Class objectives

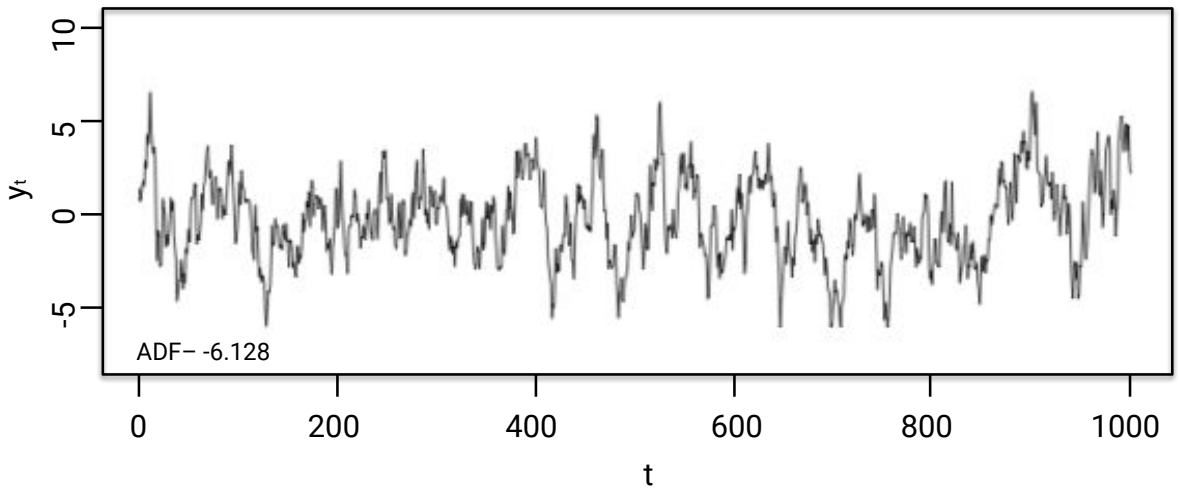
By the end of today's class you will understand:

