to 2008.')
```

/usr/local/lib/python3.6/dist-packages/pandas/plotting/_converter.py:129: FutureWarning: Using an implicitly registered datetime converter for a matplotlib plotting method. The converter was registere

```
To register the converters:
>>> from pandas.plotting import register_matplotlib_converters
>>> register_matplotlib_converters()
warnings.warn(msg, FutureWarning)
```



```
1 # Import data
2 df = pd.read_csv('/content/AirPassengers.csv', parse_dates=['Month'])
3 x = df['Month'].values
4 y1 = df['#Passengers']
5
6 # Plot
7 fig, ax = plt.subplots(1, 1, figsize=(16,5), dpi= 120)
8 plt.fill_between(x, y1=y1, y2=-y1, alpha=0.5, linewidth=2, color='seagreen')
9 plt.ylim(-800, 800)
10 plt.title('Air Passengers (Two Side View)', fontsize=16)
11 plt.hlines(y=0, xmin=np.min(df.Month), xmax=np.max(df.Month), linewidth=.5)
12 plt.show()
```

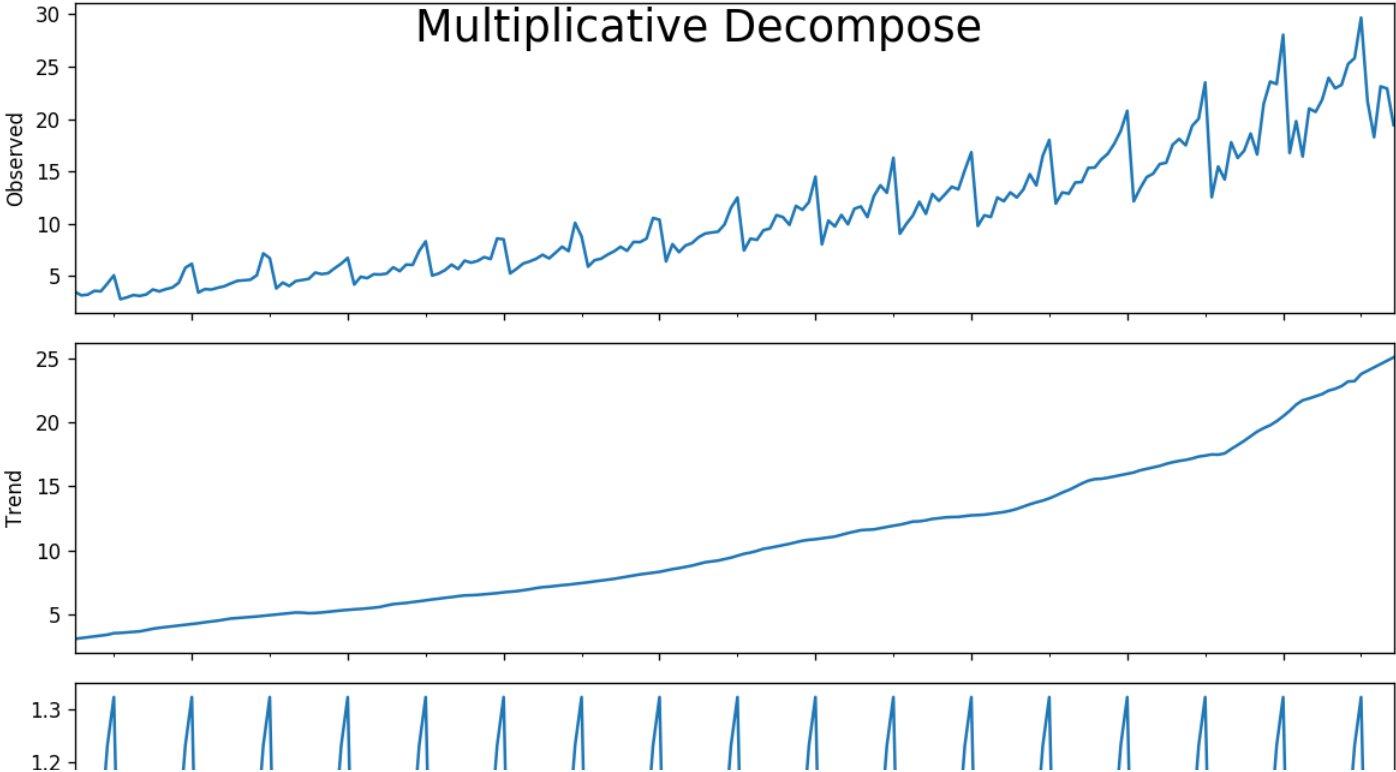


