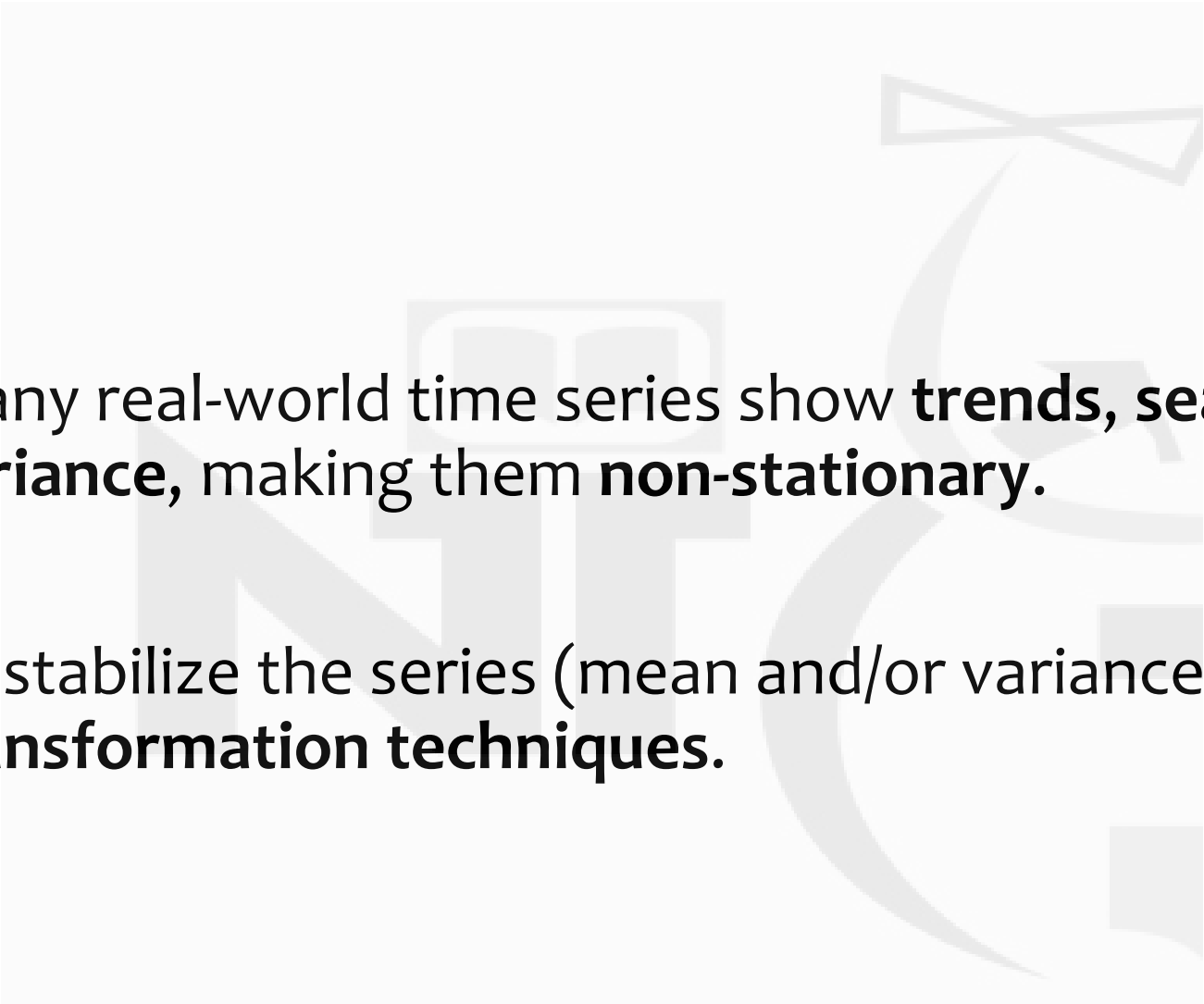


Making Time-Series Stationary

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- Many real-world time series show **trends, seasonality, or changing variance**, making them **non-stationary**.
 - To stabilize the series (mean and/or variance), we use various **transformation techniques**.

Transformation Techniques

- Differencing
- Log transformation
- Seasonal differencing

Differencing

Differencing involves **subtracting the current observation from the previous one** to remove trends and stabilize the mean.

Formula:

$$Y'_t = Y_t - Y_{t-1}.$$

Differencing

Purpose:

- Removes **trend**.
- Converts a **random walk** into a stationary series.

First-Order vs. Higher-Order Differencing:

- **First-order differencing**: one subtraction → removes linear trend.
- **Second-order differencing**: difference of the first differences → used if trend is nonlinear.

Notes:

- Don't over-difference — it can introduce unnecessary noise.
- Use **ADF test** after differencing to check for stationarity.

Log Transformation

Applying a logarithm to each data point to **compress the scale** and **reduce heteroscedasticity** (i.e., non-constant variance).

Formula:

$$Y'_t = \log(Y_t)$$

Purpose:

- Stabilizes **variance** when the magnitude of data increases over time.
- Useful for **exponential trends** or **multiplicative seasonality**.

Seasonal Differencing

Subtracting the value from the same season in the previous cycle (e.g., value from 12 months ago in monthly data).

Formula:

$$Y'_t = Y_t - Y_{t-s}$$

Where **s** is the seasonal period (e.g., $s = 12$ for monthly data with yearly seasonality).

Purpose:

- Removes **seasonal patterns** while preserving long-term trends.

Seasonal Differencing

Notes:

- Often used before applying **SARIMA**.
- Can be combined with **regular differencing** if both seasonality and trend exist.