Time Series Statistical Models

FinTech

Lesson 10.2

Software to Install for Module 11

Please install the following software before class on Aug 13

Instructions can be found here

Time Series Homework Due on Aug 18

Project 1 Links

A reminder to please submit the GitHub link for your project in BCS. All group members must submit a link (BCS does not allow us to assign grades without a submission).

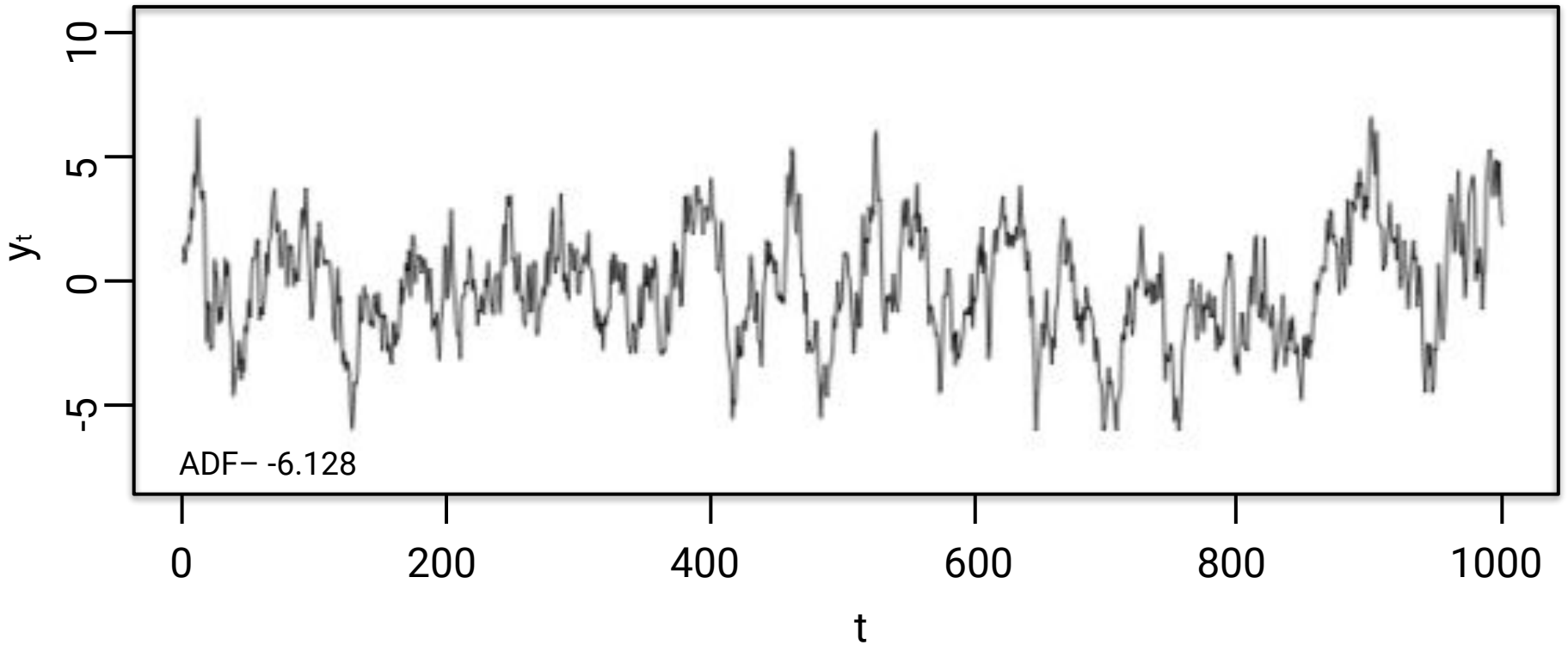
Class Objectives

- Stationary vs. non-stationary data
- Augmented Dickey-Fuller test
- Autoregressive Moving Average Model (ARMA)
- Autoregressive Integrated Moving Average (ARIMA)
- Generalized Autoregressive Conditional Heteroskedasticity (GARCH)

