# Time Series Analysis

## Lecture 5

Vector Autoregressive (VAR) Models

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# Unit Root Nonstationarity and Dickey–Fuller Test: An Example

# Unit Root Nonstationarity and Dickey–Fuller Test

Dickey and Fuller developed a test of the null hypothesis that $\alpha = 1$ against an alternative hypothesis that $\alpha < 1$ for the model $x_t = \alpha x_{t-1} + u_t$ in which $u_t$ is white noise. A more general test, which is known as the augmented Dickey-Fuller test (Said and Dickey, 1984), allows the differenced series $u_t$ to be any stationary process, rather than white noise, and approximates the stationary process with an AR model. The method is implemented in R by the function $\texttt{adf.test}$ within the $\texttt{tseries}$ library. The null hypothesis of a unit root cannot be rejected for our simulated random walk $\texttt{x}$:

Use the library called **tseries** and the embedded series to illustrate the mechanics of conduction the ADF test in R:

```
library(tseries)
adf.test(x)
```

Even though this is a series coming with the library, it is a good idea to get familiar with the series.

# Unit Root Nonstationarity and Dickey–Fuller Test

Basic structure and descriptive statistics of the series:

```
> str(x)
 num [1:1000] -0.662 -0.331 -2.089 -3.002 -2.962 ...
```

```
Min.  1st Qu.   Median     Mean 3rd Qu.     Max.
-75      -60      -33      -38     -23        0
```

In addition to the basic structure of the data and the descriptive statistics that describe various quantiles and the mean of the distribution, we will still look at graphs to examine the dynamics of the series.

# Unit Root Nonstationarity and Dickey–Fuller Test

- The series clearly is not stationary.
- The autocorrelation is almost nondecreasing while the partial autocorrelation sharp drops to zero in the first lag.
- These are all evidences of a process having unit roots.
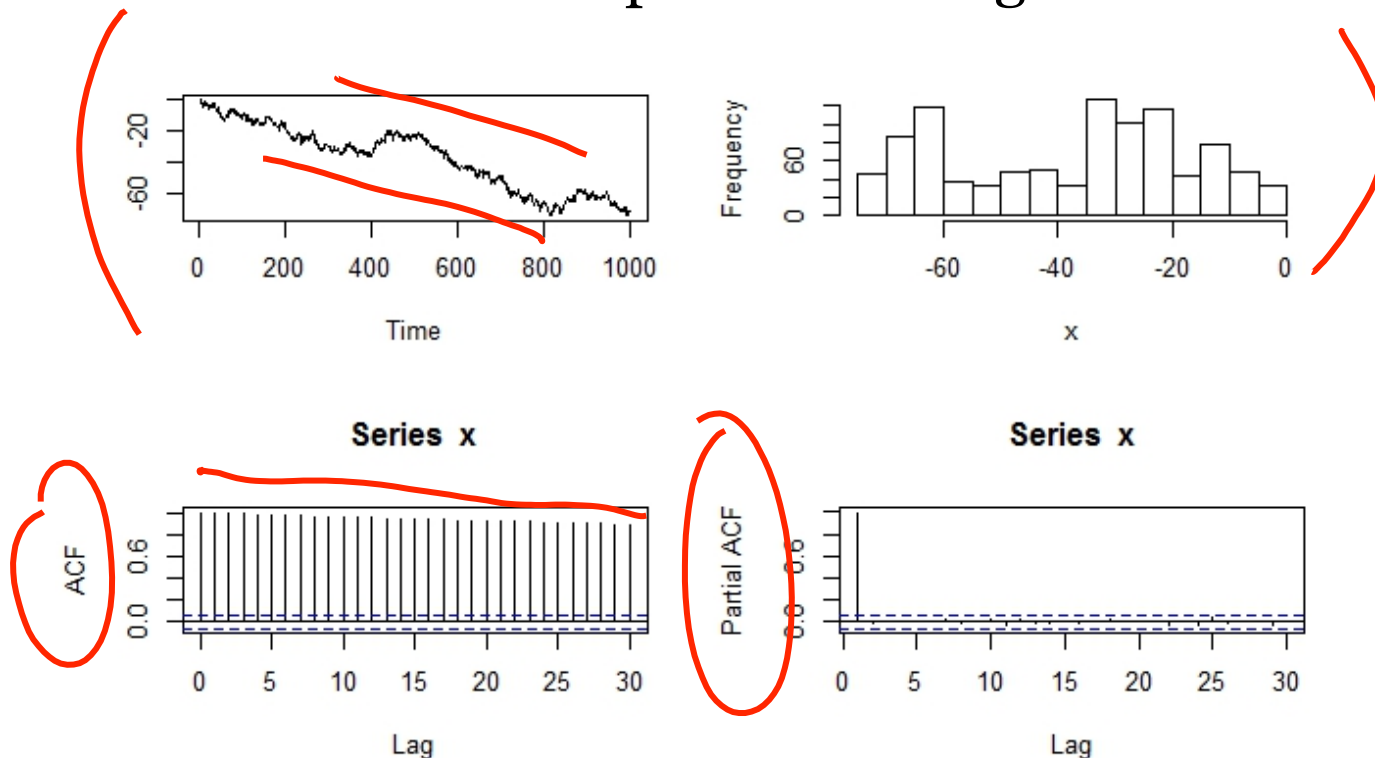
# Unit Root Nonstationarity and Dickey–Fuller Test

- The mechanism of applying the augmented Dickey–Fuller test in R is very straight-forward.
- It simply call the command adf.test(x).

```
Augmented Dickey-Fuller Test

data:   x
Dickey-Fuller = -2.2, Lag order = 9, p-value = 0.5003
alternative hypothesis: stationary
```

The ADF test result indicates that the null hypothesis (that the series has a unit root) cannot be rejected.

This result is not surprising at all, based on the data visuals that we have seen.