Tests for Time Series Data

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Introduction

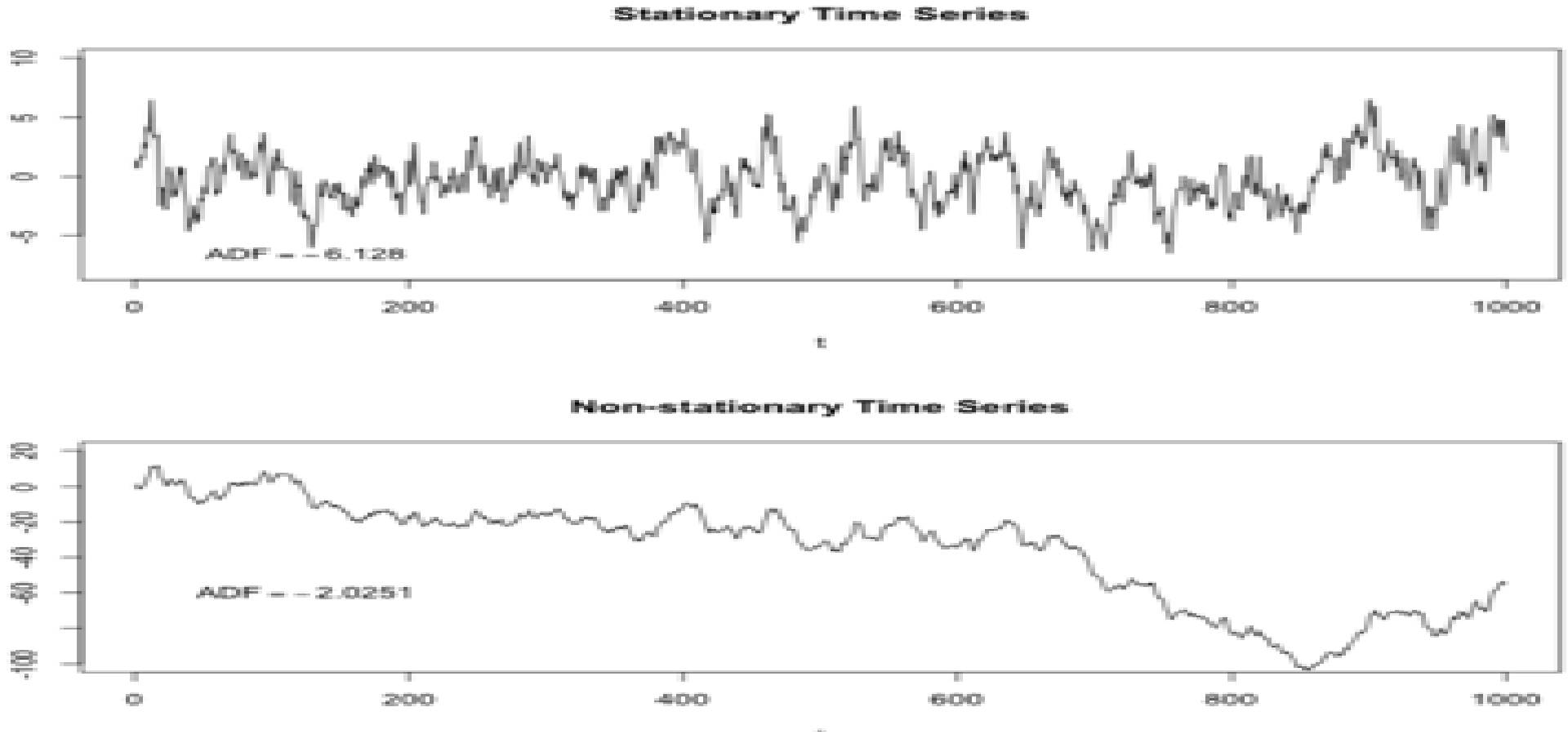
- There are several tests that are commonly used in time series analysis to assess various aspects of the data. The choice of test depends on the specific characteristics of the time series and the questions you want to answer.

