
# Time Series Statistical Models

FinTech

Lesson 10.2

# Class objectives

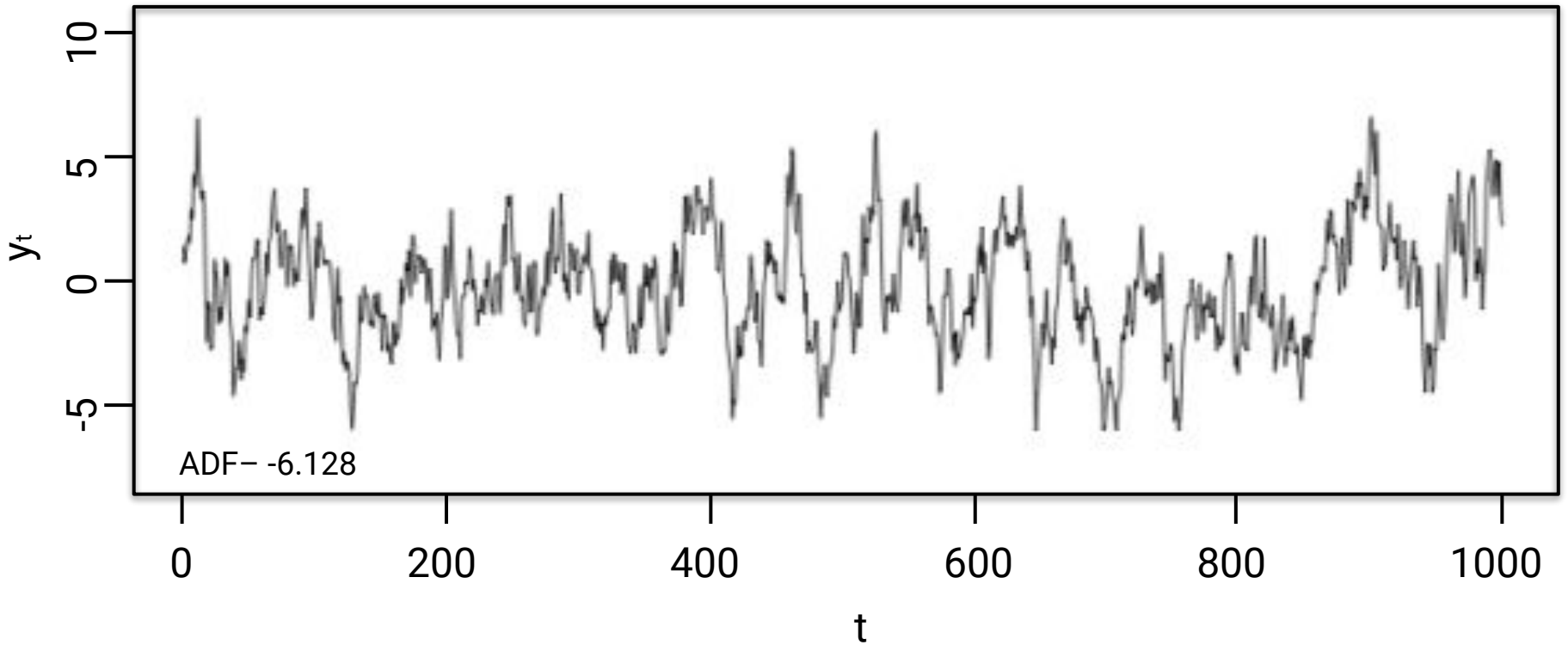
By the end of today's class you will understand:

