

# Time Series Statistical Models

FinTech  
Lesson 10.2



# Class objectives

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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)

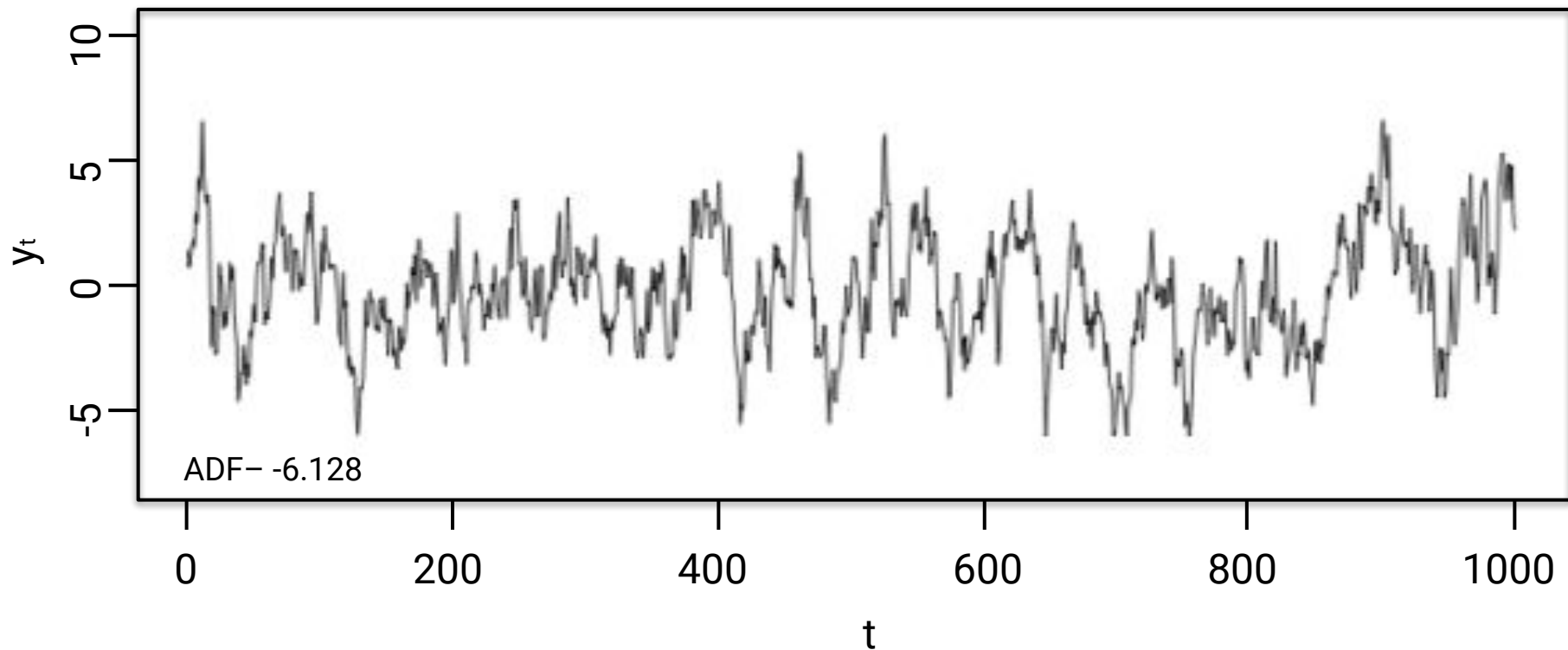


Generalized Autoregressive Conditional Heteroskedasticity (GARCH)

