Time-series Analytics

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Introduction

Time Series (brief recall from early lectures)

- A *time-series* is a set of observations on a quantitative variable collected over time.
- Examples
  - Dow Jones Industrial Averages
  - Historical data on sales, inventory, customer counts, interest rates, costs, etc.
  - Signal processing, pattern recognition, econometrics, mathematical finance, weather forecasting, earthquake prediction, electroencephalography, communications engineering, …
- Businesses are often very interested in analyzing and forecasting time series variables

Time series analysis

A statistical technique that uses time-series data for explaining the past and forecasting future events

1st foundational concept

Stationarity

Fact

If a time series is stationary,…

… it is predictable

Definition

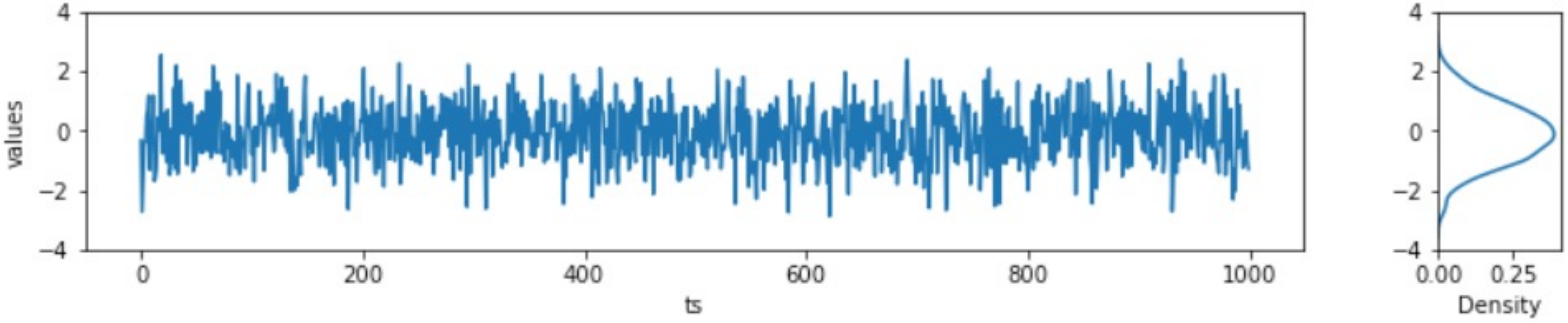
A **stationary** time series is one whose **properties do not depend on the time** at which the series is observed.

Let’s build the intuition of **stationarity**

Stationarity

White noise: the perfect time series

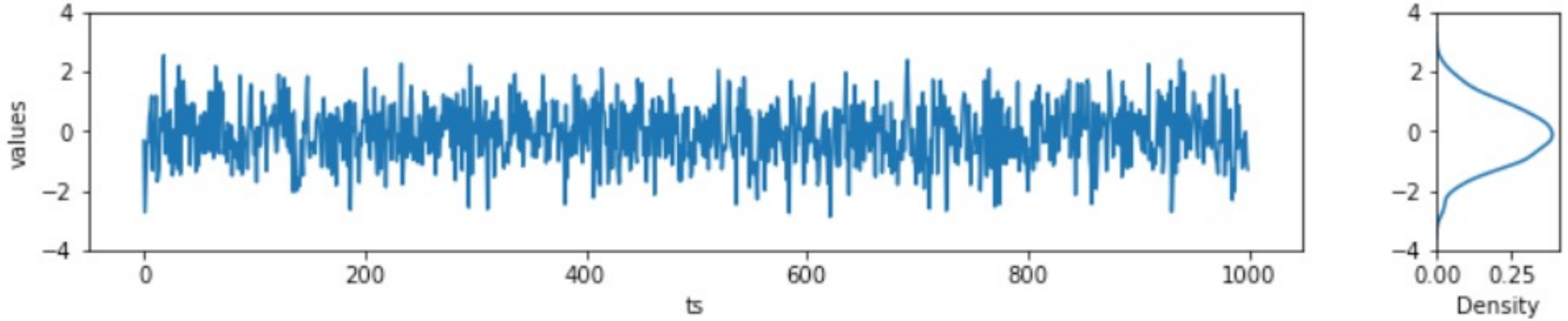
- A sequence of random numbers with zero mean and finite variance