- 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

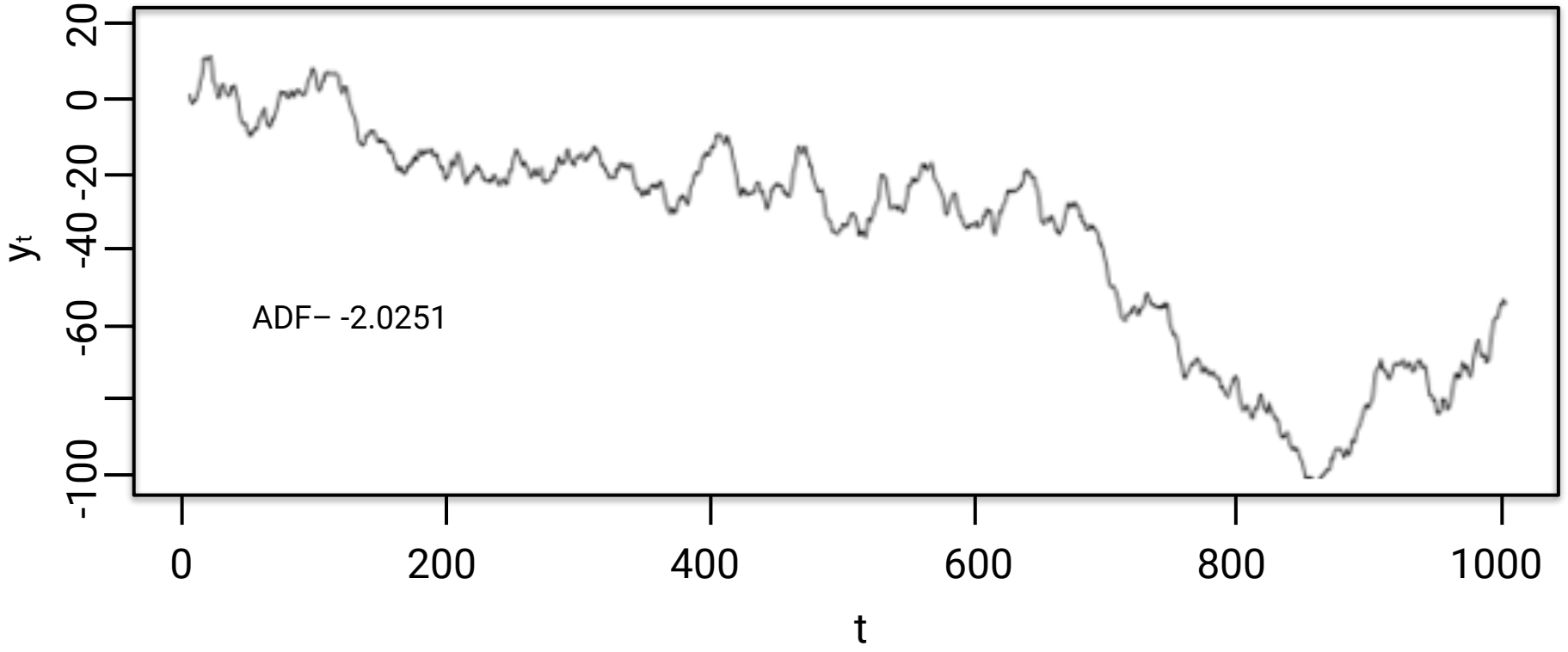
# Stationarity

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



# Non-stationary

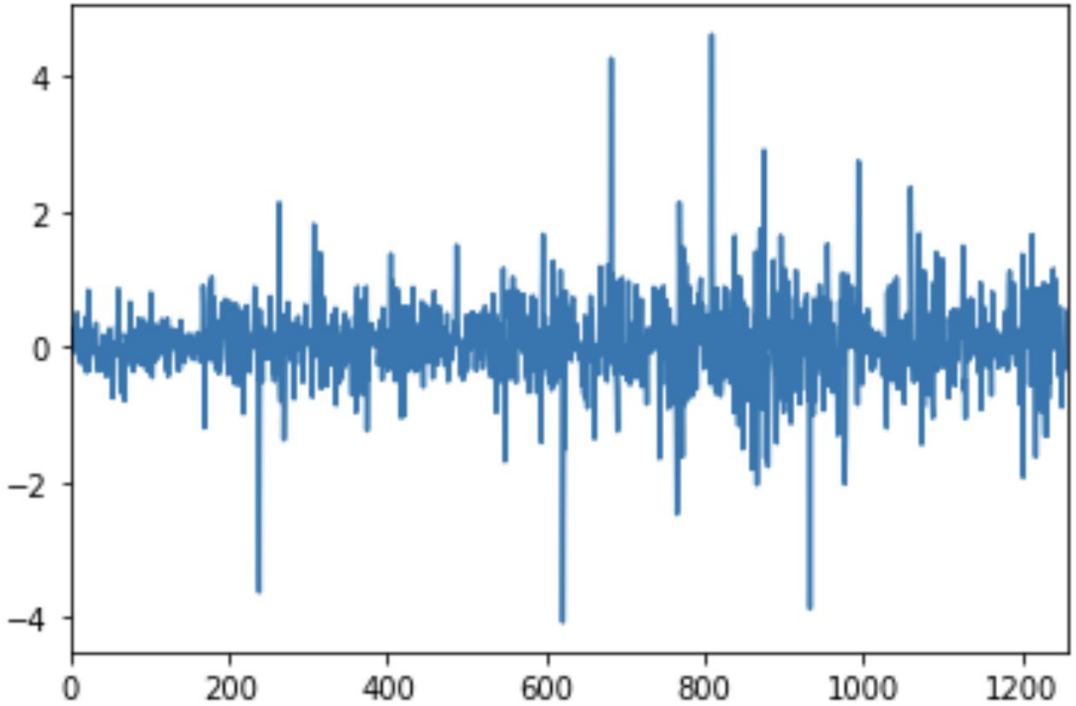
A time series with an upward or downward trend is **not stationary.**