```
6 pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/AirPassengers.csv', parse_dates=['date'], index_col='date').plot(title='Trend and Seasonality')

<matplotlib.axes._subplots.AxesSubplot at 0x7fb130d222b0>

Trend Only
Seasonality Only
Trend and Seasonality

1 from statsmodels.tsa.seasonal import seasonal_decompose
2 from dateutil.parser import parse
3
4 # Import Data
5 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'], index_col='date')
6
7 # Multiplicative Decomposition
8 result_mul = seasonal_decompose(df['value'], model='multiplicative', extrapolate_trend='freq')
9
10 # Additive Decomposition
11 result_add = seasonal_decompose(df['value'], model='additive', extrapolate_trend='freq')
12
13 # Plot
14 plt.rcParams.update({'figure.figsize': (10,10)})
15 result_mul.plot().suptitle('Multiplicative Decompose', fontsize=22)
16 result_add.plot().suptitle('Additive Decompose', fontsize=22)
17 plt.show()
18
```



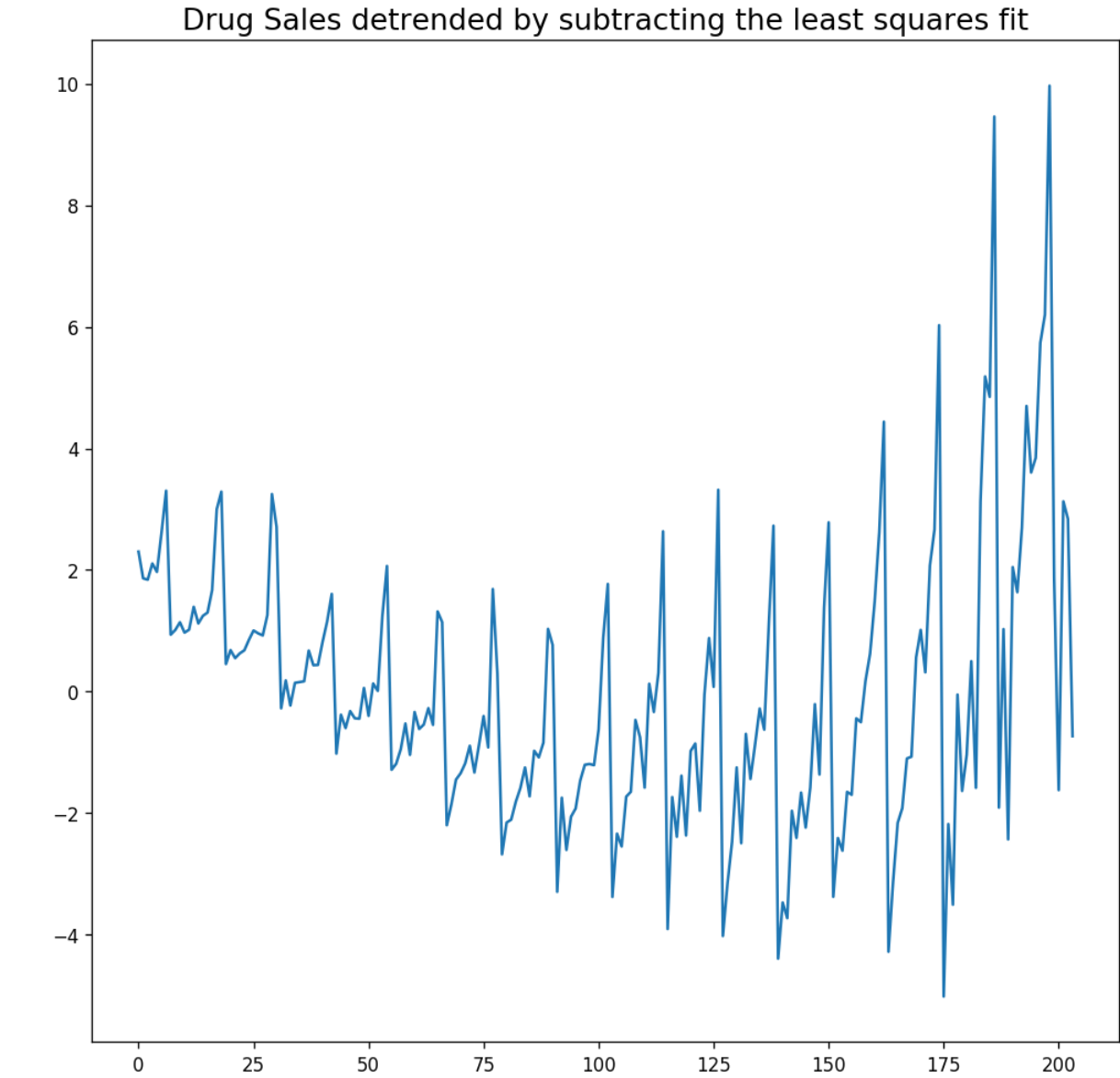
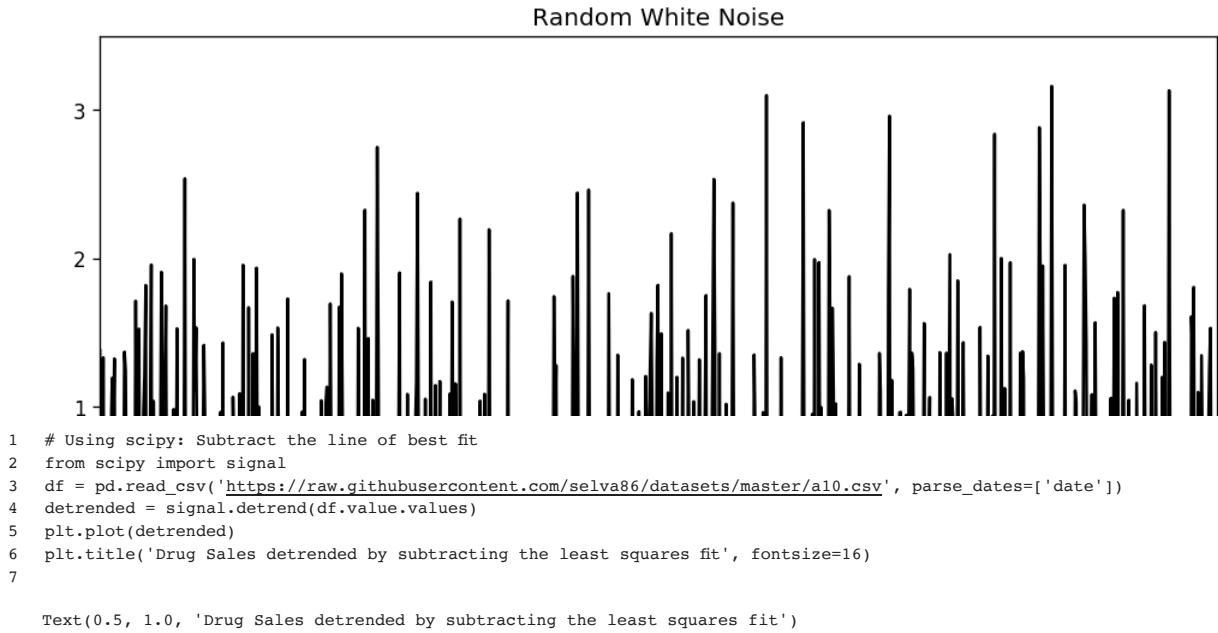
```
1 # Extract the Components ----
2 # Actual Values = Product of (Seasonal * Trend * Resid)
3 df_reconstructed = pd.concat([result_mul.seasonal, result_mul.trend, result_mul.resid, result_mul.observed], axis=1)
4 df_reconstructed.columns = ['seas', 'trend', 'resid', 'actual_values']
5 df_reconstructed.head()
```

	seas	trend	resid	actual_values
1991-07-01	0.987845	3.060085	1.166629	3.526591
1991-08-01	0.990481	3.124765	1.027745	3.180891
1991-09-01	0.987476	3.189445	1.032615	3.252221
1991-10-01	1.048329	3.254125	1.058513	3.611003
1991-11-01	1.074527	3.318805	0.999923	3.565869

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```

<matplotlib.axes._subplots.AxesSubplot at 0x7fb131003c18>



