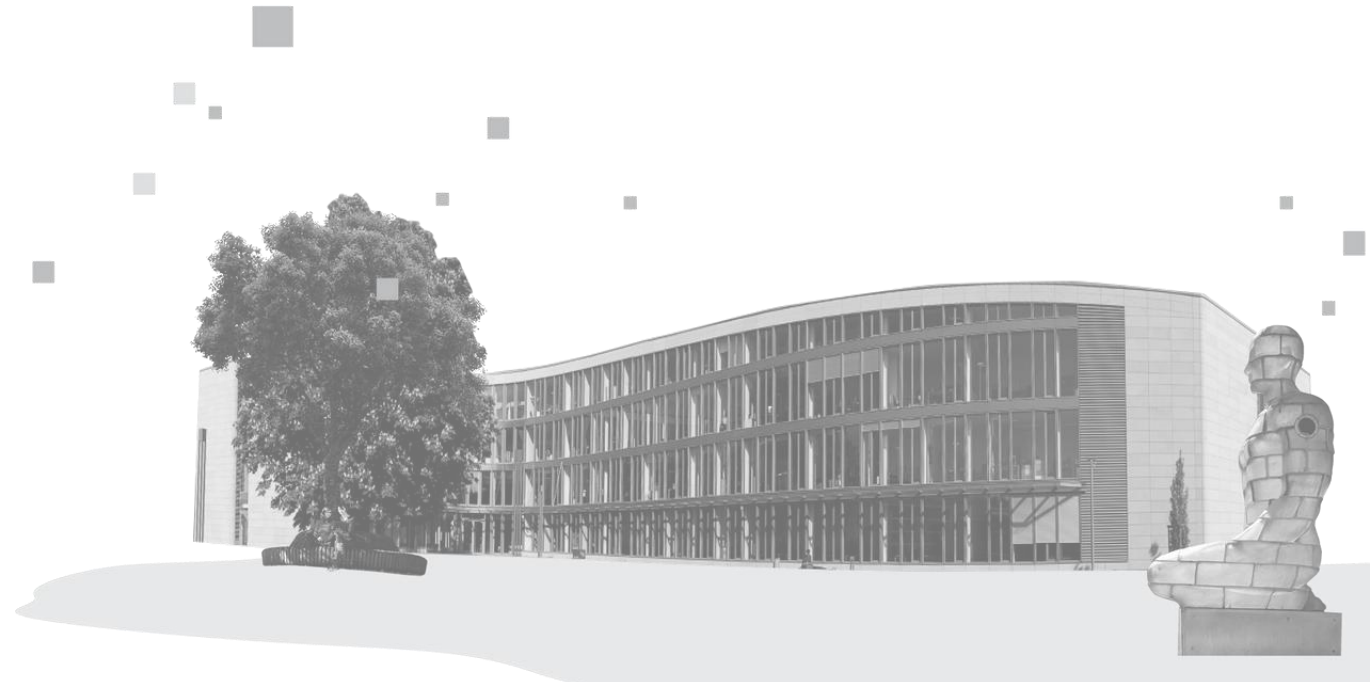# Time Series Forecasting

1.5 Forecasting Time Series

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What we'll cover in this video

- Understanding Forecastability: How predictable is a time series?

- Methods to assess forecastability

- Common Forecast Accuracy Metrics

- Interpreting metrics for better forecasting

Understanding Forecastability

*How predictable is a time series?*

- Forecastability refers to how well future values of a time series can be predicted based on its past observations.

- Some time series exhibit strong, consistent patterns that make forecasting easier.

- Others are more random or noisy, making accurate prediction challenging.