- 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

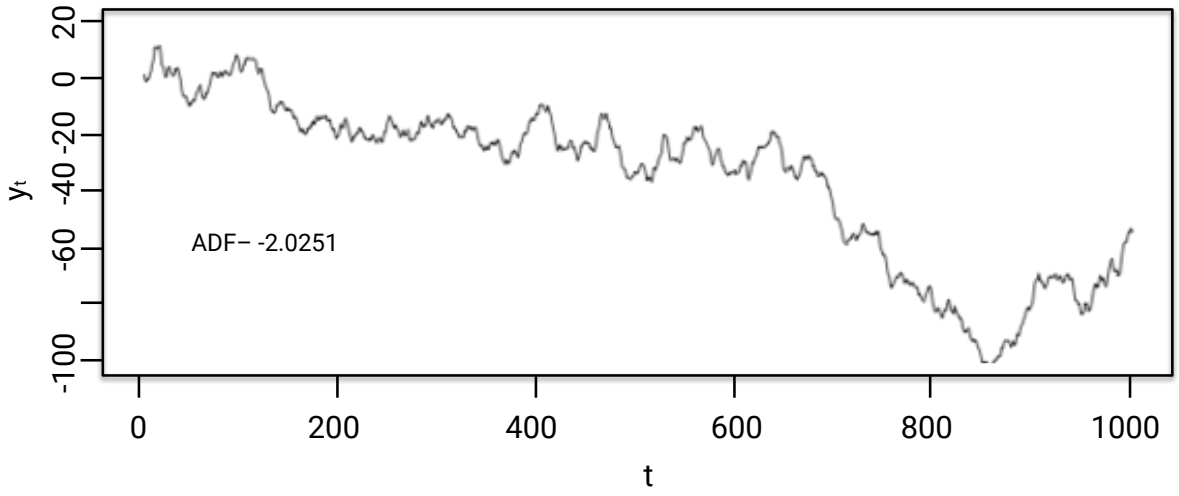
Stationarity

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



Non-stationary

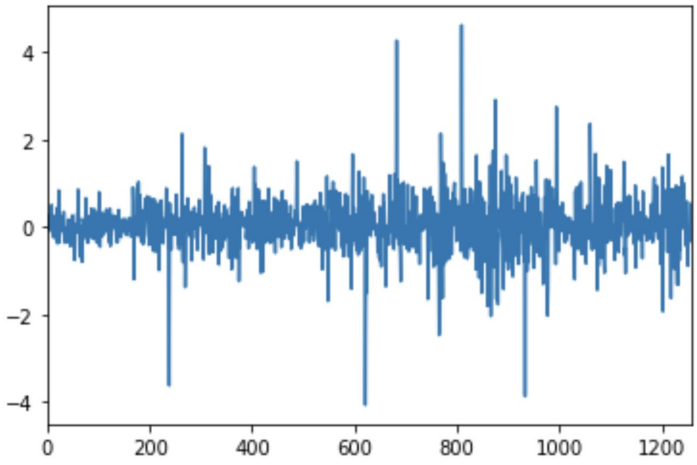
A time series with an upward or downward trend is **not stationary.**



Stationarity

Important in selecting a time series model.
Makes data easier to model.

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



ARMA

Auto-Regressive Model

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

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

$$y_t = \mu + a_1 y_{t-1} + a_2 y_{t-2} + \epsilon_t$$

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

$$y_t = m\epsilon_{t-1} + \epsilon_t$$

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

ARMA Model

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

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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.

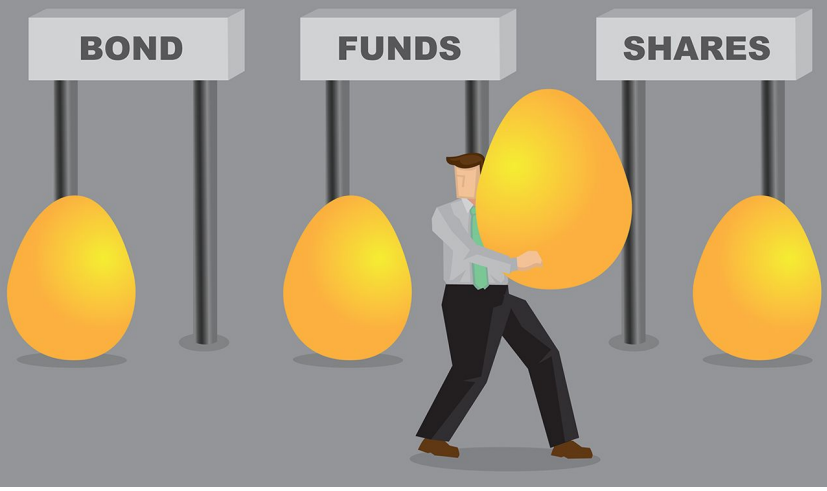
Why is Volatility Important to Understand?

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.

GARCH

ARMA

Auto-Regressive component:
Future values predicted based on **past values**.

Moving Average component:
Future values predicted based on **past errors**.