```
1 # Using statmodels: Subtracting the Trend Component.
2 from statsmodels.tsa.seasonal import seasonal_decompose
3 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'], index_col='date')
4 result_mul = seasonal_decompose(df['value'], model='multiplicative', extrapolate_trend='freq')
5 detrended = df.value.values - result_mul.trend
6 plt.plot(detrended)
7 plt.title('Drug Sales detrended by subtracting the trend component', fontsize=16)
```

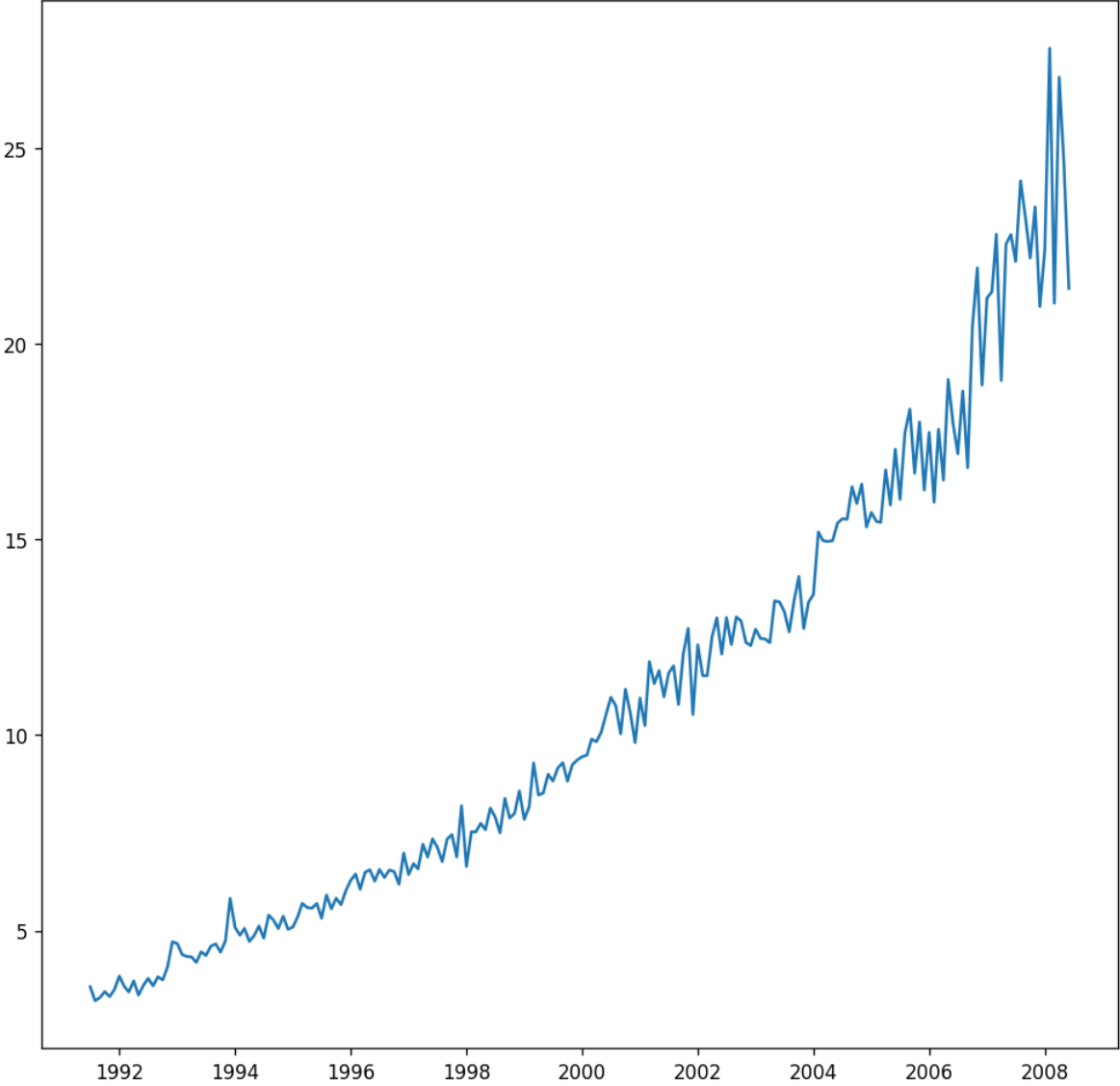
Text(0.5, 1.0, 'Drug Sales detrended by subtracting the trend component')

Drug Sales detrended by subtracting the trend component



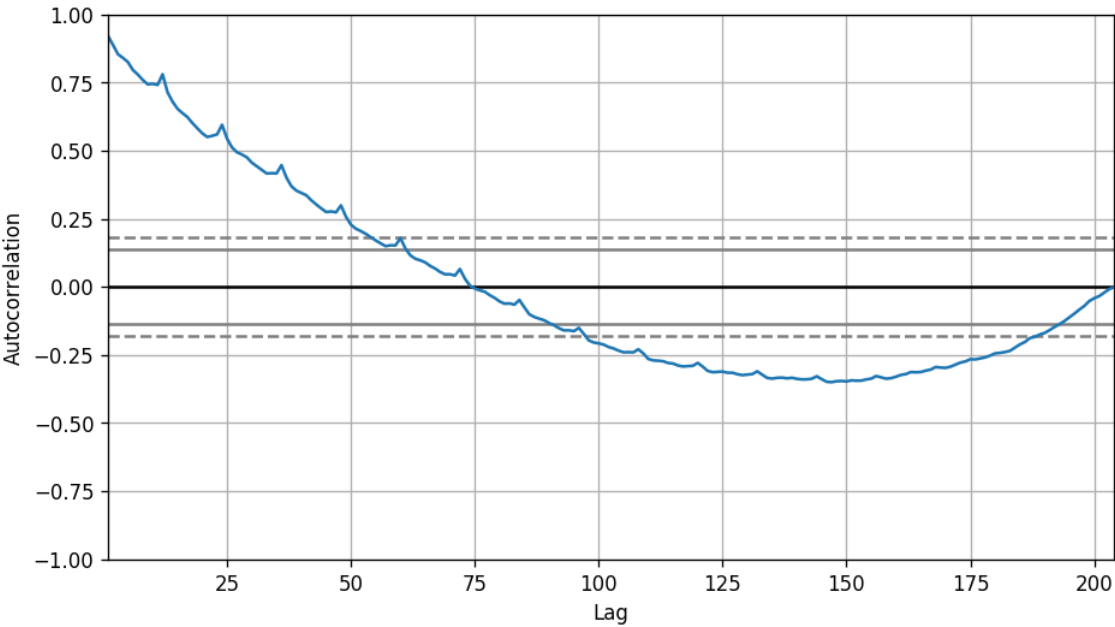