- Assessing forecastability helps decide if forecasting is worthwhile and guides method selection
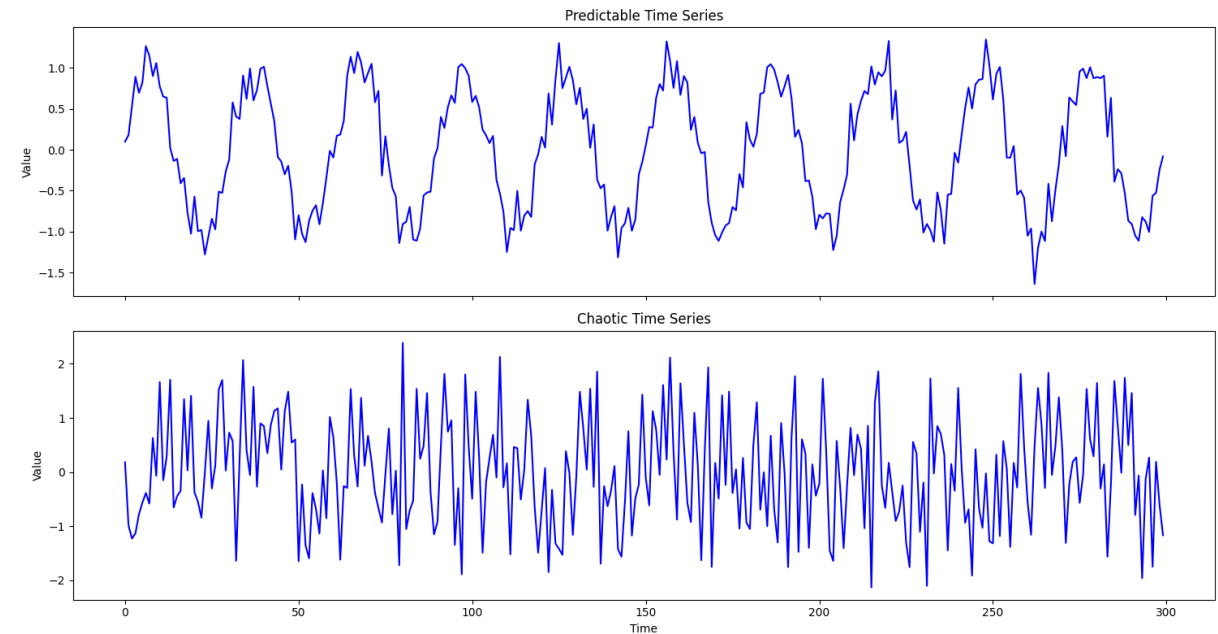
Forecastability Measures

Coefficient of Variation (CV)

- CV is the ratio of the standard deviation to the mean of a time series.

- It provides a standardized measure of relative variability, allowing comparison between series with different scales.