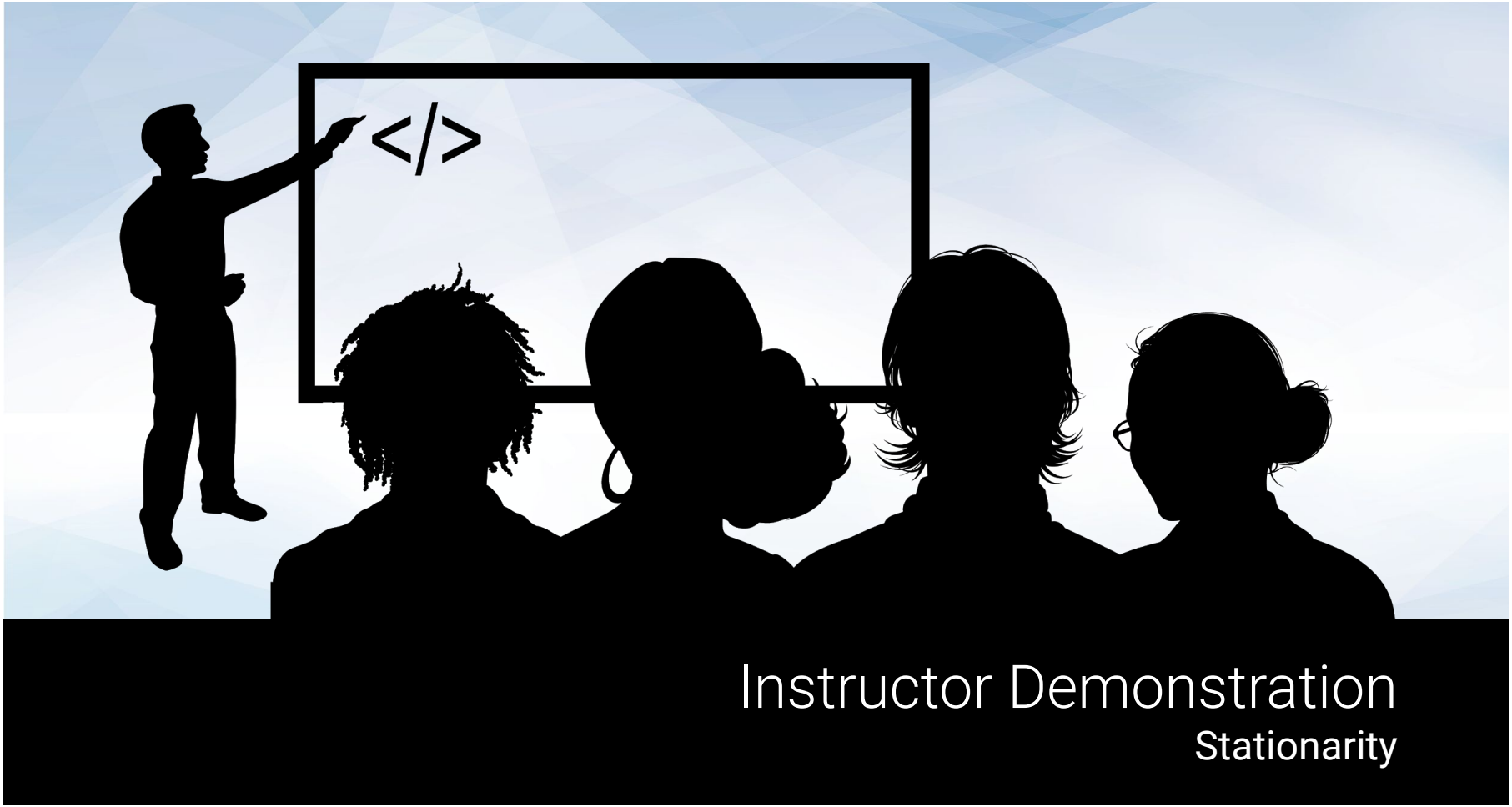


# Stationarity

Understanding stationarity is important in selecting a time series model.

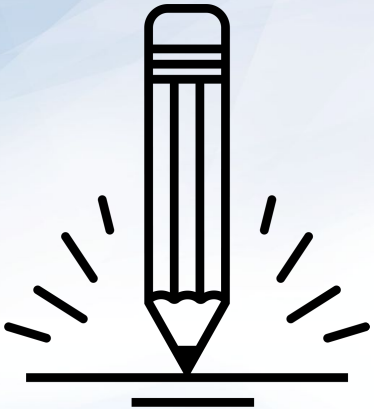
There are strategies to transform a non-stationary time series into a stationary one.






# Instructor Demonstration

## Stationarity



# Activity: Stationarize It

In this activity, you will stationarize a non-stationary time series. The dataset is a time series of Amazon stock prices from years 2009 through 2011.

**Suggested Time:**
15min

# ARMA

# Auto-Regressive Moving Average (ARMA) model

ARMA is a tool to understand and predict future values for time-series data.

Uses historical data correlations to predicted future values

Uses historical unexpected events (aka, shocks/errors) to predict future values

Uses two models: Auto-Regressive and Moving Average

# Auto-Regressive Model

$$y_t = \mu + a_1 y_{t-1} + \epsilon_t$$

Value at a certain time period

Average

Alpha coefficient (the slope of the regression line)

Value at previous time period (lag 1)

Epsilon is a shock term or considered white noise (the residuals/errors to the regression line)

# Auto-Regressive (AR) Models

01 Past values are used to predict future values.

02 Therefore assumes some degree of autocorrelation.

03 An AR model may have one significant lag, or it may have multiple.

# Second-order AR model

$$y_{\mathrm{t}} = \mu + a_1 y_{\mathrm{t\text{-}1}} + a_2 y_{\mathrm{t\text{-}2}} + \epsilon_{\mathrm{t}}$$

# AR Model Summary

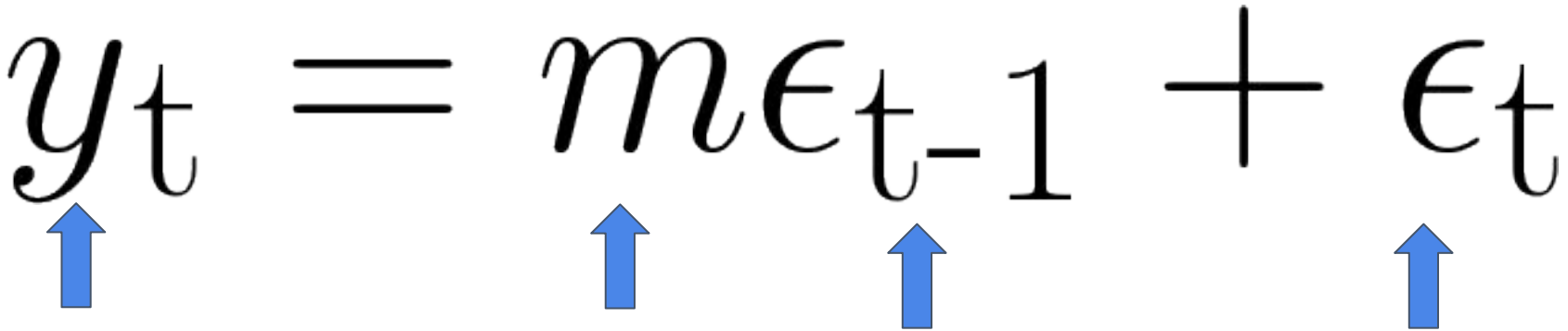
An AR model predicts future values based on:

01 Past values at a specified lag.

02 The number of significant lags.

# Moving Average Model

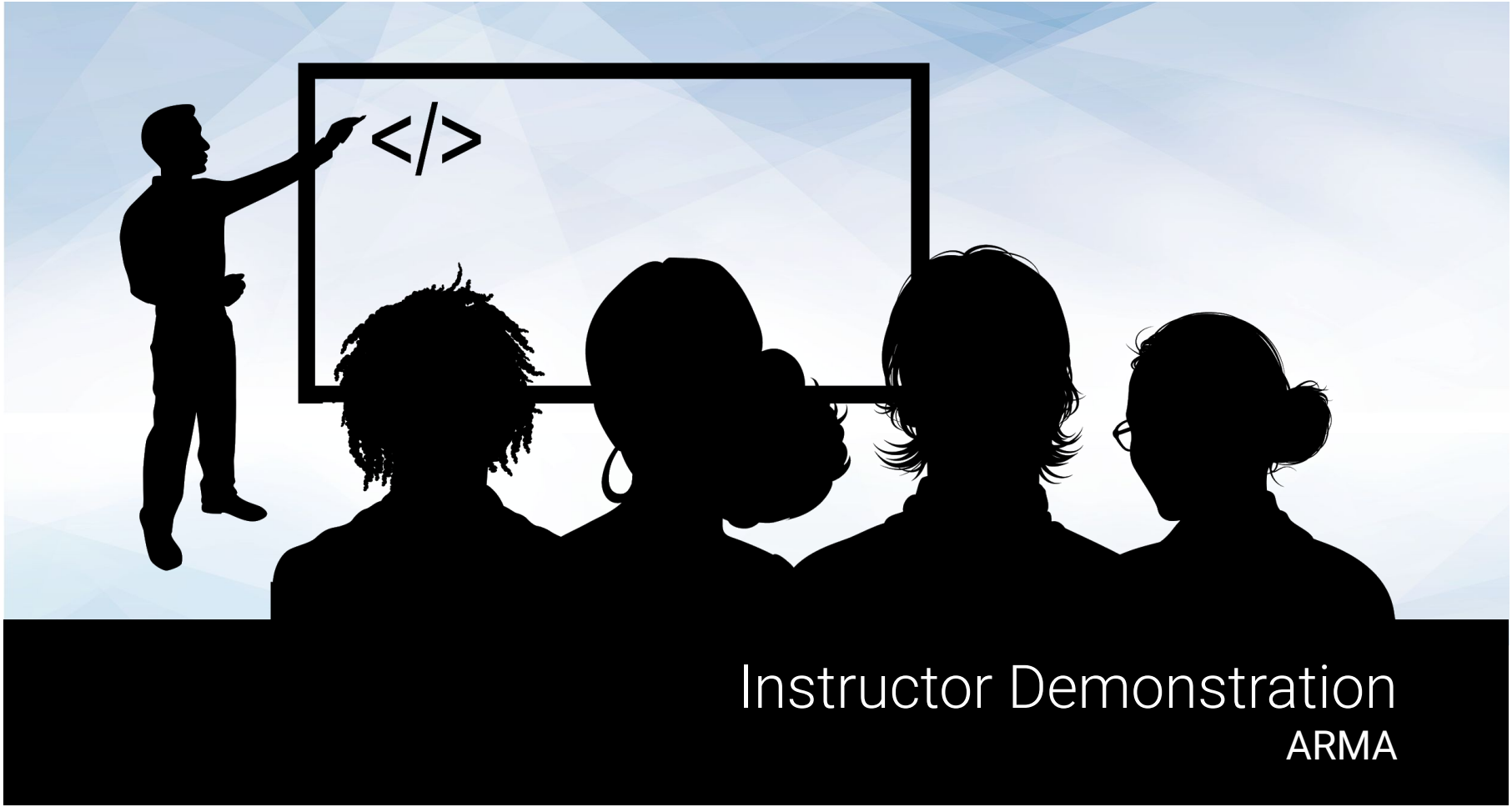
Epsilon is a shock term



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

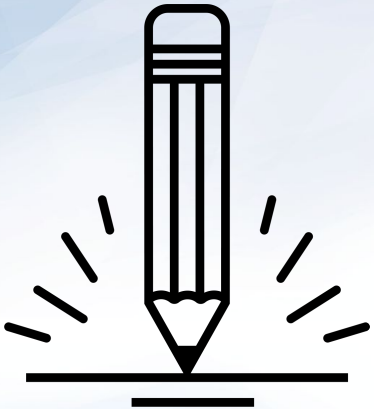
# ARMA Model

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




# Instructor Demonstration

## ARMA



# Activity: Yields

Create an ARMA model using the data provided.