```
1 # Subtracting the Trend Component.
2 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'], index_col='date')
3
4 # Time Series Decomposition
5 result_mul = seasonal_decompose(df['value'], model='multiplicative', extrapolate_trend='freq')
6
7 # Deseasonalize
8 deseasonalized = df.value.values / result_mul.seasonal
9
10 # Plot
11 plt.plot(deseasonalized)
12 plt.title('Drug Sales Deseasonalized', fontsize=16)
13 plt.plot()
[]
```

Drug Sales Deseasonalized

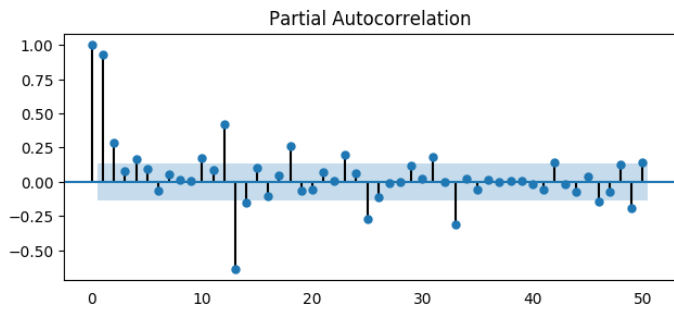
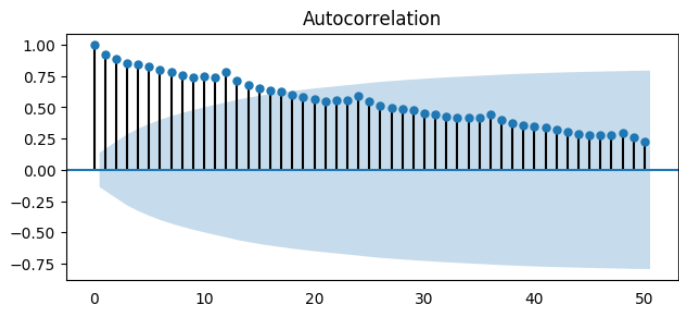
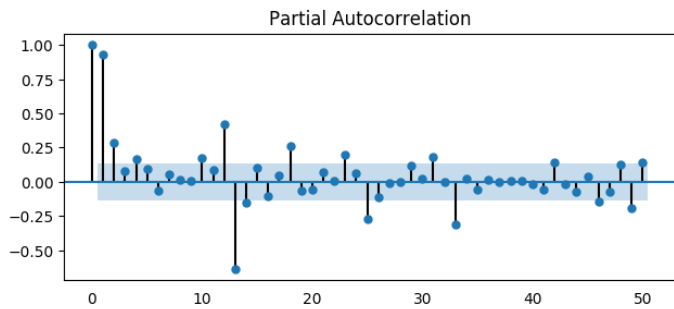
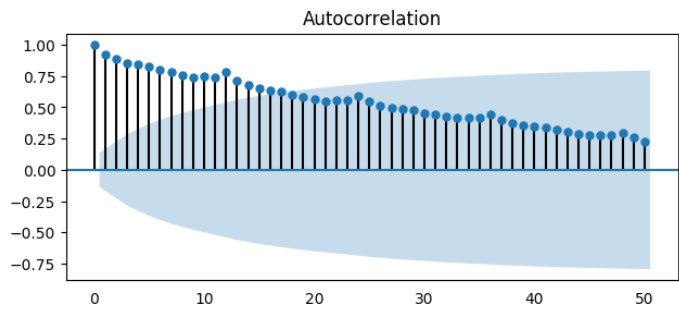