Stationarity

Stationarity

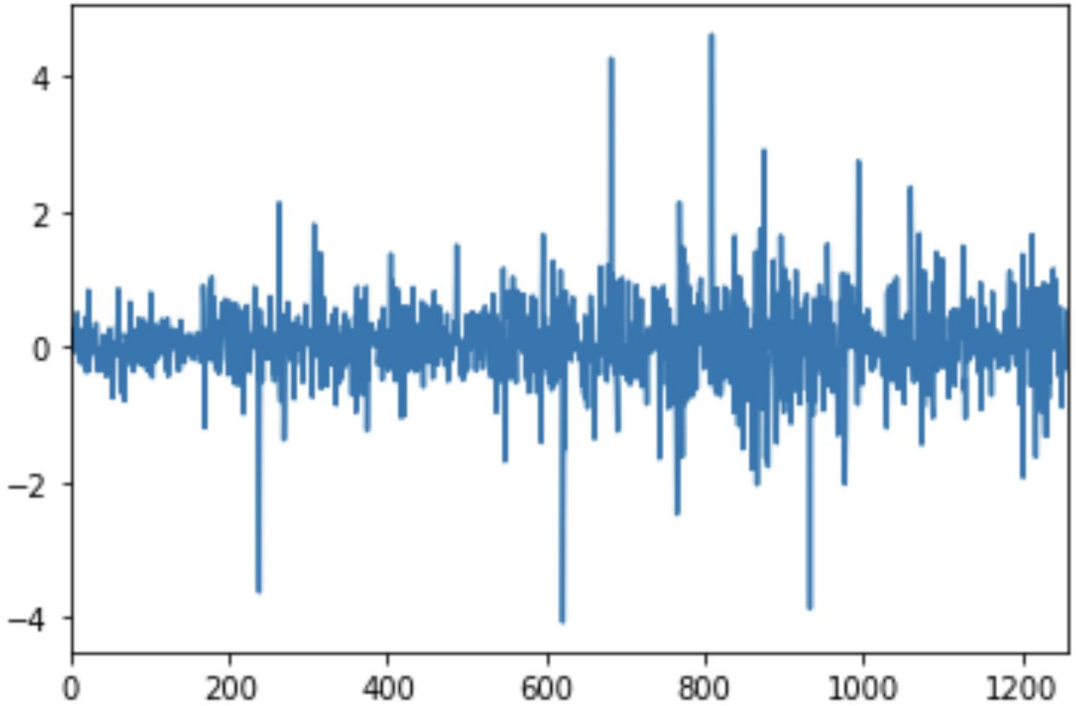
In a stationary process, the mean and variance are constant across time.