**Suggested Time:**
15min


AdobeStock_56885471

# ARIMA

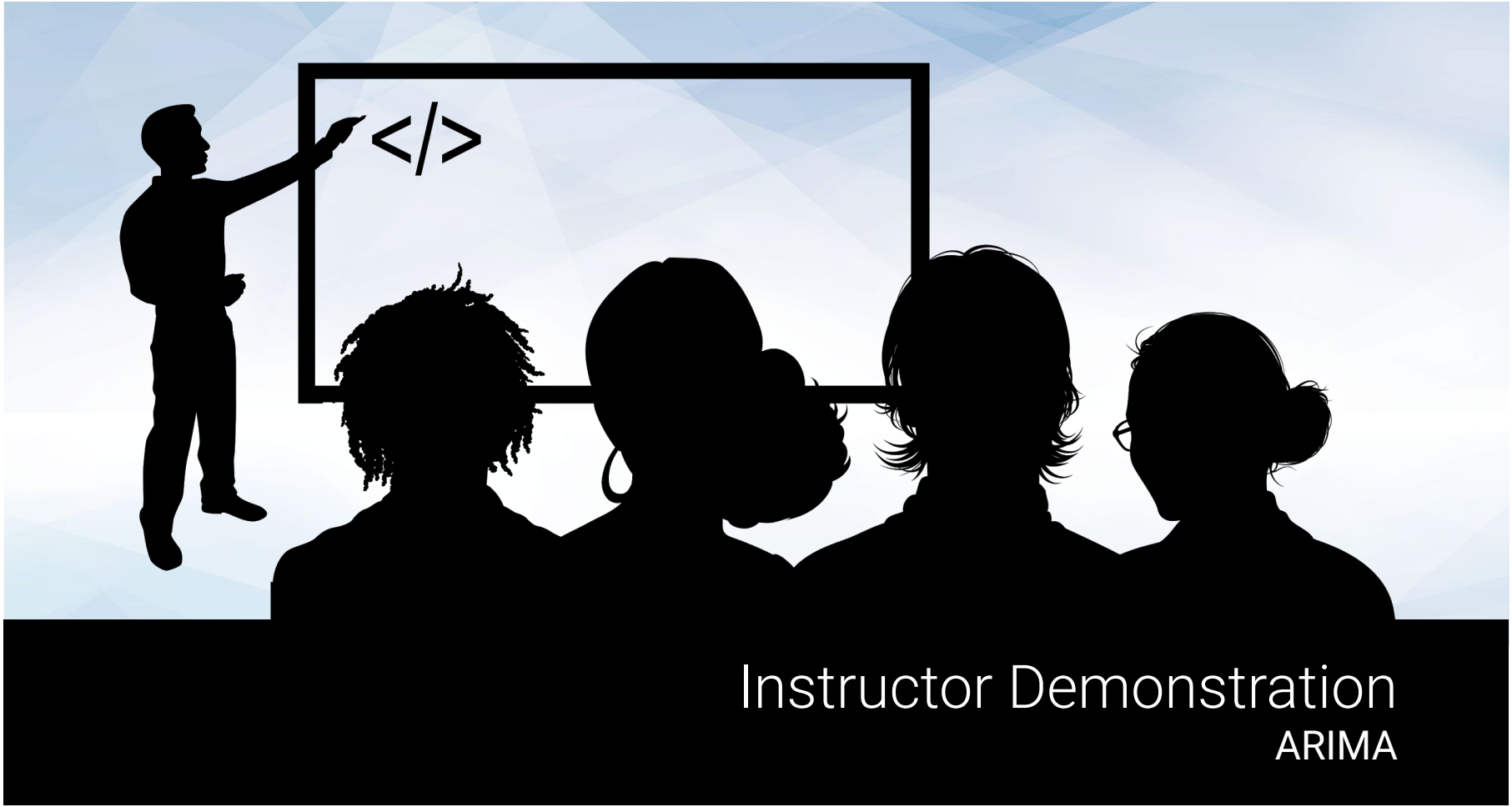
# ARIMA Model

$$\Delta y_t = \mu + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \epsilon_t$$

- Combines features of AR and MA models.
- Past values and errors are used to predict future values.
- **ARIMA** creates differences (**Δy**) of the data as part of the process.

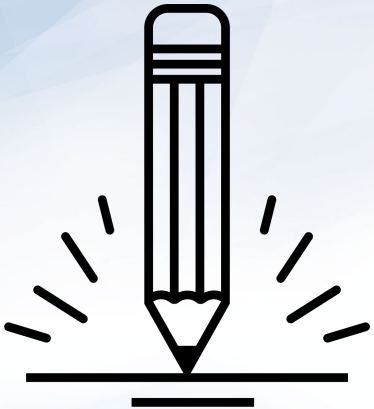
# AIC & BIC

- 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.




# Instructor Demonstration

## ARIMA



# Activity: An ARIMA and a Leg

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

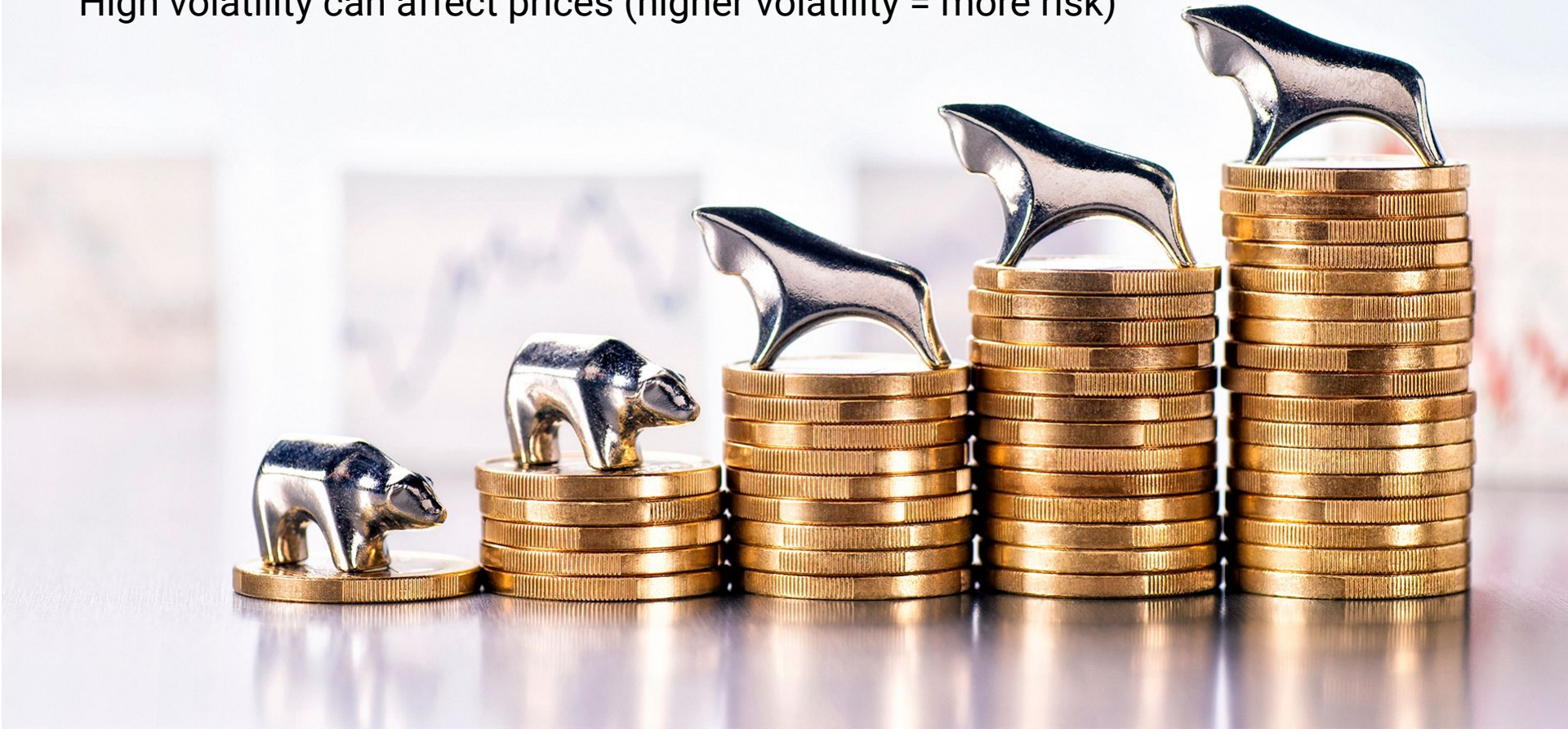
**Suggested Time:**
15min

# Volatility

# 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.


Volatility
can beget
volatility,
i.e. cluster.