- Interpretation:
    - A lower CV indicates less relative variability, meaning the series is more stable and generally easier to forecast.
    - A higher CV suggests greater relative fluctuations and more unpredictability.
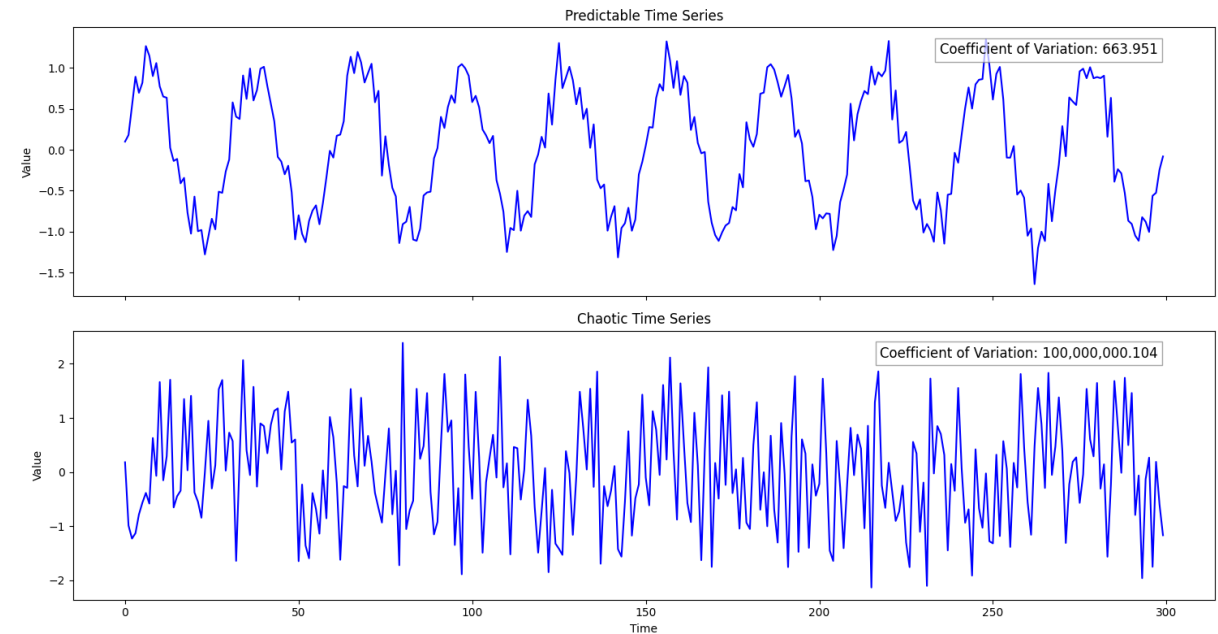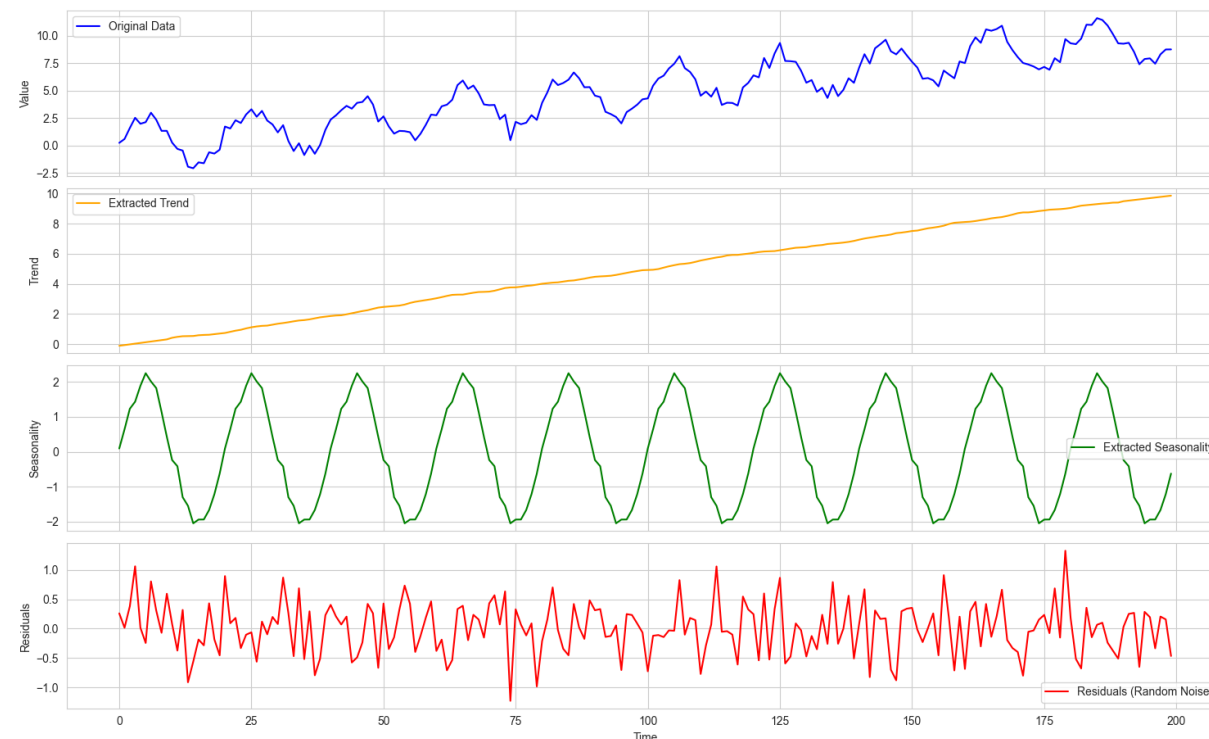
Forecastability Measures

Residual variability

- Residual variability measures the unpredictability that remains after removing known structures like trend and seasonality.