# Stationarity

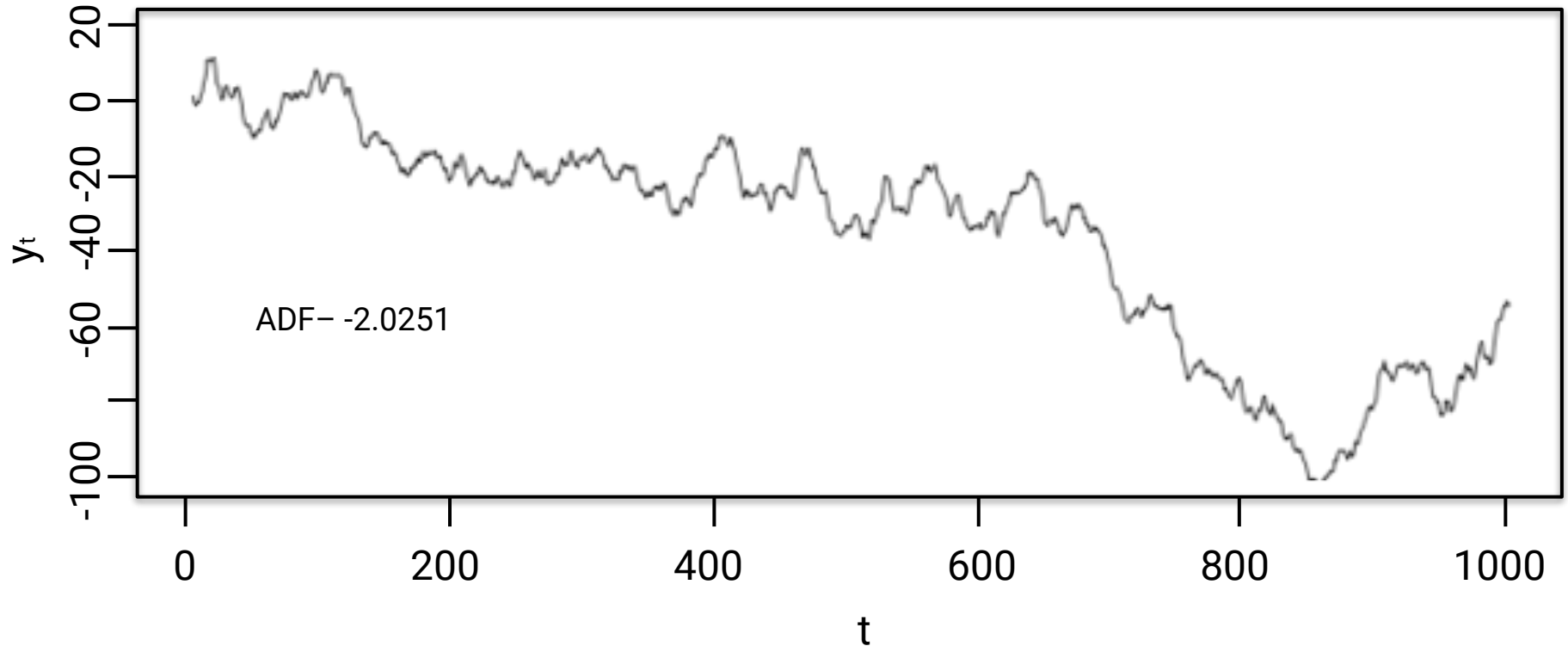
# Stationarity

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



# Non-stationary

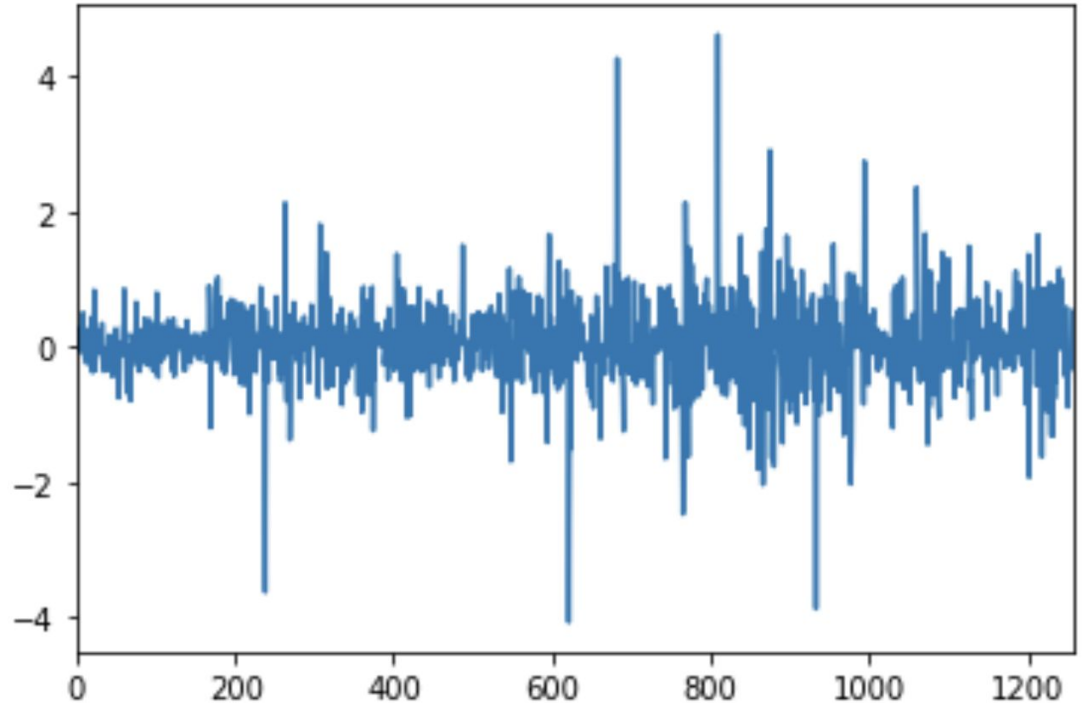
A time series with an upward or downward trend is **not stationary**.