Stationarity

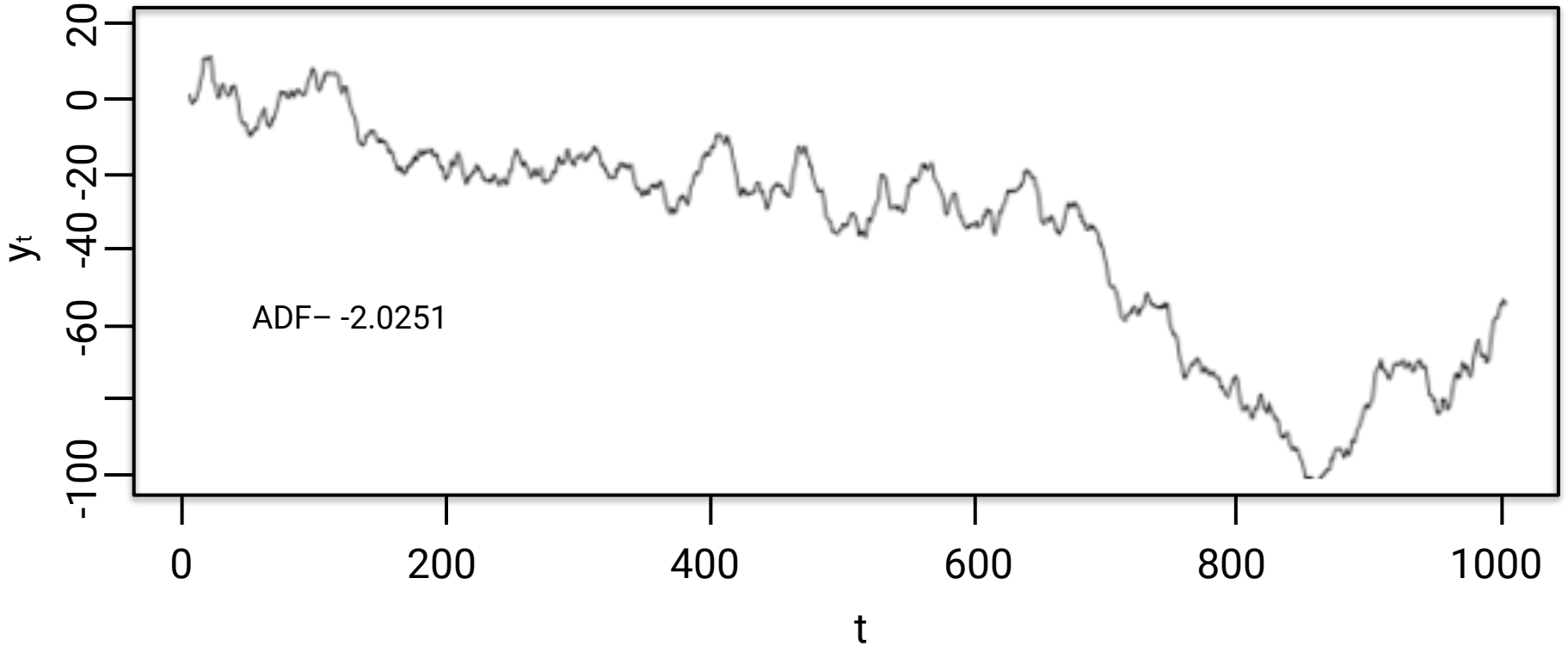
Stationarity is important in selecting a time series model, and makes data easier to model.

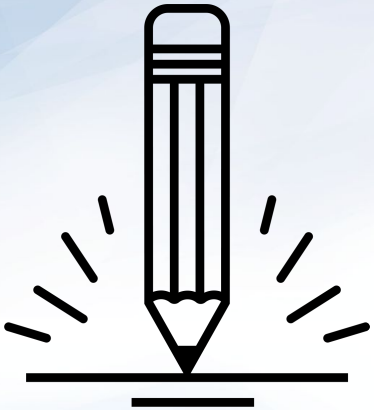
There are strategies to transform a non-stationary time series into a stationary one.



Non-stationary

A time series with an upward or downward trend is **not stationary.**





Activity: Stationarity

In this activity, you will perform techniques to make a non-stationary time series stationary.

Documentation on AdFuller function

Suggested Time:
15 minutes

Time’s Up! Let’s Review.

ARMA

Auto-Regressive (AR) Models

In an AR model…

01 Past values are used to predict future values.

02 Therefore, it assumes some degree of autocorrelation.

03 It may have one significant lag, or multiple lags.

Auto-Regressive Models

$$Y_t = \delta + \phi_1 x_{t-1} + \varepsilon_t$$

Second-order AR Model

$$Y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \epsilon_t.$$

AR Model Summary

An AR model predicts future values based on:

01 Past values at a specified lag.

02 The number of significant lags.

Moving Average Model

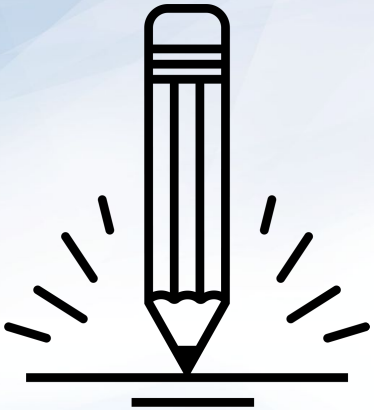
$$Y_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1}$$

First Order Moving Average Model

$$Y_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$$

Second Order Moving Average Model

Past **errors** (plus current error) are used to predict future values.



