Stationarity in Time Series

May 8, 2020

1 Stationarity in Time Series (TS)

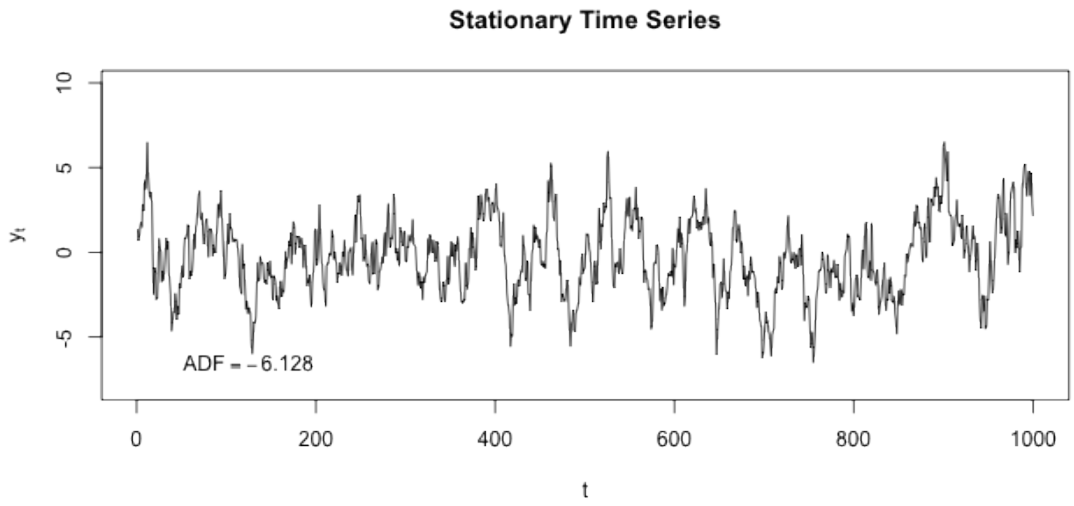
This notebook is with reference to the task:

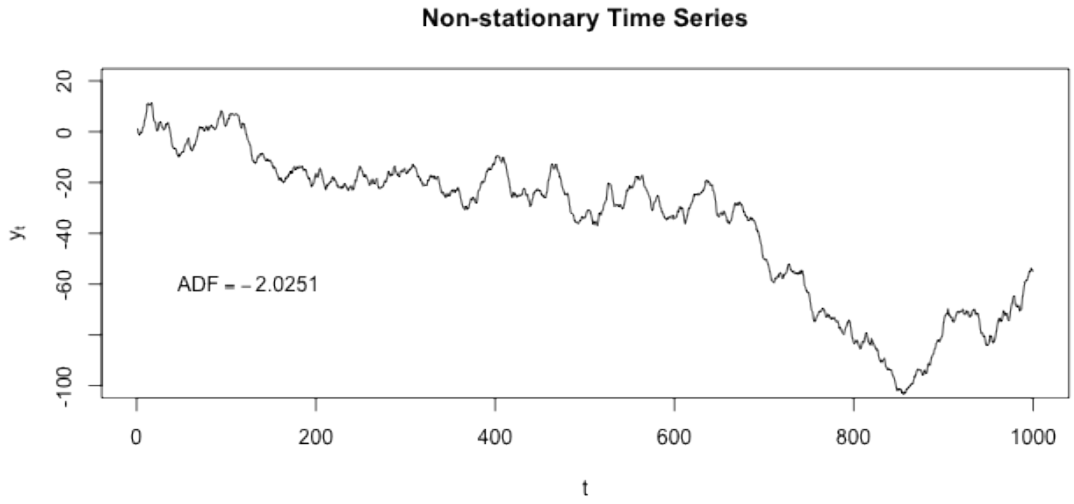
> DS4: How can a time-series data be declared as stationery?

1.0.1 Why do we need stationarity in Time Series Analysis (TSA)?

1. Stationary processes are easier to analyze
2. Assumed by most of the TS algorithms

Example of stationary and non-stationary TS:





1.1 Weak-form stationarity

- Stationarity implies that taking consecutive samples of data with the same size should have identical covariances regardless of the starting point.