# GARCH

# ARMA

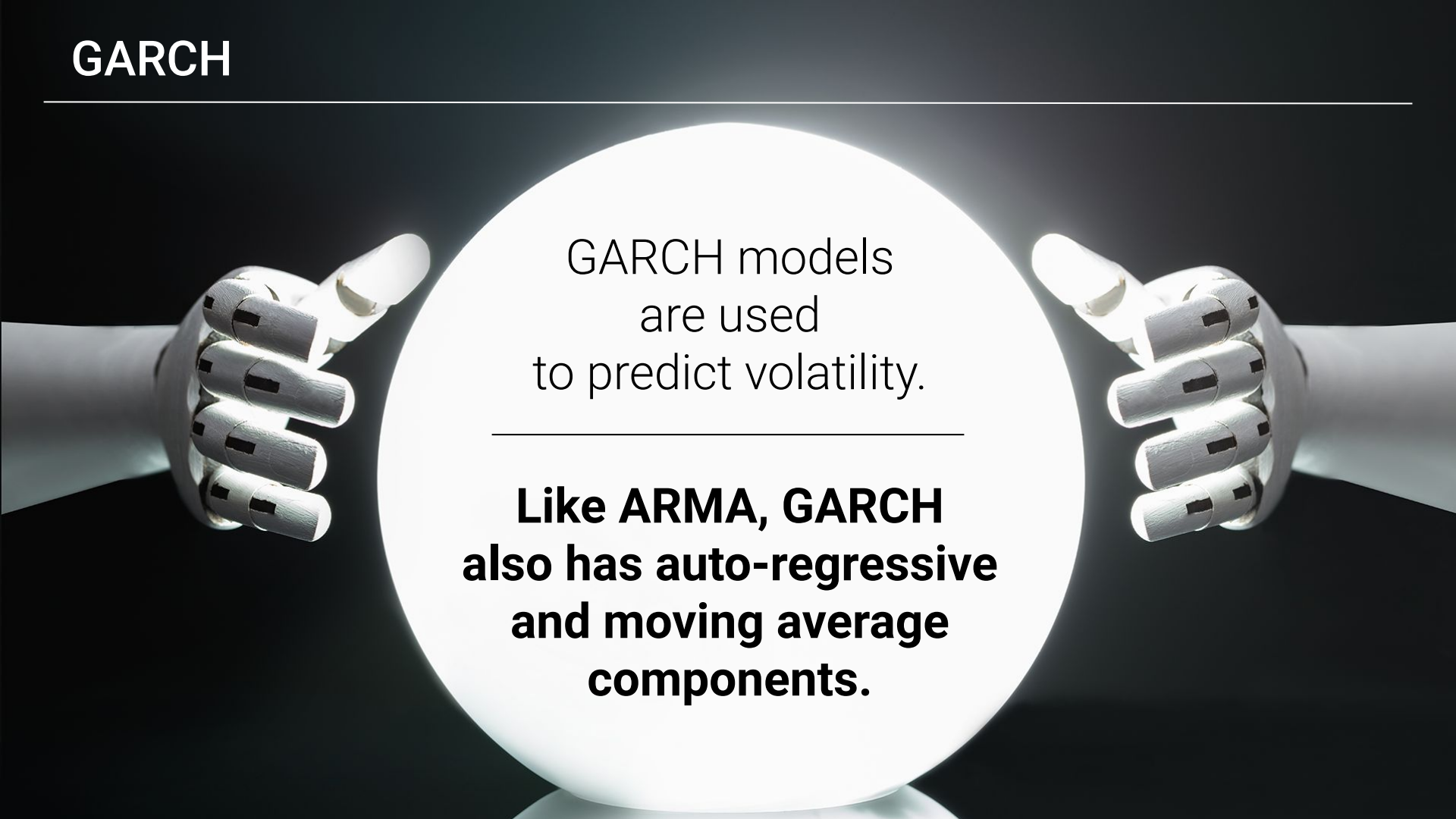
**Auto-Regressive component:**

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

**Moving Average component:**

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