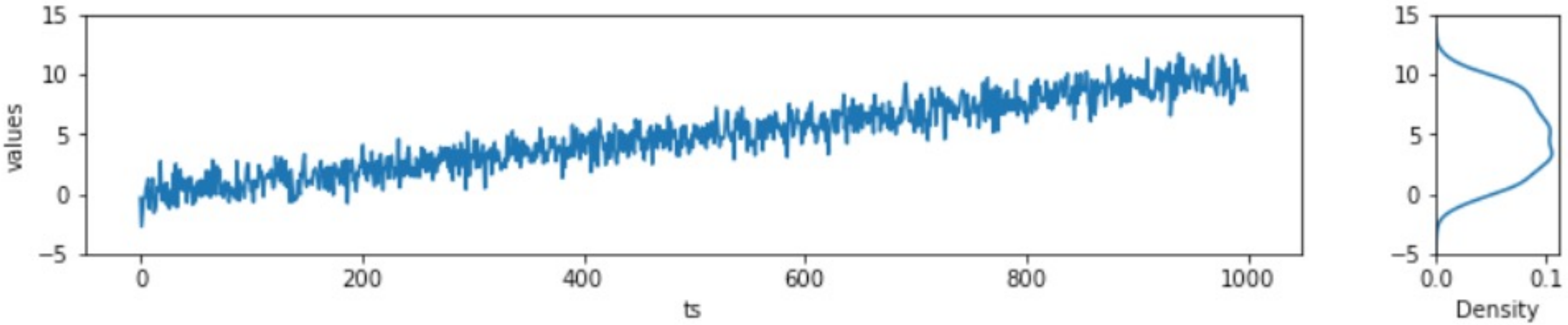


- NOTE: indeed it is perfectly predictable
  - If you predict 0 (the mean), you minimize the error (which is proportional to the variance)

Stationarity

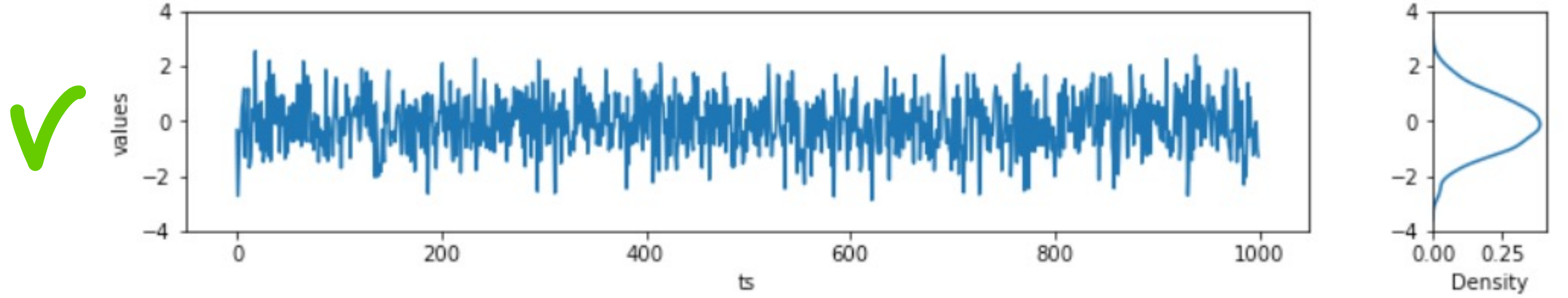
Mean is **constant** over time (a.k.a., with trend)