# 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

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



# Auto-Regressive (AR) Models

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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

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

# AR Model Summary

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An AR model predicts future values based on:

01

Past values at a specified lag.

02

The number of significant lags.

# Moving Average Model

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



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

# ARMA Model

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Combines features of AR and MA models.



Past values and errors are used to predict future values.



# ARIMA



# ARIMA Model

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



Combines features of AR and MA models.



Past values and errors are used to predict future values.



**ARIMA** creates differences ( $\Delta y$ ) of the data as part of the process.

# AIC & BIC

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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.

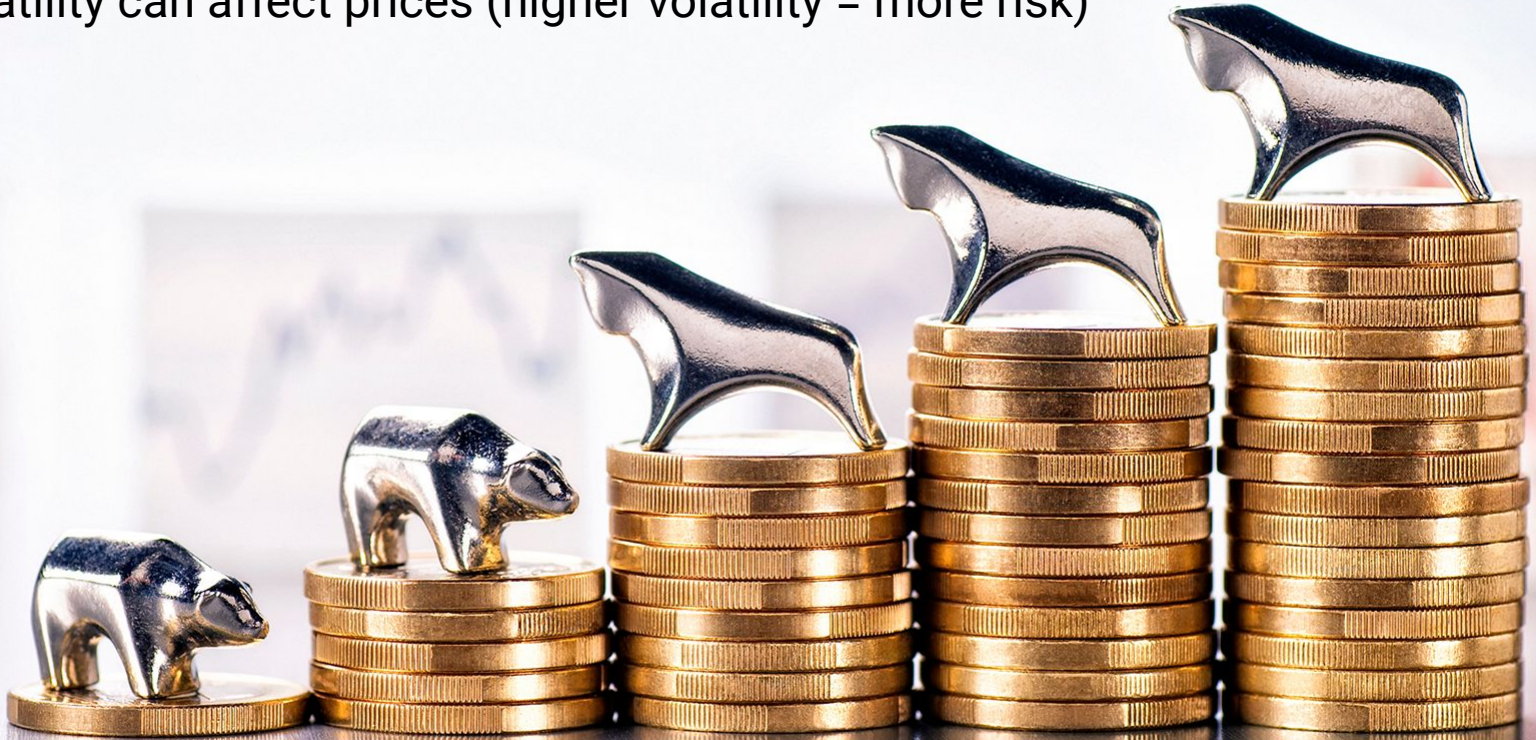