1.2 Strict stationarity

- Stationarity implies samples of identical size have identical distribution.
- very restrictive form hence hardly observed

1.3 Conditions to be stationary

In order to be weak form stationary, the time-series data must hold the following conditions:

1. Constant mean
2. Constant variance
3. Constant covariance between periods of identical distance

1.4 ADF Testing

- Augmented Dicky Fuller test (ADF-test)
- hypothesis testing for stationarity
- where:
  - H0: Time series is not stationary
  - H1: Time series is stationary

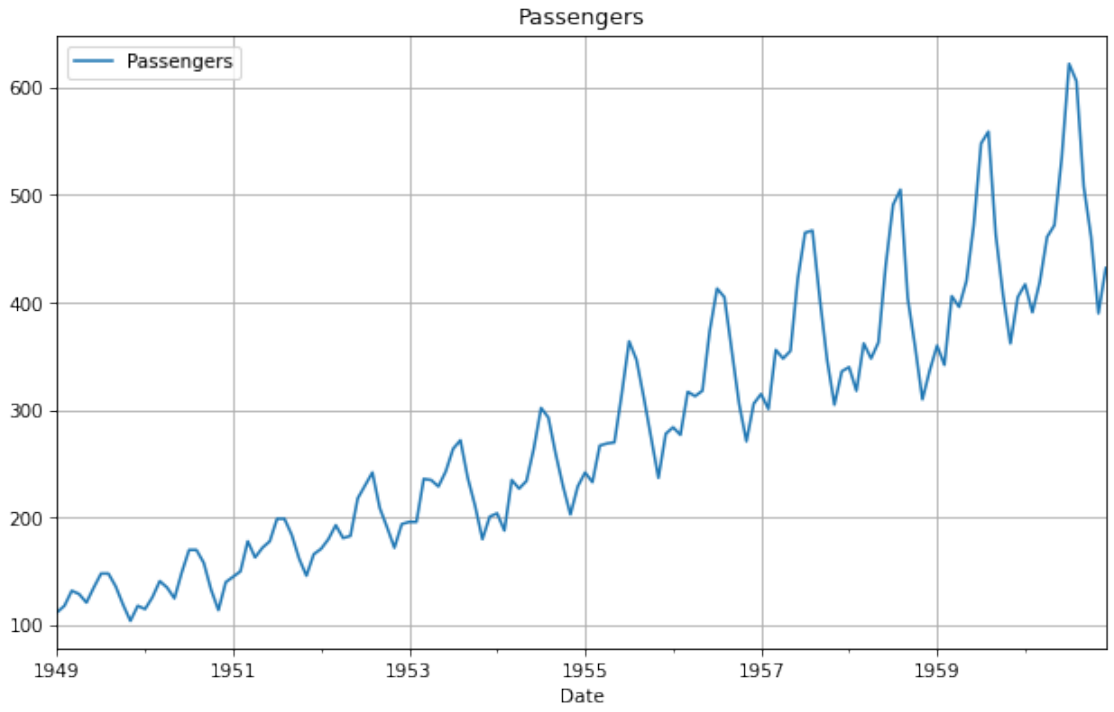
[1]:
```
import numpy as np
import pandas as pd
import statsmodels.tsa.stattools as sts
import matplotlib.pyplot as plt
```

[2]:
```
df = pd.read_csv('data/airline-passengers.csv', index_col = 'Month',␣
 ↪parse_dates = True)
df.head(5)
```

[2]:
```
            Passengers
Month
1949-01-01         112
1949-02-01         118
1949-03-01         132
1949-04-01         129
1949-05-01         121
```

[3]:
```
# displaying plot

fig = plt.figure(figsize=(10, 6), dpi=75)
df.plot(ax = plt.gca())
plt.title('Passengers')
plt.xlabel('Date')
plt.grid()
plt.show()
```



We'll perform this ADF Test using a time series with a differentiation order determined using the function below:

[4]:
```
# alpha is significance level
def make_stationary(time_series, alpha = 0.05, column_name = None):
    if column_name is None:
        column_name = time_series.columns[0]

    p_values = []

    # testing differentiation orders from 1 to 10
    for i in range(1, 10):
        test = sts.adfuller(time_series[column_name].diff(i).dropna())
        p_values.append((i, test[1]))

    # keeping only values where p-value is less than alpha
    significant = [p for p in p_values if p[1] < alpha]

    # sort and keep best diff
    diff_order = sorted(significant)[0][0]

    # make stationary time series out of that diff
    stationary_series = time_series[column_name].diff(diff_order).dropna()
```

```
    # return differentiation order and time series
    return diff_order, stationary_series
```

[5]:
```
diff_order, stationary_series = make_stationary(df)
```

[6]:
```
print(diff_order)
```

```
2
```

[7]:
```
sts.adfuller(stationary_series)
```

[7]:
```
(-2.9616951355554217,
 0.03862975767698862,
 11,
 130,
 {'1%': -3.4816817173418295,
  '5%': -2.8840418343195267,
  '10%': -2.578770059171598},
 985.7309222414162)
```

Since our p-value < 0.05, we can reject our null hypothesis and state the time series is stationary with a 95% confidence interval

1.5 References

1. Towardsdatascience - What is Stationarity in Time Series and why should you care