Time Series

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Introduction. Time series are commonly thought as a superposition of several components

- *Trend*: long-term direction of time series
- *Seasonal*: pattern that repeats with known and fixed periodicity
- *Cycle*: pattern that repeats but with unknown und changing periodicity.
- *Autocorrelation*:
- *Error*: unpredictable component of time series.

The aim to time series modelling is to capture all effects until only error (=noise) is left. More precisely if there ist still come uncaptured trend, seasonal, cylce or autocorrelation then we can be pretty sure that we can improve the model. However, this does not imply that a model that just has unexplained white noise cannot be improved.

Model diagnostics. The autocorrelation function (ACF) is the Pearson correlation of a time dependent random variable Y_t with itself shifted in time by τ.

$$\rho(\tau) = \frac{\sum_{t=\tau+1}^{T} (y_t - \bar{y})\,(y_{t-\tau} - \bar{y})}{\sum_{t=1}^{T} (y_t - \bar{y})^2} \tag{1}$$

The autocorrelation function depends on τ. For white noise 95 % of its (τ-dependent) values are within the interval $\pm 2/\sqrt{T}$. Thus the and is used to identify white noise. [1]

Definition 1 (Evaluation metrics)**.** *Let y_t be the observed time series and $\hat{y}_t$ the corresponding predictions of T timesteps.*

- *Mean absolute error:* $\frac{1}{T}\sum_{t=1}^{T}|y_t - \hat{y}_t|$
- *Mean squared error:* $\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2$.
- *Root mean squared error:* $\sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}$
- *Mean absolute percentage error*
- *Symmetric mean absolute percentage error*
- *Huber loss:*
- *ρ-risk metric:*

Overview of methods

- Regression models
- Exponential smoothing methods
- Arima
- Dynamic Regression
- Hierarchical forecasting
- Vector autoregression
- Neural networks
- survival analysis

Transformations.

References

[1] Robin John Hyndman and George Athanasopoulos. *Forecasting: Principles and Practice.* OTexts, Australia, 2nd edition, 2018.