# **Why is Volatility Important to Understand?**

# Higher volatility = More Risk

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



# Diversified Portfolio

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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.



The background of the image is a blurred financial chart. It features a grid with various data points and lines. A hand is visible in the lower right, holding a pen and pointing at a smartphone screen. The chart includes vertical bars and lines with numerical values. A dark blue circle is overlaid on the left side, containing the text 'Volatility can beget volatility, i.e. cluster.'

Volatility  
can beget  
volatility,  
i.e. cluster.

+2,11 %  
-1,11 %  
+7,14 %  
-3,12 %

-4,28  
+13,28  
-11,28  
+17,28  
-2,28  
+13,28  
-11,28  
+17,28





# GARCH



# ARMA

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## Auto-Regressive component:

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

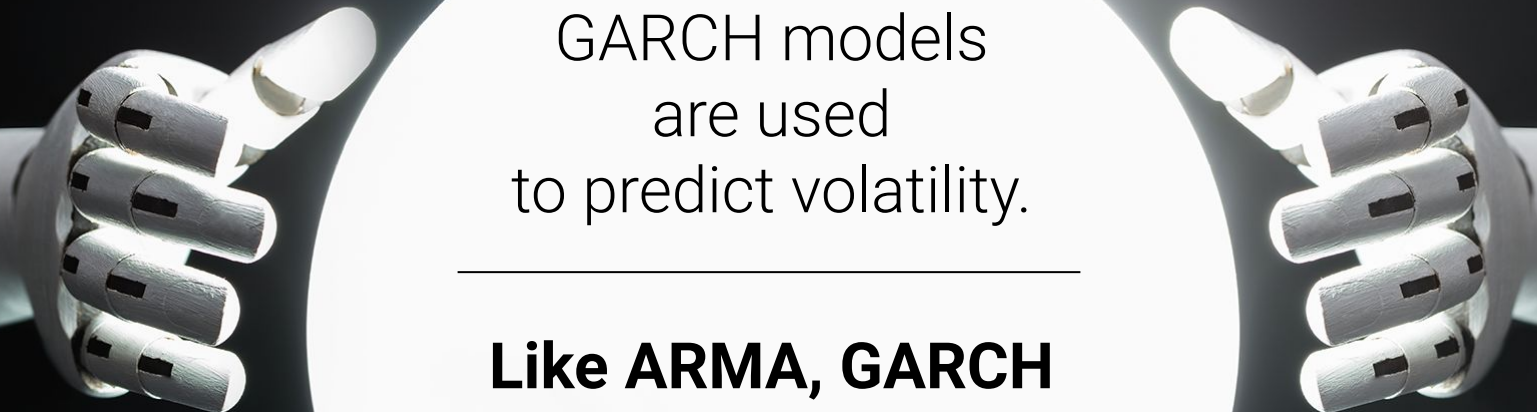
## Moving Average component:

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



# GARCH

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GARCH models  
are used  
to predict volatility.