GARCH

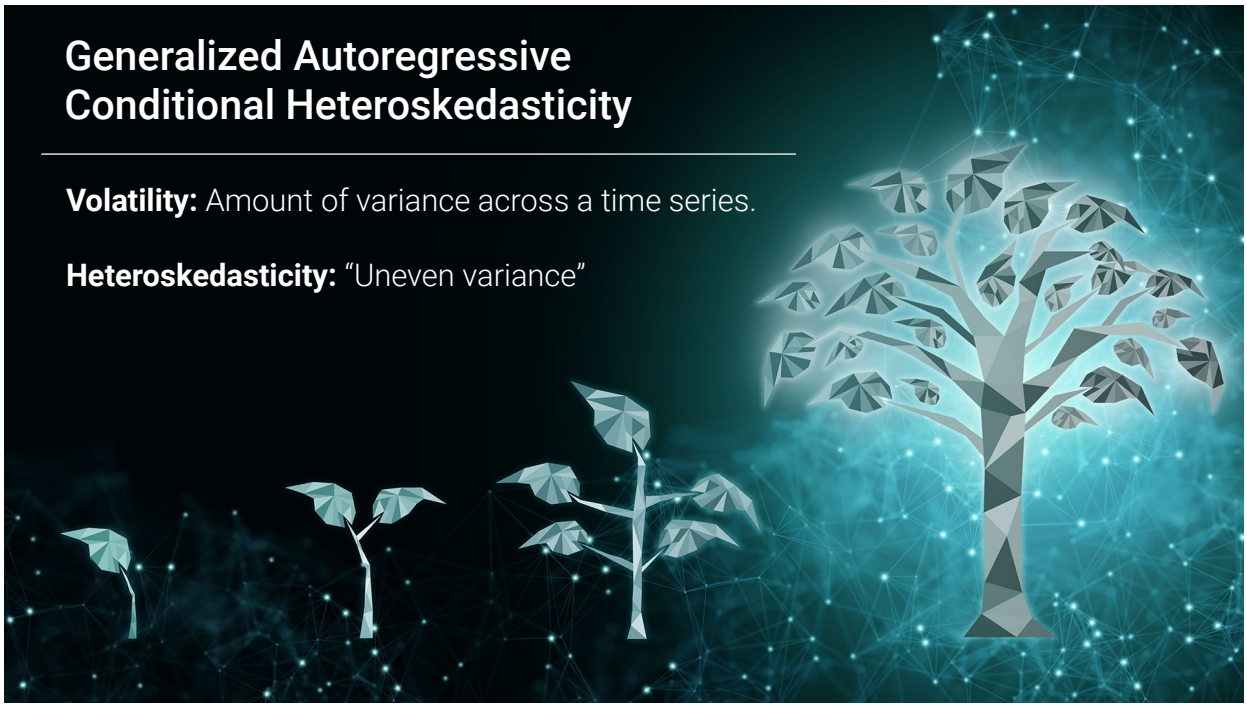
GARCH models are used to predict volatility.

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

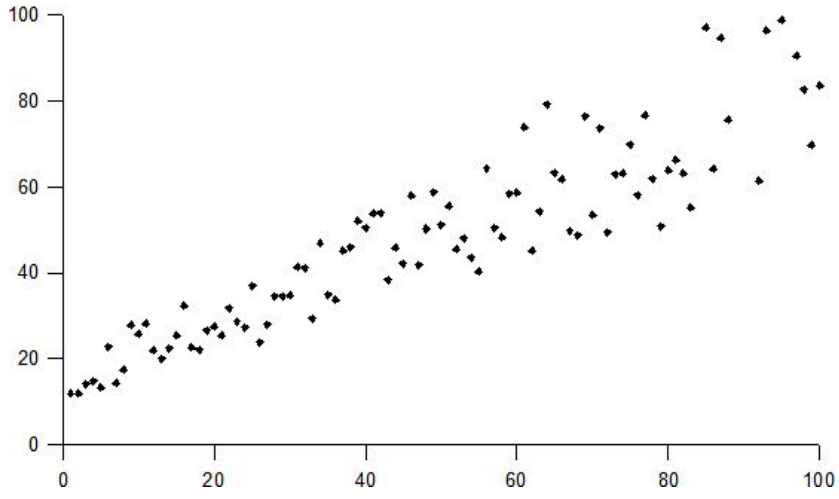
Generalized Autoregressive Conditional Heteroskedasticity

Volatility: Amount of variance across a time series.

Heteroskedasticity: "Uneven variance"



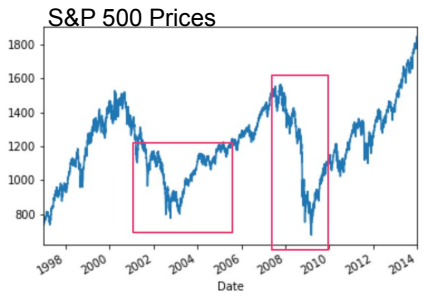
Heteroskedasticity

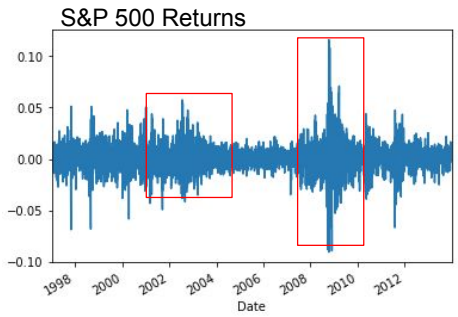


Volatile Periods in the US Stock Market

Volatility and returns tend to cluster.

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





Questions?