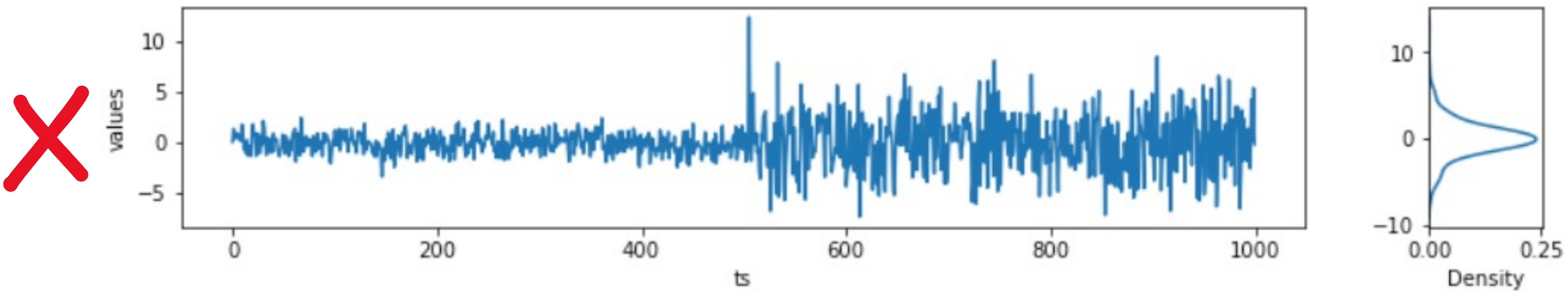




Stationarity

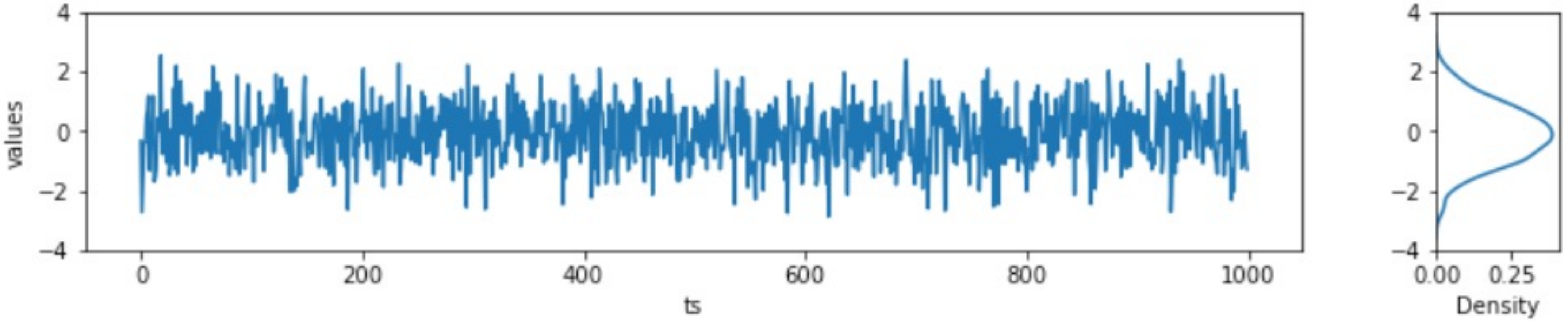
Variance is **constant** over time

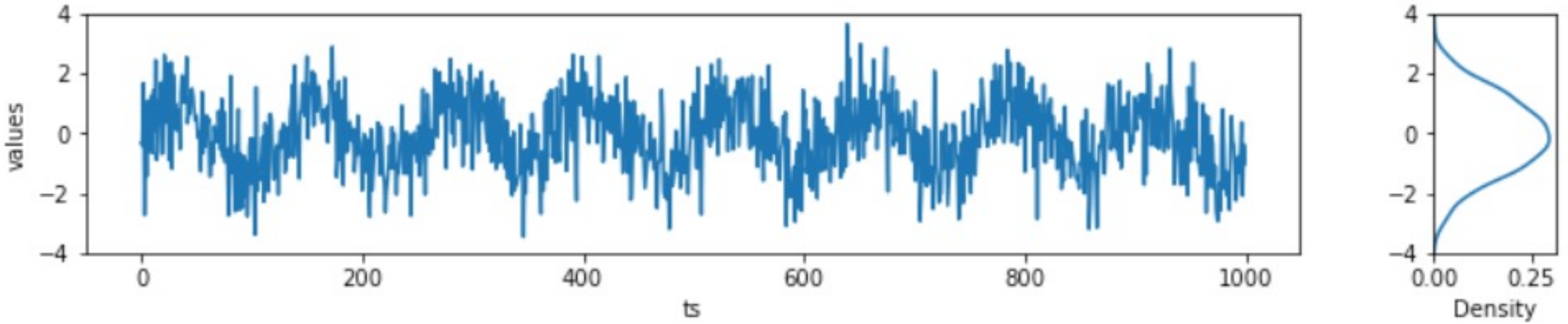




Stationarity

No repetitive pattern (a.k.a. **seasonality**)