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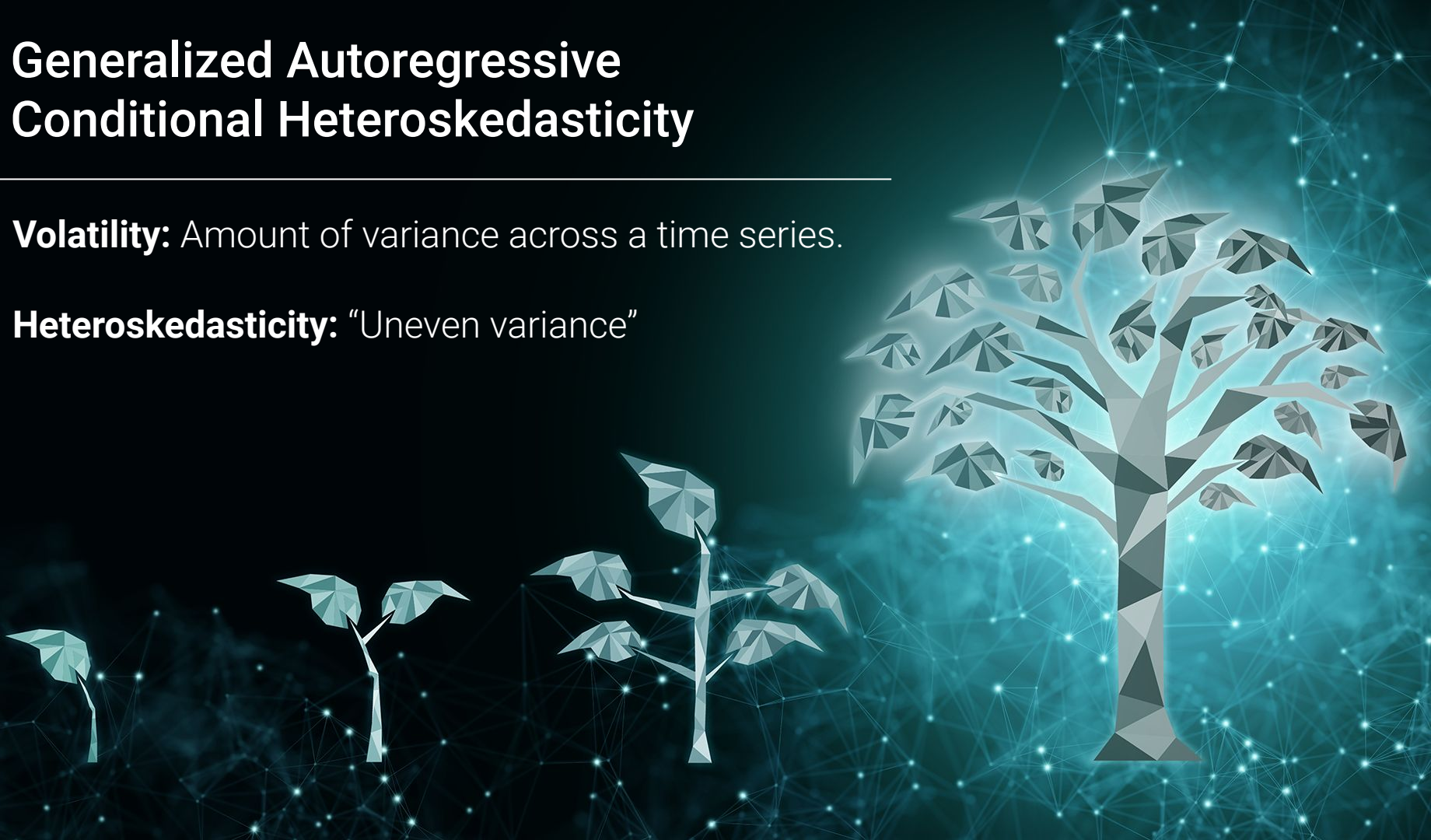
**Like ARMA, GARCH  
also has auto-regressive  
and moving average  
components.**