Activity: Yields

In this activity, you will create an ARMA model on yield data.

Suggested Time:
15 minutes

Time’s Up! Let’s Review.

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ARIMA

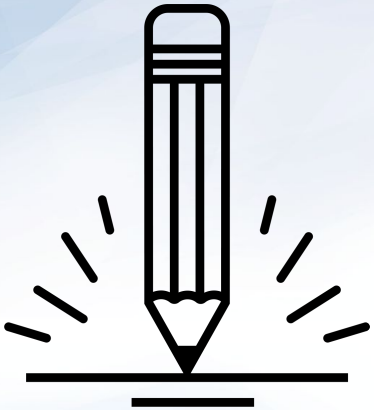
ARIMA Model

$$x_t = \delta + \phi_1 x_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t$$

- Combines features of AR and MA models.
- Past values and errors are used to predict future values.

AIC & BIC

- Akaike Information Criterion, Bayesian Information Criterion.
- Assess how well a model fits the data (goodness of fit), and complexity.
- Higher-order models are penalized for complexity.
- Lower scores are better.



Activity: An ARIMA and a Leg

In this activity, you will use an ARIMA model to forecast the prices of oil futures.

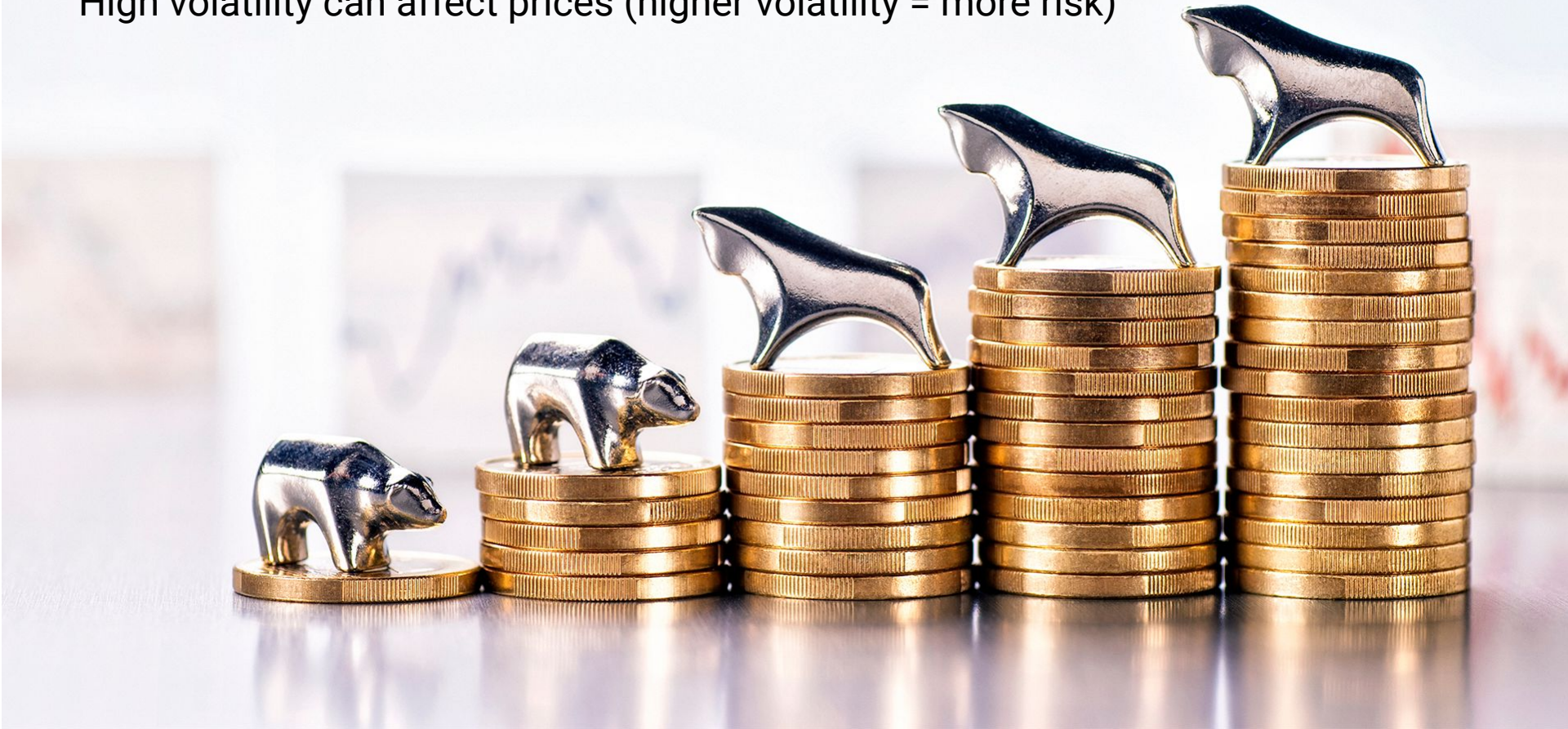
Suggested Time:
15 minutes

Time’s Up! Let’s Review.

Why is volatility important to understand?

Higher Volatility = More Risk

High volatility can affect prices (higher volatility = more risk)



Diversified Portfolio

By understanding volatility of individual assets (stocks, bonds, etc.), a more diversified portfolio can be constructed.

Derivatives

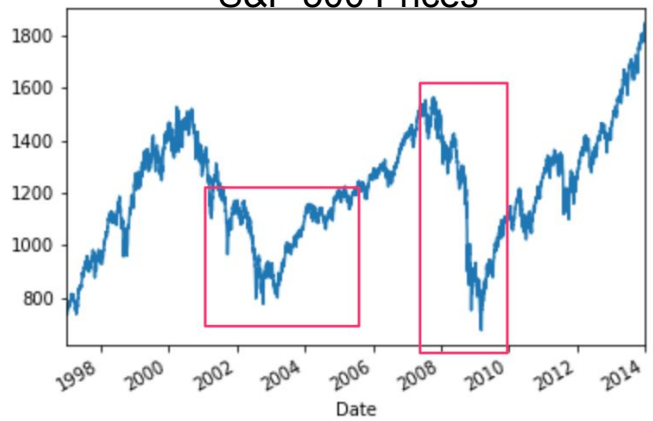
Some assets are particularly sensitive to volatility – e.g., derivatives.

Volatile Periods in the US Stock Market

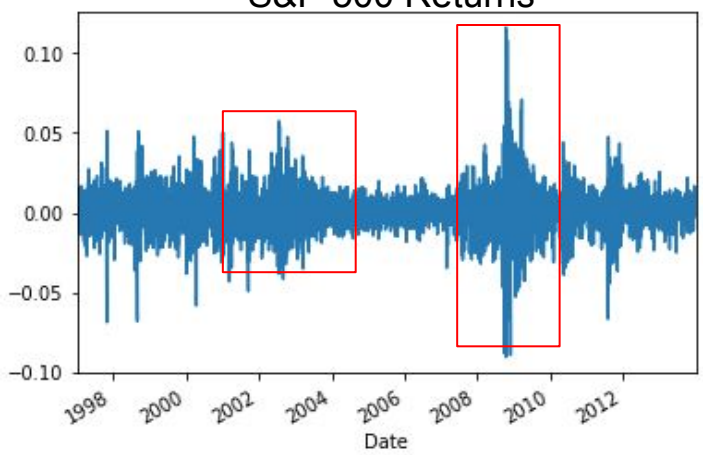
Volatility and returns tend to cluster.

GARCH is a model designed to take specific advantage of that.