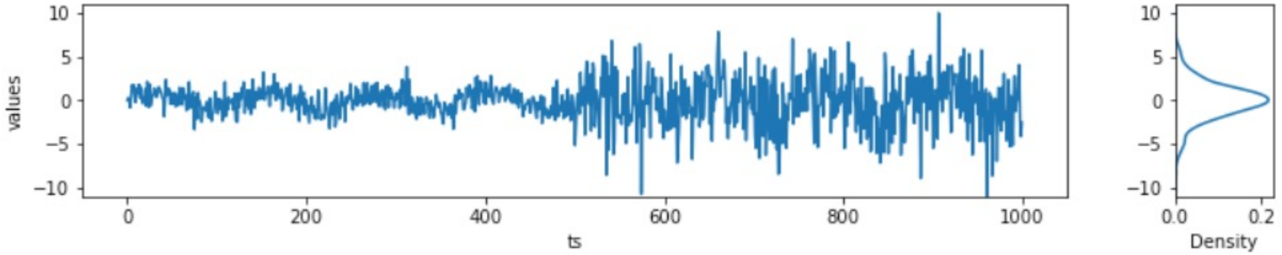




Stationarity
No combinations of the previous ones :-P

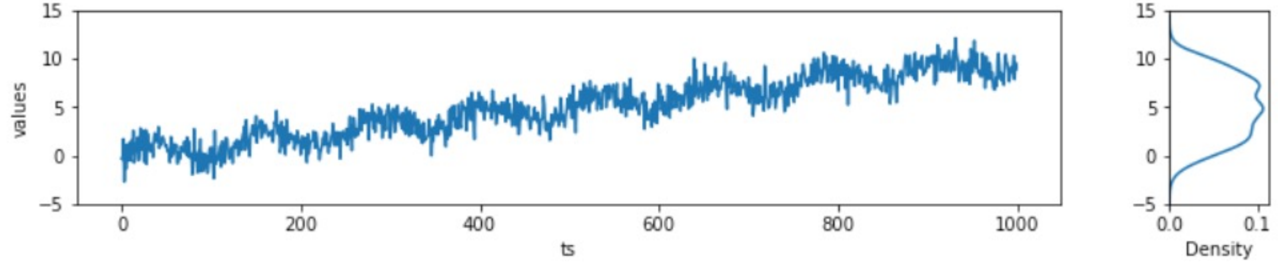
non-constant variance

+ seasonality



non-constant mean

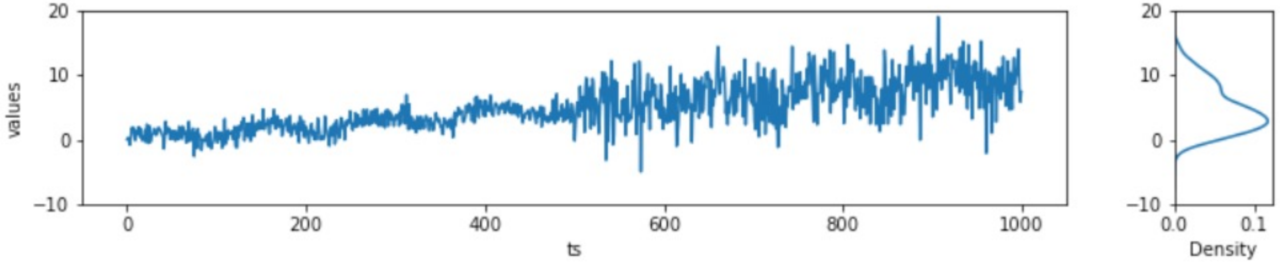
+ seasonality



Non-constant mean

+ non-constant variance

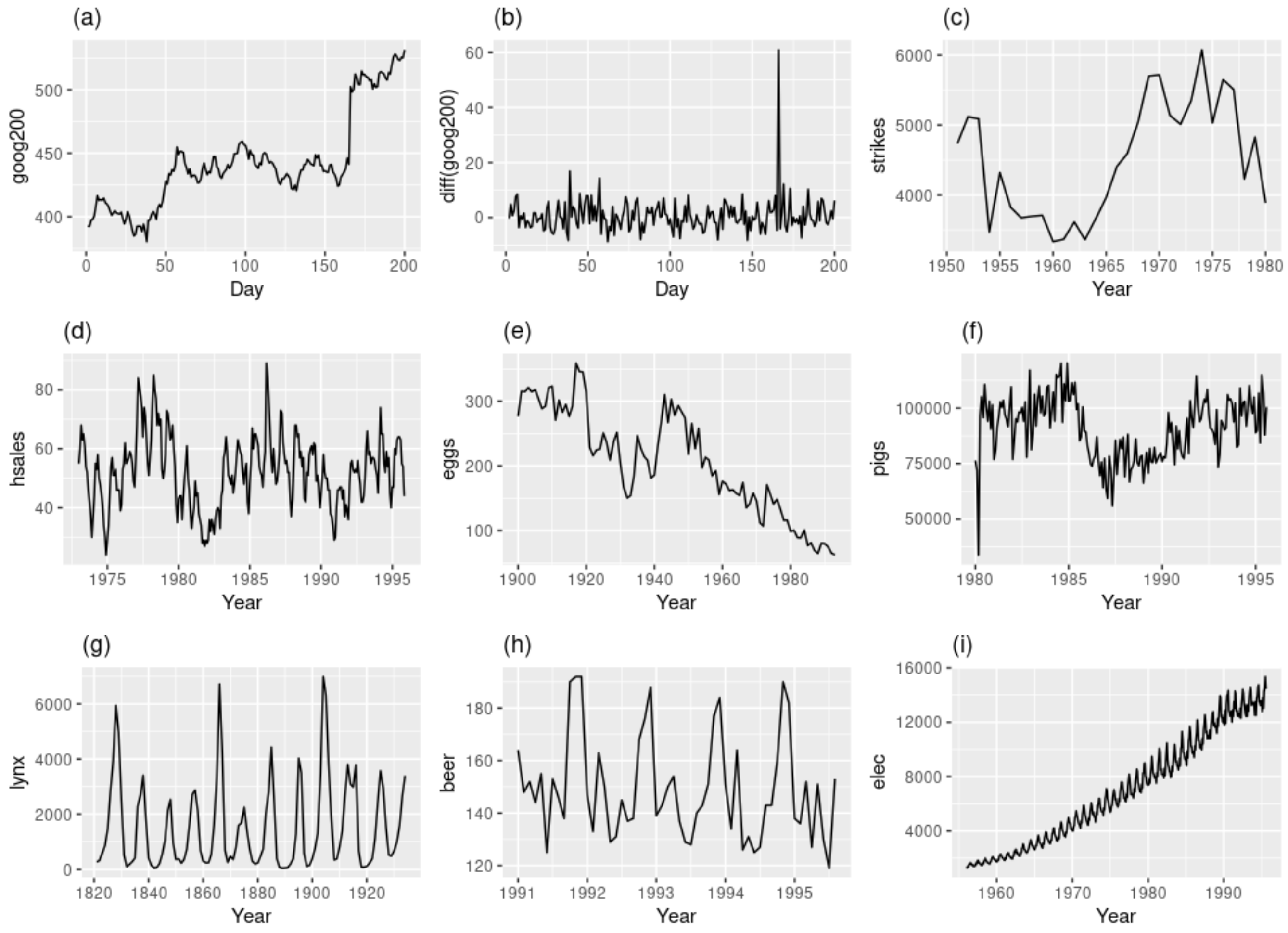
+ seasonality



Stationarity

Let’s see if you got the point

- Which of these time series is stationary?
- Why?



Quiz

Formally…

Photo by George Becker from Pexels

Stationary
Formal definition

- Let $\{X_t\}$ be a stochastic process and let $F_X(t_{1+\tau}, \ldots, t_{k+\tau})$ represent the cumulative distribution function of the unconditional (i.e., with no reference to any particular starting value) joint distribution of $\{X_t\}$ at times $t_{1+\tau}, \ldots, t_{k+\tau}$.
- Then, $\{X_t\}$ is said to be **strictly stationary, strongly stationary or strict-sense stationary** if

$$F_X(t_1, \ldots, t_k) = F_X(t_{1+\tau}, \ldots, t_{k+\tau}) \text{ for any } \tau \text{ e } k.$$

How to **test** for **stationarity**

Stationary

By hand …

1. Load a time series
2. Split it two parts
3. Compute mean and variance of the two parts
4. Compare them

Stationary

Statistical tests

- We can test for stationarity using statistical tests called **Unit Root Tests**.
- ADF test: Augmented Dickey Fuller test
- KPSS test: Kwiatkowski-Phillips-Schmidt-Shin test

Stationarity

2^{nd} Quiz

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