```
1 from pandas.plotting import autocorrelation_plot
2 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv')
3
4 # Draw Plot
5 plt.rcParams.update({'figure.figsize':(9,5), 'figure.dpi':120})
6 autocorrelation_plot(df.value.tolist())
```

<matplotlib.axes._subplots.AxesSubplot at 0x7fb12ddefba8>



```
1 from statsmodels.tsa.stattools import acf, pacf
2 from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
3
4 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv')
5
6 # Calculate ACF and PACF upto 50 lags
7 # acf_50 = acf(df.value, nlags=50)
8 # pacf_50 = pacf(df.value, nlags=50)
9
10 # Draw Plot
11 fig, axes = plt.subplots(1,2,figsize=(16,3), dpi= 100)
12 plot_acf(df.value.tolist(), lags=50, ax=axes[0])
13 plot_pacf(df.value.tolist(), lags=50, ax=axes[1])
```

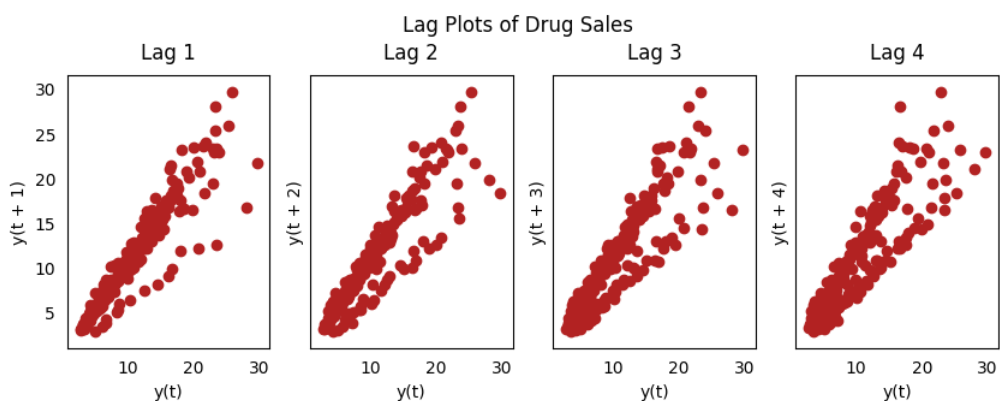
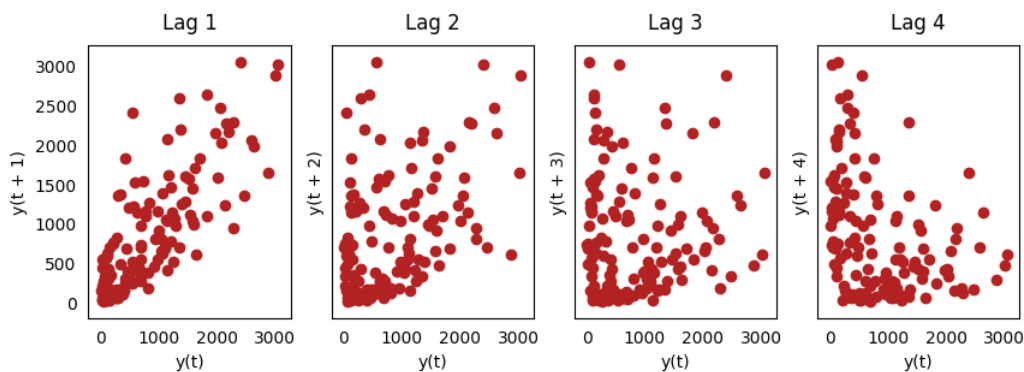