S&P 500 Prices



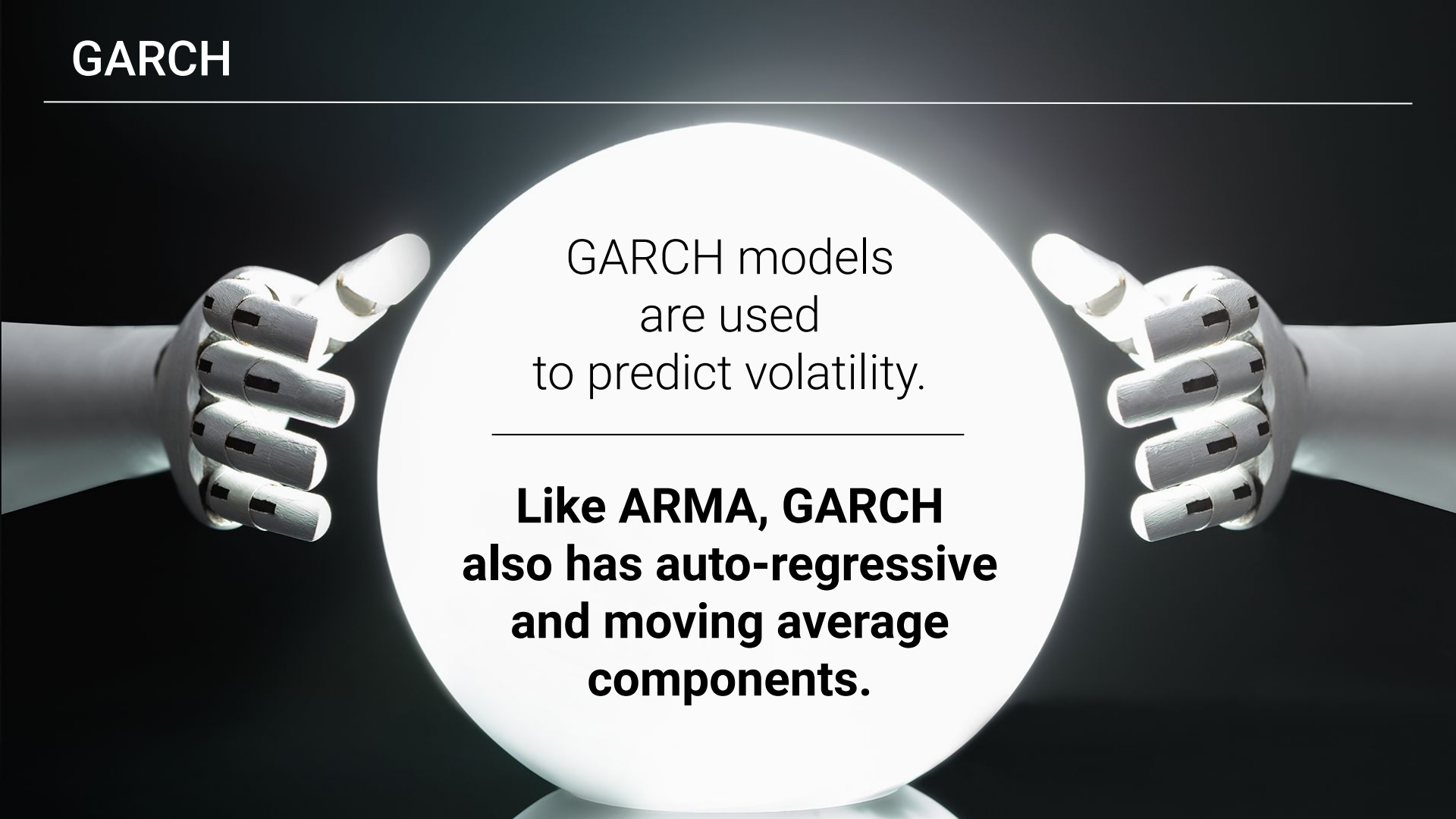
S&P 500 Returns




Volatility
can beget
volatility,
i.e., cluster.

GARCH

GARCH



GARCH models
are used
to predict volatility.

Like ARMA, GARCH also has auto-regressive and moving average components.

ARMA

Auto-Regressive Component:

Future values are predicted based on **past values**.