1. **Augmented Dickey-Fuller (ADF) Test:** Used to test for stationarity
2. **Granger Causality Test:** Determines whether one time series can help predict another time series. Used to assess causality and directionality between variables in a multivariate time series.
3. **Johansen Test:**Tests for cointegration among multiple time series variables. Used for assessing long-term relationships between variables in a multivariate time series.

1. Stationarity Test (ADF test)

- **Definition:** **The Augmented Dickey-Fuller (ADF)** test is a statistical test used to determine whether a univariate time series is stationary or not. Stationarity is a fundamental assumption in time series analysis, as it implies that the statistical properties of the series do not change over time.
- The ADF test specifically focuses on testing for the presence of a unit root in the time series data, which is a common cause of non-stationarity.

1. Stationarity Test (ADF test)



1. Stationarity Test (ADF test)

- **Hypotheses:**

. **Null Hypothesis (*H*0):** The time series has a unit root, indicating non-stationarity.

. **Alternative Hypothesis (*Ha*):** The time series is stationary, indicating the absence of a unit root.

1. Stationarity Test (ADF test)

- **Test Procedure:**

1. Estimate the regression.
2. Compare the computed t-statistic with critical values from the Dickey-Fuller distribution to determine statistical significance.
3. If the absolute value of the computed t-statistic is greater than the critical value, reject the null hypothesis and conclude that the time series is stationary.
4. Otherwise, fail to reject the null hypothesis, indicating that the time series has a unit root and is non-stationary.

1. Stationarity Test (ADF test)

- **Example of Test Procedure: stationarity test at level**

Null Hypothesis: UNEMPLOYMENT_RATE_____ has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.441726	0.5236
Test critical values:	1% level	-4.200056	
	5% level	-3.175352	
	10% level	-2.728985	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 11

According to the table the absolute value of the computed t-statistic is less than the critical value, so, accept the null hypothesis and conclude that the time series is not stationary (or has Unit root). In this case we go to the first difference

1. Stationarity Test (ADF test)

Null Hypothesis: D(UNEMPLOYMENT_RATE____) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.004463	0.0025
Test critical values:	1% level	-4.121990	
	5% level	-3.144920	
	10% level	-2.713751	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 12

According to the table the absolute value of the computed t-statistic is Greater than the critical value, so, reject the null hypothesis and conclude that the time series is stationary.

2. Cointegration test

- **Definition:** **Cointegration tests** are used to determine whether there exists a long-run relationship between two or more non-stationary time series variables.
- Before conducting cointegration tests, it's essential to check whether each individual time series is stationary or non-stationary.
- Johansen’s test comes in two main forms, i.e., Trace tests and Maximum Eigenvalue test. In the context of cointegration tests, the terms "K" and "K_0" are related to the number of cointegrating relationships in a set of time series data.

2. Cointegration test

- Hypothesis
- $\begin{cases} H_0: there\ is\ no\ Cointegration\ (No\ Long-run\ relationship\ between\ variables \\ H_a: there\ is\ a\ cointegration\ (there\ is\ a\ long-run\ relationship\ between\ variables \end{cases}$
- **Trace test**
- H_0: K = K_0
- H_a: K > K_0
- **Maximum Eigenvalue test**
- H_0: K = K_0
- H_a: K = K_0 + 1

K_0 could be ‘ None, At most 1, At most 2……., K mean the number of coitegration relationship

2. Cointegration test

Date: 04/20/24 Time: 11:37
Sample (adjusted): 2012 2023
Included observations: 12 after adjustments
Trend assumption: Linear deterministic trend
Series: UNEMPLOYMENT_RATE_____ GDP_GROWTH_RATE_____ INFL
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.885172	43.22112	29.79707	0.0008
At most 1 *	0.595628	17.24925	15.49471	0.0269
At most 2 *	0.412581	6.384206	3.841465	0.0115

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to the results, trace statistic value related to the hypothesis of (K= None, K=at most 1 and K=at most 2) long run relationship is greater than the critical value at 5% level of significance so, we reject the null hypothesis of (this is confirmed by the p-value too), indicates the existence of three long relationship between the variables.