# GARCH



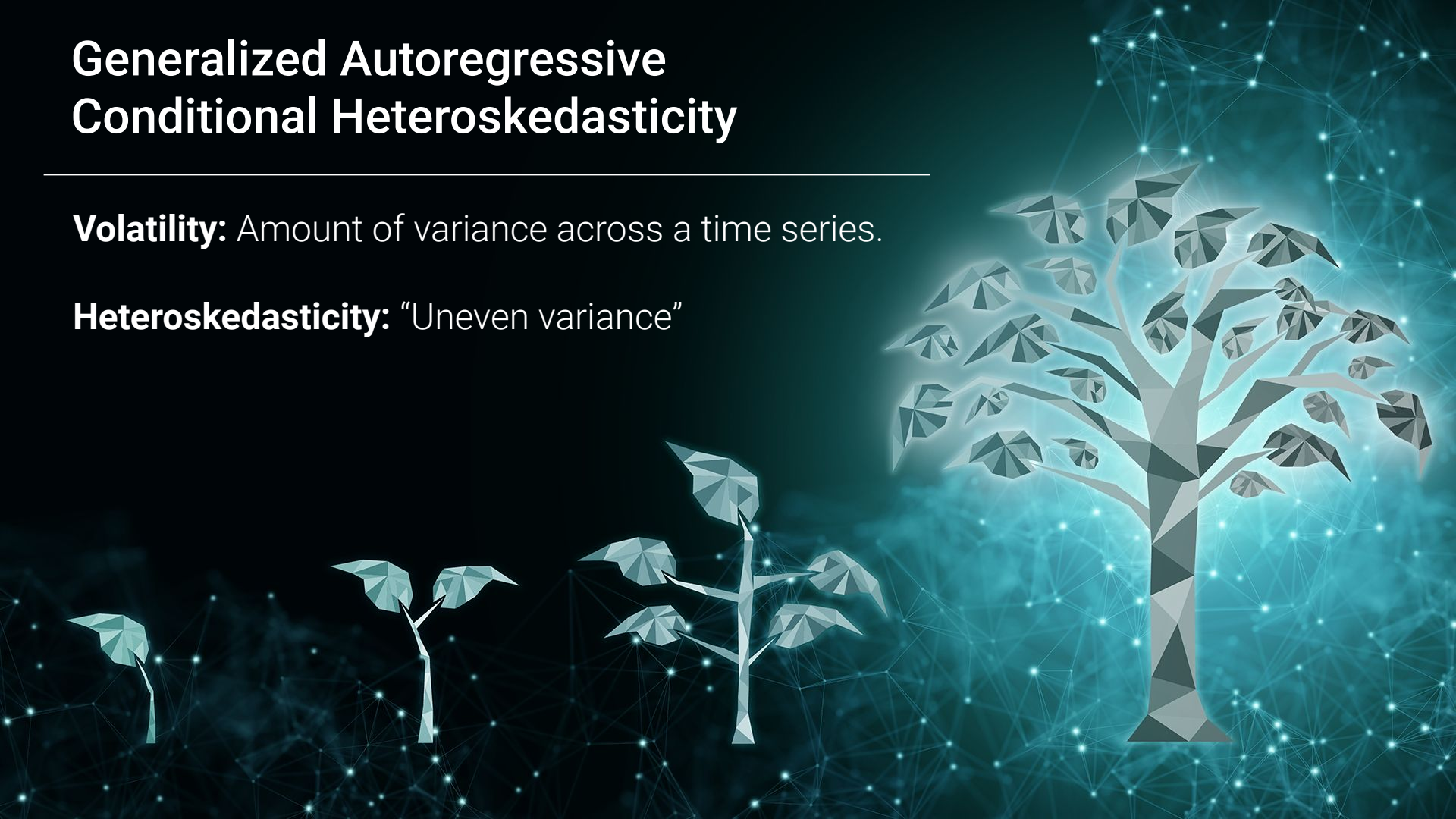
GARCH models
are used
to predict volatility.

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

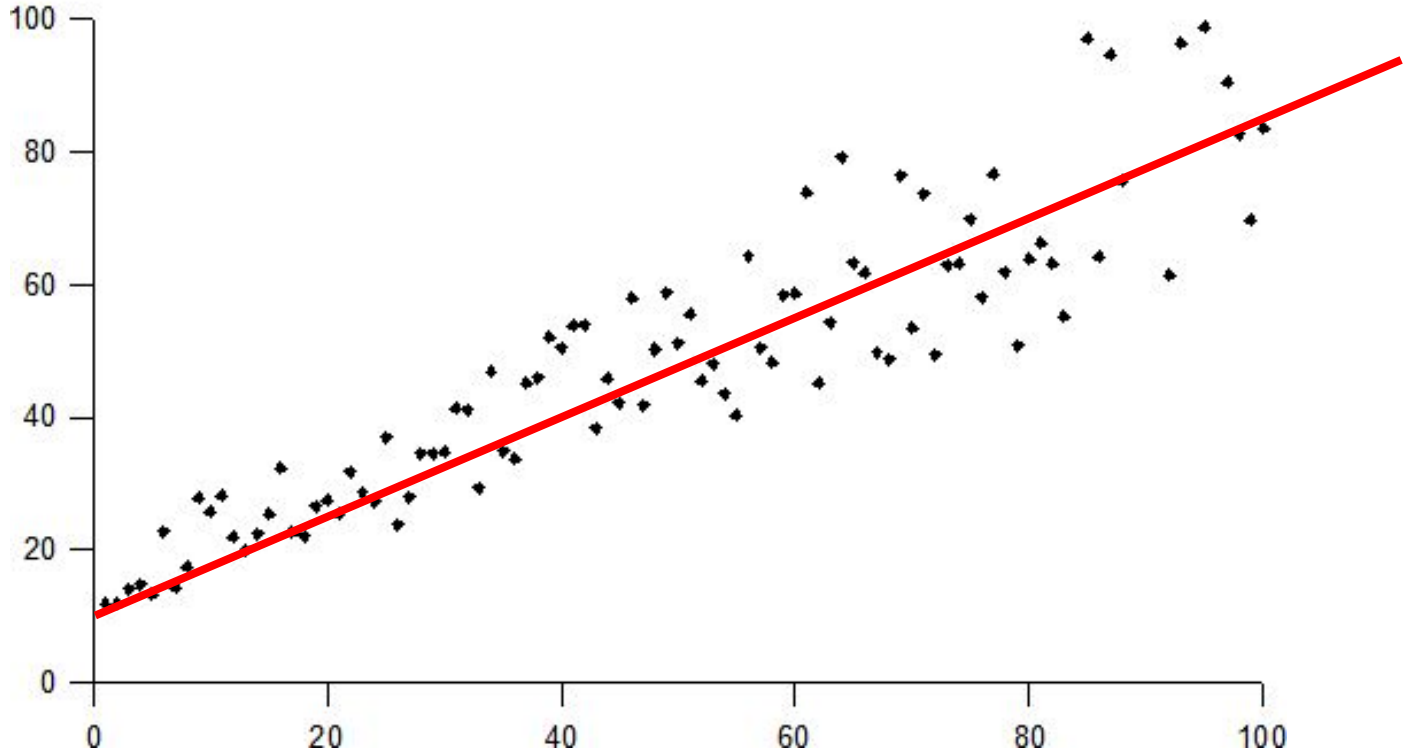
# Generalized Autoregressive Conditional Heteroskedasticity

