

## Time Series

→ Time / Temporal dependent

$t$  = time period [index of EQUAL time periods]

$Y$  = value (data) [A series of  $n$  values over  $n$  time periods.]

$F$  = forecast value [Forecasted value for a time period]

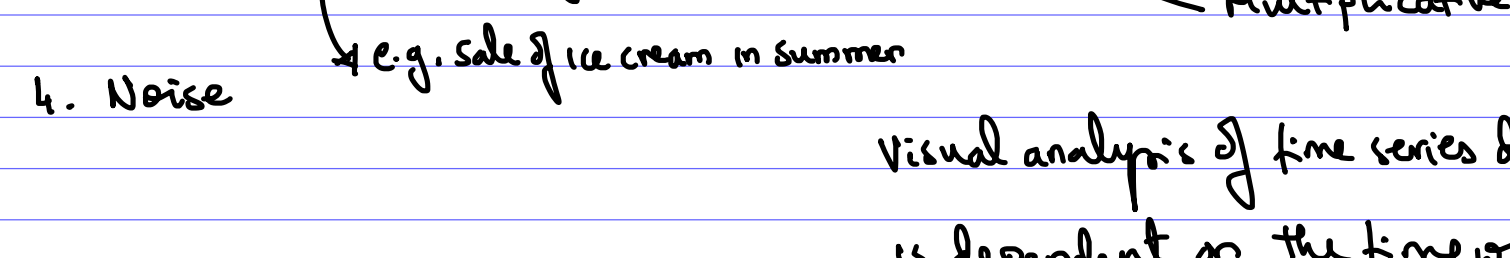
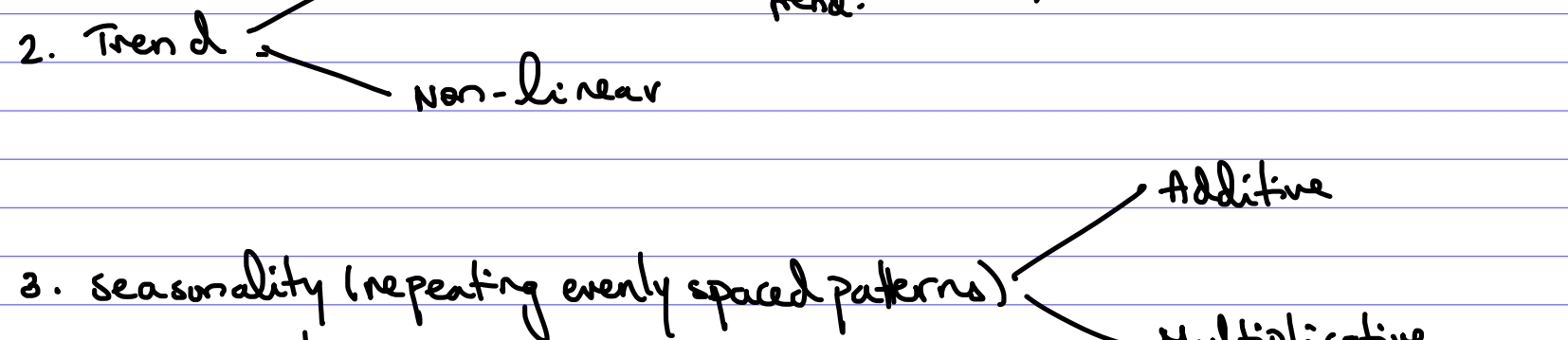
$e$  = forecast error [Forecast error at time  $t$  is  $e_t$ . i.e.  $Y_t - F_t$ ]

$i$  = equal steps forward / backwards e.g.  $Y_{t+i}$

$$\left| \text{Percentage error} = \frac{Y_{t+1} - \hat{F}_{t+1}}{Y_{t+1}} = \frac{e_{t+1}}{Y_{t+1}} \right|$$

## \* Creating & evaluating forecasts

### Time Series Components



Visual analysis of time series data is dependent on the time window.

$$\boxed{\text{Original Time series Data} - \text{Trend} - \text{Seasonality} = \text{Noise or Residual}}$$