- It helps assess how much of the time series can be explained by patterns, and how much is purely random noise.

- Interpretation:
  - Lower residual variability: Indicates that most patterns have been captured, making forecasting easier.
  - Higher residual variability: Suggests a high level of randomness, making forecasting difficult.


Time Series Decomposition: Original Data, Trend, Seasonality, and Residuals

Forecastability Measures

Entropy-Based Measures

- Entropy measures the level of randomness or uncertainty in a time series.
- A series with low entropy has more structure and predictability.
- A series with high entropy is more random and harder to forecast.
- Common Approaches:
  - Approximate Entropy (ApEn): Quantifies the likelihood that patterns repeat in the time series.
  - Sample Entropy (SampEn): Similar to ApEn but more consistent and less biased for short data series.
- Interpretation:
  - Lower entropy → easier to forecast.
 - Higher entropy → less predictable.
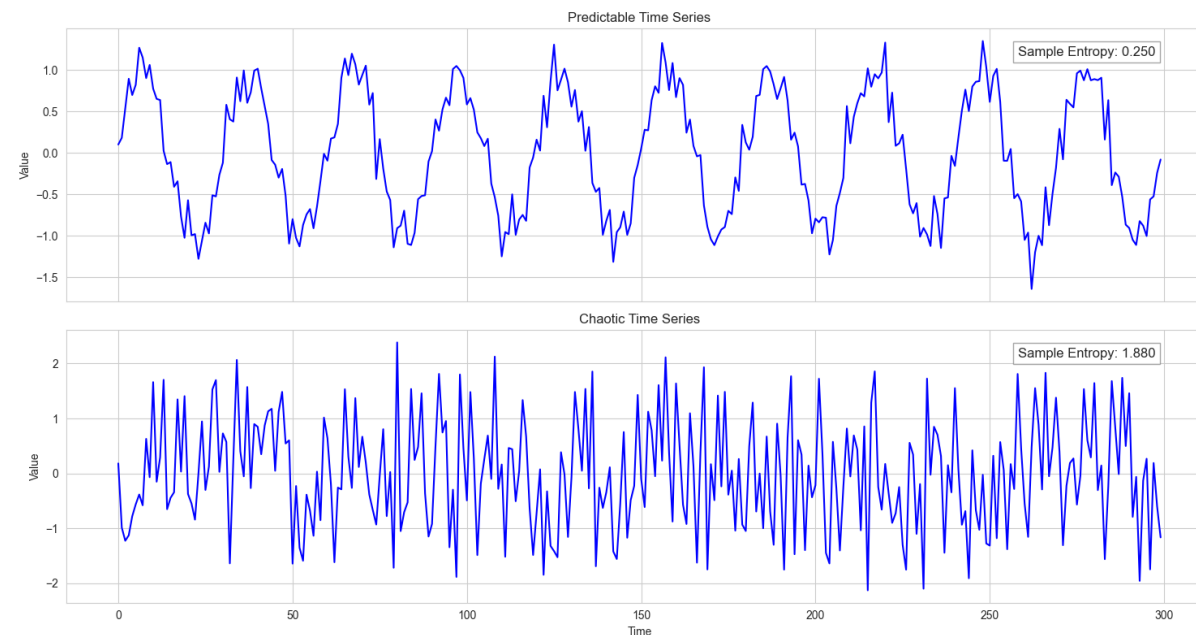
Forecastability Measures

Kaboudan Metric

- This metric quantifies how inherently predictable a time series is by comparing its forecasting error to that of a randomized version.