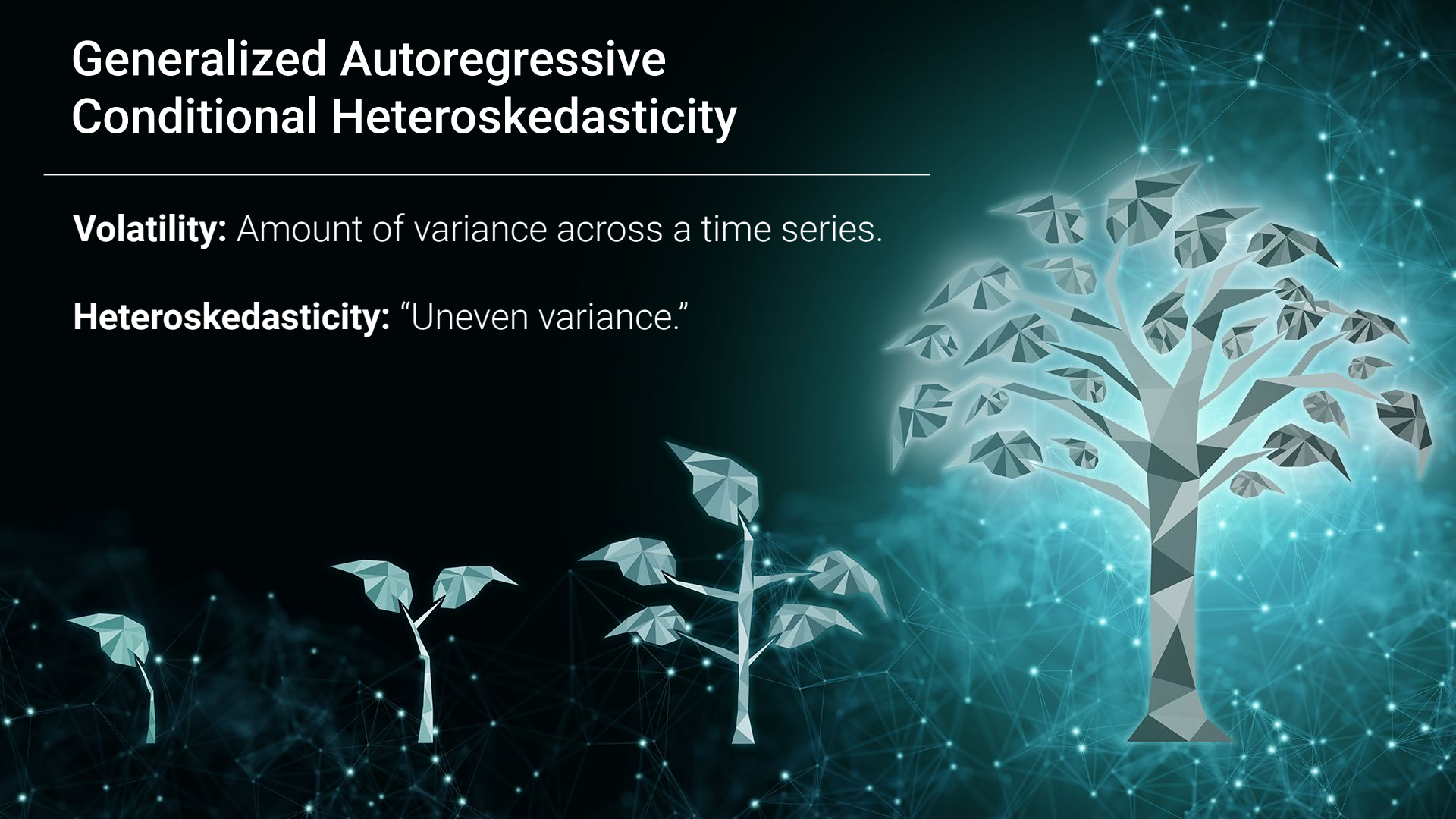
Moving Average Component:

Future values are predicted based on **past errors**.