# Generalized Autoregressive Conditional Heteroskedasticity

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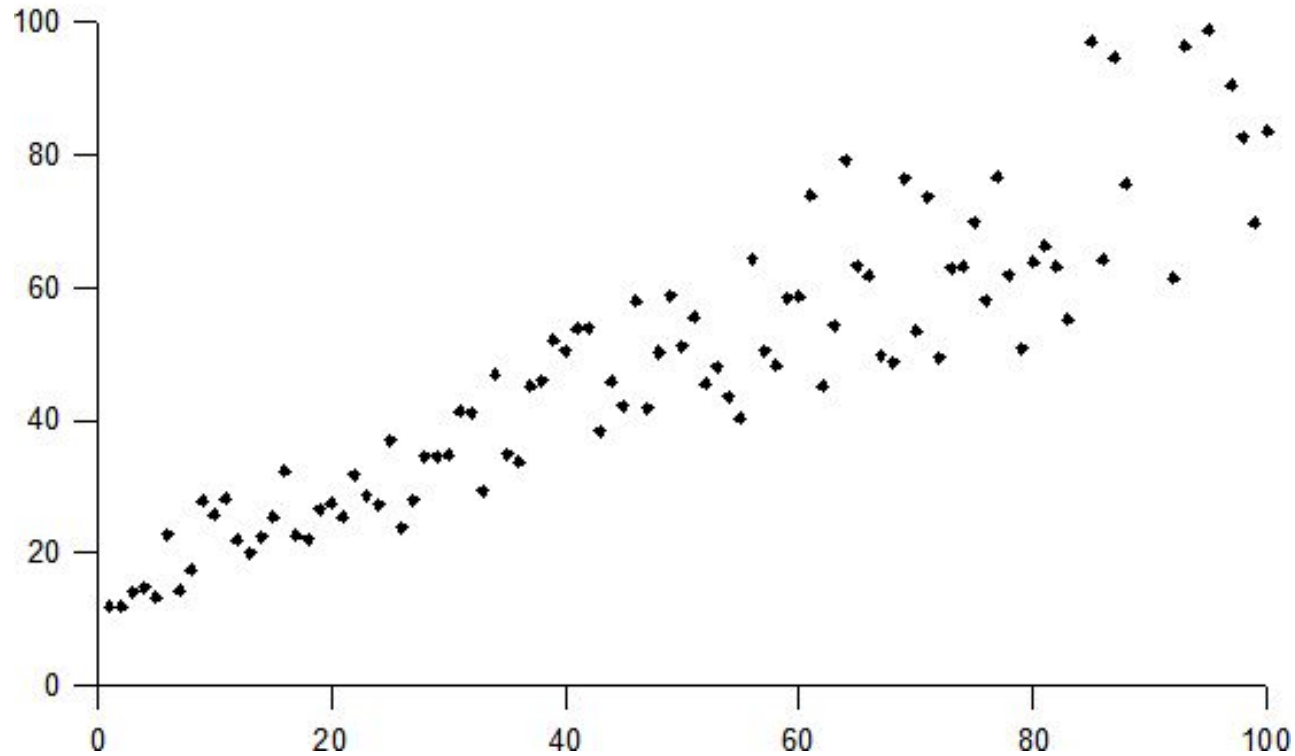
**Volatility:** Amount of variance across a time series.

**Heteroskedasticity:** “Uneven variance”



# Heteroskedasticity

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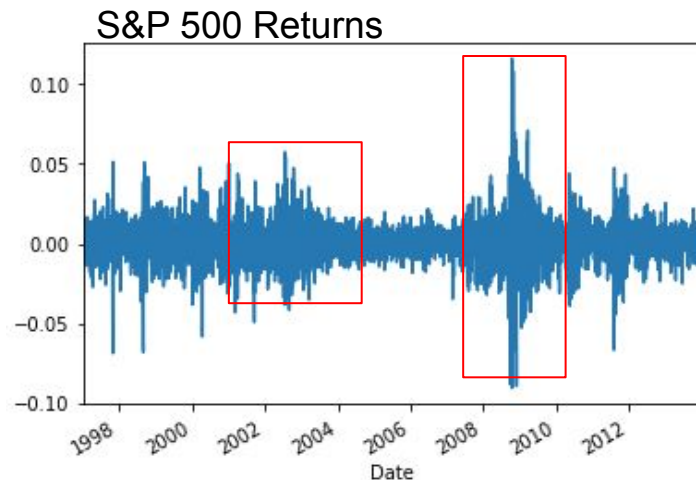
# Volatile Periods in the US Stock Market



Volatility and returns tend to cluster.



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





Questions?