- Method:
  - Train a forecasting model and compute the sum of squared errors: SSE_n on the original series.
  - Randomly shuffle the series in blocks (breaking temporal structure) to create a shuffled version.
  - Forecast again, computing SSE_s on the shuffled series.
  - Compute the Kaboudan metric:

    $$1 - \frac{SSE_n}{SSE_s}$$

  - A higher value (close to 1) indicates the series is much more predictable than random noise; a lower value (near 0) suggests low predictability
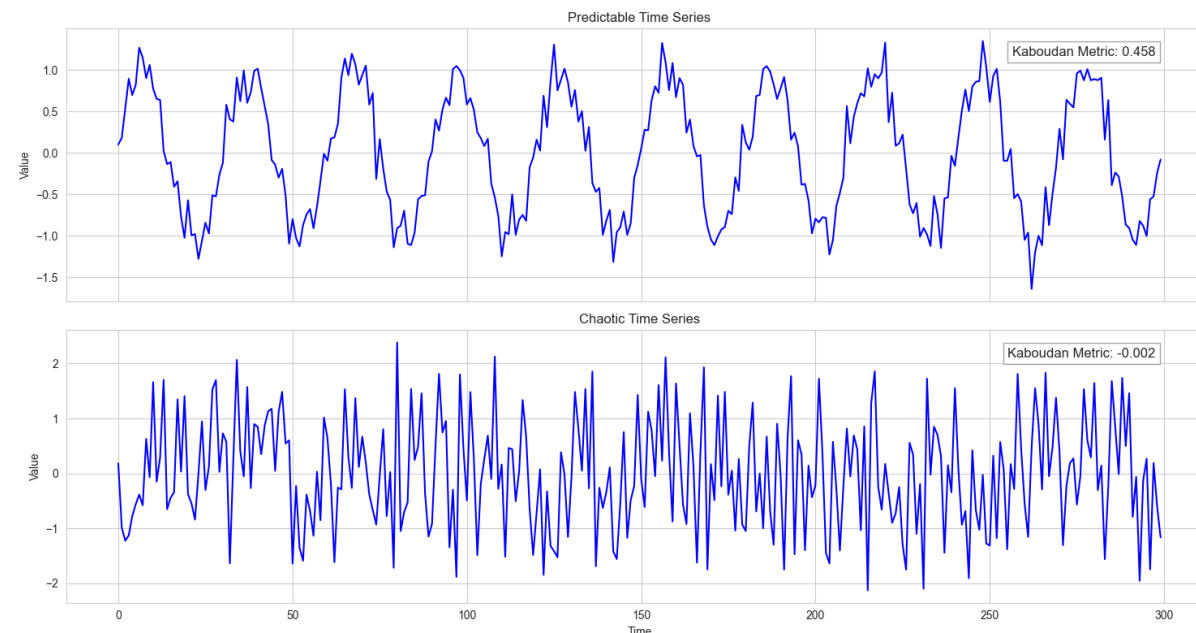
Common Forecast Accuracy Metrics

- **Mean Absolute Error (MAE)**:
  - Average of absolute differences between predicted and actual values
  - Easy to interpret, same units as the data

- **Mean Squared Error (MSE)**:
  - Average of squared differences between predicted and actual values
  - Penalizes larger errors more than MAE

- **Root Mean Squared Error (RMSE)**:
  - Square root of MSE.
  - Same units as data; emphasizes larger errors

- **Mean Absolute Percentage Error (MAPE):**
  - Average absolute error expressed as a percentage of actual values.
  - Useful for comparing across datasets with different scales.

- **Forecast Bias**:
  - Measures systematic over- or under-prediction.
  - Positive bias means over-forecasting; negative means under-forecasting.

What we've learnt

- Forecastability helps us understand whether a time series is predictable at all, using measures like:

  - Coefficient of Variation

  - Residual Variability

  - Entropy-Based Measures

  - Kaboudan Metric

- Forecast Accuracy Metrics allow us to evaluate how well our models perform, including:

  - Mean Absolute Error (MAE)

  - Mean Squared Error (MSE) and Root Mean Squared Error (RMSE)

  - Mean Absolute Percentage Error (MAPE)

  - Forecast Bias

- Before investing effort in forecasting, it's important to assess predictability of the data, then use appropriate accuracy metrics to measure model performance.