```

1  from pandas.plotting import lag_plot
2  plt.rcParams.update({'ytick.left' : False, 'axes.titlepad':10})
3
4  # Import
5  ss = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/sunspotarea.csv')
6  a10 = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv')
7
8  # Plot
9  fig, axes = plt.subplots(1, 4, figsize=(10,3), sharex=True, sharey=True, dpi=100)
10 for i, ax in enumerate(axes.flatten()[:4]):
11     lag_plot(ss.value, lag=i+1, ax=ax, c='firebrick')
12     ax.set_title('Lag ' + str(i+1))
13
14 fig.suptitle('Lag Plots of Sun Spots Area \n(Points get wide and scattered with increasing lag -> lesser correlation)\n', y=1.15)
15
16 fig, axes = plt.subplots(1, 4, figsize=(10,3), sharex=True, sharey=True, dpi=100)
17 for i, ax in enumerate(axes.flatten()[:4]):
18     lag_plot(a10.value, lag=i+1, ax=ax, c='firebrick')
19     ax.set_title('Lag ' + str(i+1))
20
21 fig.suptitle('Lag Plots of Drug Sales', y=1.05)
22 plt.show()

```

Lag Plots of Sun Spots Area
(Points get wide and scattered with increasing lag -> lesser correlation)



```

1  # https://en.wikipedia.org/wiki/Approximate_entropy
2  ss = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/sunspotarea.csv')
3  a10 = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv')
4  rand_small = np.random.randint(0, 100, size=36)
5  rand_big = np.random.randint(0, 100, size=136)
6
7  def ApEn(U, m, r):
8      """Compute Aproximate entropy"""
9      def _maxdist(x_i, x_j):
10         return max([abs(ua - va) for ua, va in zip(x_i, x_j)])
11
12     def _phi(m):
13         x = [[U[j] for j in range(i, i + m - 1 + 1)] for i in range(N - m + 1)]
14         C = [len([1 for x_j in x if _maxdist(x_i, x_j) <= r]) / (N - m + 1.0) for x_i in x]
15         return (N - m + 1.0)**(-1) * sum(np.log(C))
16
17     N = len(U)
18     return abs(_phi(m+1) - _phi(m))
19
20 print(ApEn(ss.value, m=2, r=0.2*np.std(ss.value))) # 0.651
21 print(ApEn(a10.value, m=2, r=0.2*np.std(a10.value))) # 0.537
22 print(ApEn(rand_small, m=2, r=0.2*np.std(rand_small))) # 0.143
23 print(ApEn(rand_big, m=2, r=0.2*np.std(rand_big))) # 0.716

```

0.6514704970333534
0.5374775224973489
0.0898376940798844
0.6725953850207098