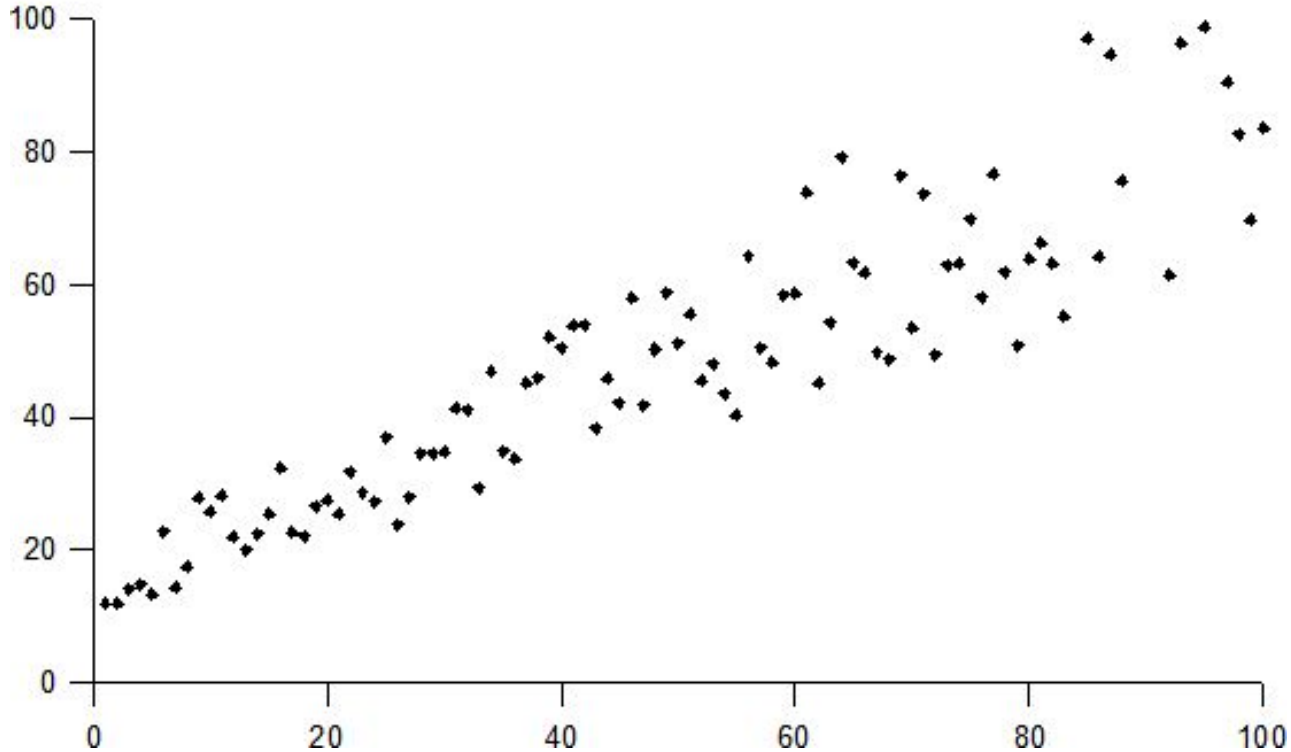
Generalized Autoregressive Conditional Heteroskedasticity

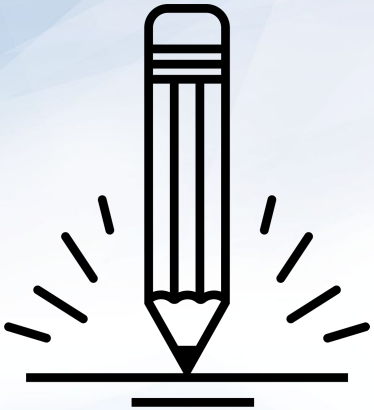
Volatility: Amount of variance across a time series.

Heteroskedasticity: “Uneven variance.”



Heteroskedasticity





Activity: EUR-CAD Volatility

In this activity, you will use GARCH to forecast volatility of the EUR-CAD exchange rate.

Suggested Time:
10 minutes

Time’s Up! Let’s Review.

Questions?