2. Cointegration test

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.885172	25.97187	21.13162	0.0096
At most 1	0.595628	10.86504	14.26460	0.1611
At most 2 *	0.412581	6.384206	3.841465	0.0115

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to the results, Max-Eigen statistic related to the hypothesis of K= None long run relationship is greater than the critical value at 5% level of significance so, we reject the null hypothesis of no relationship (this is confirmed by the p-value too), indicates the existence of one long run relationship between the variables.

2. Cointegration test

Dependent Variable: UNEMPLOYMENT_RATE____
Method: Fully Modified Least Squares (FMOLS)
Date: 04/20/24 Time: 11:42
Sample (adjusted): 2011 2023
Included observations: 13 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_GROWTH_RATE___	-2.065876	0.506189	-4.081237	0.0022
INFLATION_RATE____	1.688013	0.434823	3.882073	0.0030
C	6.222981	1.574794	3.951616	0.0027

R-squared	0.360759	Mean dependent var	4.446154
Adjusted R-squared	0.232910	S.D. dependent var	0.989626
S.E. of regression	0.866750	Sum squared resid	7.512560
Long-run variance	0.416730		

The cointegration equation is:

$$\text{Unemp} = 6.223 + 1.688\,Inf - 2.065\,GDP$$
$$(0.4348) \qquad (0.506)$$

2. Cointegration test

- According to the equations above, both the inflation (*inf*) and GDP growth (GDP) have significant impact on the Unemployment (Unem). This mean when the inflation increase the unemployment increase too, and when the GDP increase the unemployment decrease/

3. Granger causality test

- **Definition: The Granger causality test** is a statistical hypothesis test used to determine whether one time series variable Granger-causes another time series variable. Granger causality is a concept in econometrics named after Clive Granger, who introduced it in the 1960s.
- **Granger Causality Test Procedure:** Formulation of Hypotheses:

- **Null Hypothesis (*H*0):** The lagged values of one time series variable do not Granger-cause the other time series variable.
- **Alternative Hypothesis (*Ha*):** The lagged values of one time series variable Granger-cause the other time series variable.

3. Granger causality test

- **Decision Rule:**

- **Comparison with Critical Value:** Compare the calculated F-statistic with the critical value from the F-distribution at a chosen significance level (e.g., 0.05 or 0.01).
- **Rejection of Null Hypothesis:** If the calculated F-statistic exceeds the critical value, reject the null hypothesis and conclude that there is Granger causality from the potential causal variable to the dependent variable.

3. Granger causality test

- **Interpretation:**

- **Direction of Causality:** The direction of Granger causality is inferred based on the lagged variables included in the unrestricted model.
  - If the lagged values of *Xt* are significant predictors of *Yt*, it suggests that *Xt* Granger-causes *Yt*.
  - Conversely, if the lagged values of *Yt* are significant predictors of *Xt*, it suggests that *Yt* Granger-causes *Xt*.
- **Bidirectional Causality:** It is possible for both variables to Granger-cause each other, indicating bidirectional causality.

Pairwise Granger Causality Tests
Date: 04/20/24 Time: 11:04
Sample: 2010 2023
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP_GROWTH_RATE___ does not Granger Cause UNEMPLOYMENT_RATE___	13	5.66254	0.0386
UNEMPLOYMENT_RATE___ does not Granger Cause GDP_GROWTH_RATE___		0.21240	0.6548

Pairwise Granger Causality Tests
Date: 04/20/24 Time: 11:08
Sample: 2010 2023
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
INFLATION_RATE___ does not Granger Cause UNEMPLOYMENT_RATE___	13	0.15255	0.7043
UNEMPLOYMENT_RATE___ does not Granger Cause INFLATION_RATE___		3.41382	0.0944

Pairwise Granger Causality Tests
Date: 04/20/24 Time: 11:11
Sample: 2010 2023
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP_GROWTH_RATE___ does not Granger Cause INFLATION_RATE___	13	0.03048	0.8649
INFLATION_RATE___ does not Granger Cause GDP_GROWTH_RATE___		1.66294	0.2262