**Volatility:** Amount of variance across a time series.

**Heteroskedasticity:** “Uneven variance”



# Heteroskedasticity

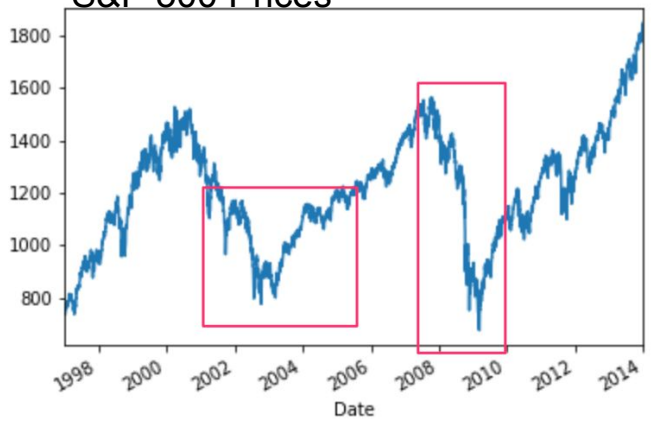


# Volatile Periods in the US Stock Market

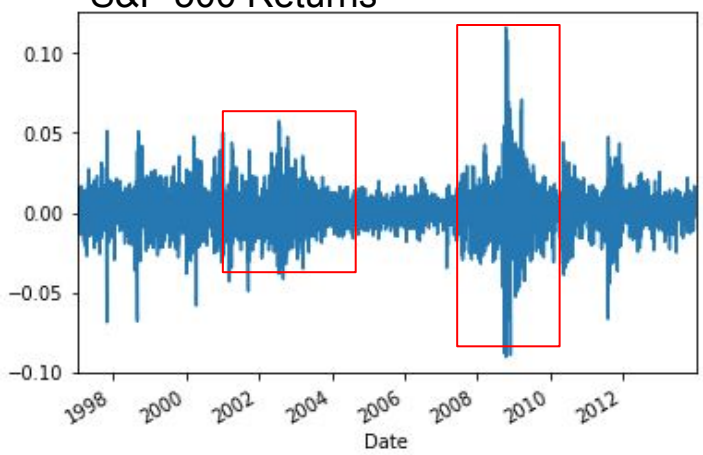
Volatility and returns tend to cluster.

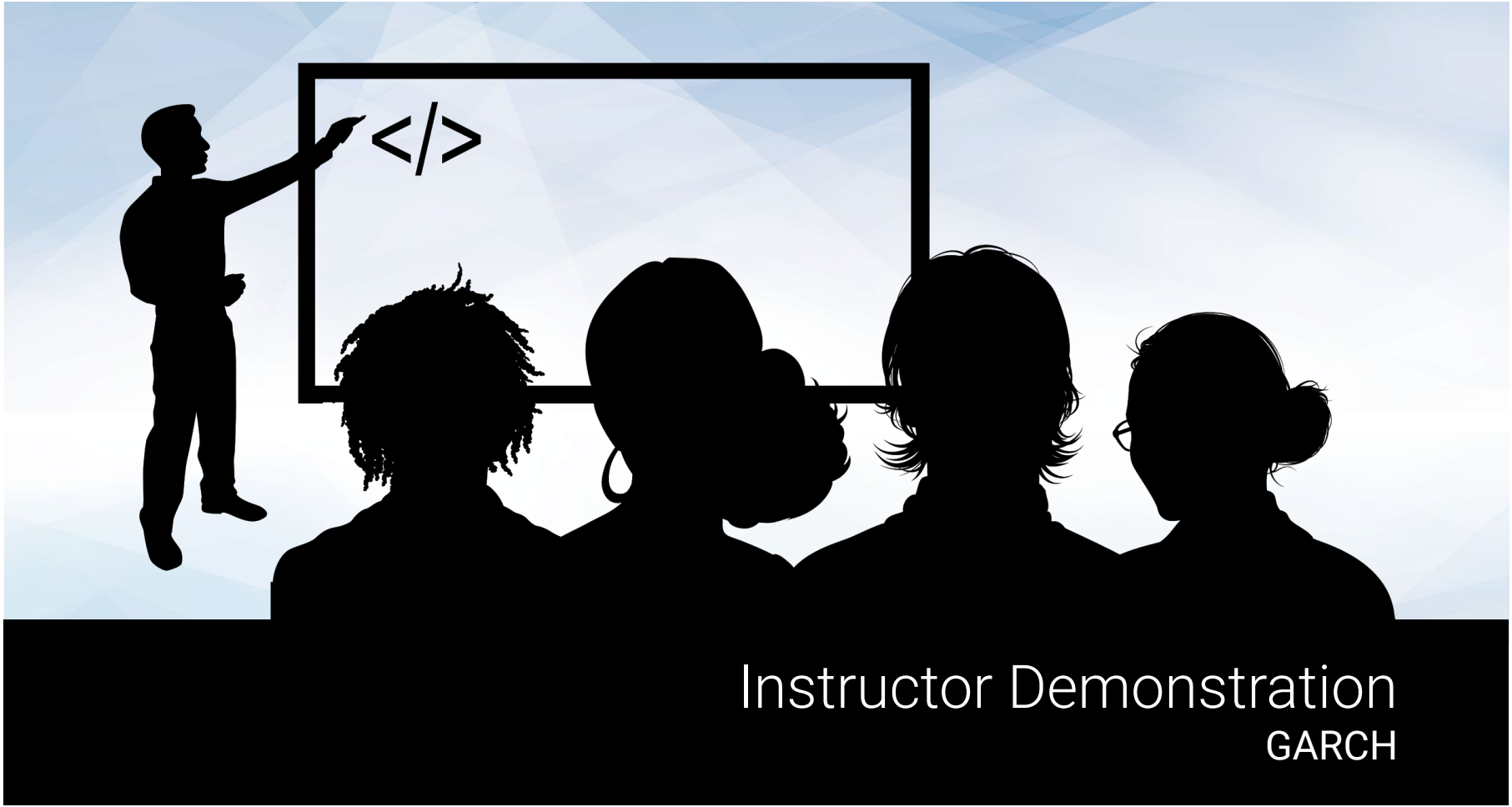
GARCH is a model designed to take specific advantage of that.

S&P 500 Prices




S&P 500 Returns






# Instructor Demonstration

## GARCH

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# Questions?