```

1  # https://en.wikipedia.org/wiki/Sample_entropy
2  def SampEn(U, m, r):
3      """Compute Sample entropy"""
4      def _maxdist(x_i, x_j):
5         return max([abs(ua - va) for ua, va in zip(x_i, x_j)])
6
7     def _phi(m):
8         x = [[U[j] for j in range(i, i + m - 1 + 1)] for i in range(N - m + 1)]
9         C = [len([1 for x_j in x if _maxdist(x_i, x_j) <= r]) / (N - m + 1.0) for x_i in x]
10        return (N - m + 1.0)**(-1) * sum(np.log(C))

```

```
9         C = [len([i for j in range(len(x)) if i != j and _maxdist(x[i], x[j]) <= r]) for i in range(len(x))]
10         return sum(C)
11
12     N = len(U)
13     return -np.log(_phi(m+1) / _phi(m))
14
15 print(SampEn(ss.value, m=2, r=0.2*np.std(ss.value)))      # 0.78
16 print(SampEn(a10.value, m=2, r=0.2*np.std(a10.value)))   # 0.41
17 print(SampEn(rand_small, m=2, r=0.2*np.std(rand_small))) # 1.79
18 print(SampEn(rand_big, m=2, r=0.2*np.std(rand_big)))     # 2.42

```

0.7853311366380039
0.41887013457621214
inf
2.2721258855093374
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: RuntimeWarning: divide by zero encountered in log
if sys.path[0] == '':

```
1 from statsmodels.tsa.stattools import grangercausalitytests
2 df = pd.read_csv('https://raw.githubusercontent.com/selva86/datasets/master/a10.csv', parse_dates=['date'])
3 df['month'] = df.date.dt.month
4 grangercausalitytests(df[['value', 'month']], maxlag=2)
```

```
Granger Causality
number of lags (no zero) 1
ssr based F test:          F=54.7797 , p=0.0000 , df_denom=200, df_num=1
ssr based chi2 test:      chi2=55.6014 , p=0.0000 , df=1
likelihood ratio test:    chi2=49.1426 , p=0.0000 , df=1
parameter F test:         F=54.7797 , p=0.0000 , df_denom=200, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:          F=162.6989, p=0.0000 , df_denom=197, df_num=2
ssr based chi2 test:      chi2=333.6567, p=0.0000 , df=2
likelihood ratio test:    chi2=196.9956, p=0.0000 , df=2
parameter F test:         F=162.6989, p=0.0000 , df_denom=197, df_num=2
{1: ({'lrtest': (49.14260233004984, 2.38014300604565e-12, 1),
      'params_ftest': (54.77967483557335, 3.661425871353419e-12, 200.0, 1.0),
      'ssr_chi2test': (55.6013699581072, 8.876175235021508e-14, 1),
      'ssr_ftest': (54.7796748355736, 3.661425871353102e-12, 200.0, 1)},
    [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fb12bcd05c0>,
     <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fb12bcd06a0>,
     array([[0., 1., 0.]])]),
 2: ({'lrtest': (196.99559277182186, 1.6709003499116746e-43, 2),
      'params_ftest': (162.69891799873227, 1.9133235086857535e-42, 197.0, 2.0),
      'ssr_chi2test': (333.65666432227346, 3.5267600881280646e-73, 2),
      'ssr_ftest': (162.69891799873236, 1.9133235086857257e-42, 197.0, 2)},
    [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fb12bdf22b0>,
     <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fb12bdf2eb8>,
     array([[0., 0., 1., 0., 0.],
            [0., 0., 0., 1., 0.]])])}]
```