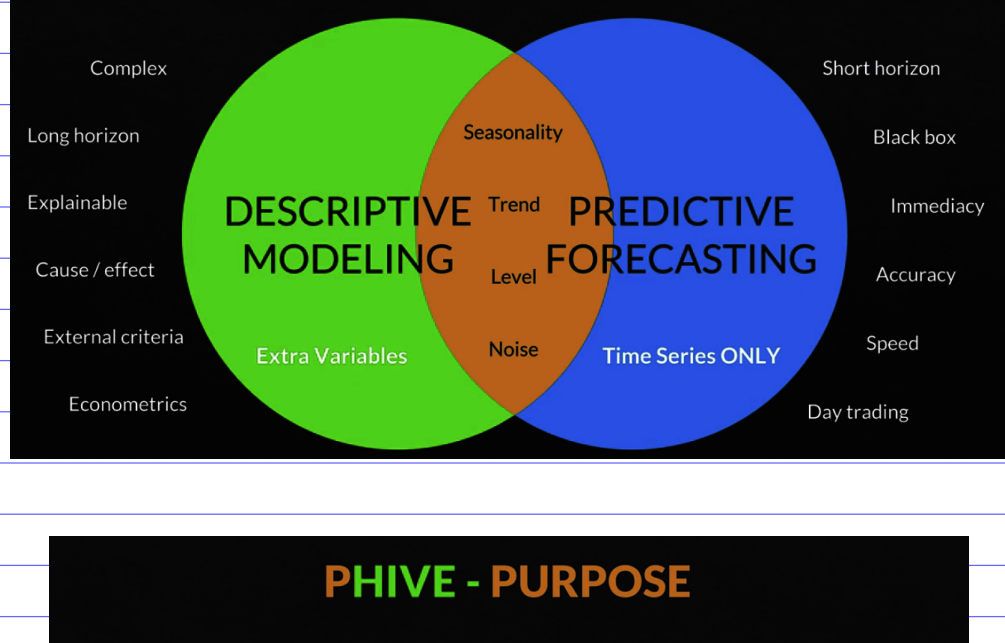
### Two basic component models

1. Additive:  $Y_t = \text{level} + \text{trend} + \text{seasonality} + \text{noise}$

2. Multiplicative:  $Y_t = \text{level} \times \text{trend} \times \text{seasonality} \times \text{noise}$

- The main difference is that in additive change, values change by a **constant amount**. With multiplicative change, values change by a **percentage amount** and often take on "V" shapes or curves.
- When conducting time series analysis and/or making predictions, we are essentially **deconstructing the time series** back to a constant level; flattening the series, removing trend and seasonality
- Some time series methods REQUIRE / ASSUME a constant trend

\* **Foundational idea of forecasting**: Robust accurate forecasts are made when future conditions are like past conditions



- #### PHIVE - PURPOSE
- We should first express a defined and specific **purpose**, use, or reason for generating the forecast.
    - Business decisions? (Stock buybacks, hiring cadence, investments, etc.)
    - Planning purposes? (Resourcing, staff allocation, policy, etc.)
    - Optimization strategy? (Supply / demand, inventory planning, etc.)
  - Allow the **purpose** to inform the forecasting process.
  - Once the forecast is generated how will it be used and shared?
  - What action(s) may result of the forecast outcome?

- #### PHIVE - HORIZON
- Related to the purpose is the **horizon**; how far into the future do we wish to forecast and why? Tolerance for uncertainty?
  - Oftentimes, the length of the forecasting horizon is directly related to the scope and complexity of past information used to make the forecast.
    - Short-term forecasting values the most recent information.
    - Long-term forecasting necessitates both a larger quantity and wider variety of information and possibility the inclusion of other variables.
  - What is the starting point, aggregation level, and scale?

- #### PHIVE - INFORMATION
- What **information** is available and what are its characteristics?
    - Public? Proprietary? Accurate? Timely? Standard? Niche? Automatic? Manual? Clean? Dirty? Gaps?
  - Of the available information, what is necessary to meet the needs of the forecast purpose and horizon?
  - What information is most stable vs more volatile?
  - When will the information be available? Is it subject to revision?
  - Can estimations be used?

- #### PHIVE - VALUE
- What are the stakes for the forecast being (in)correct? How **valuable** is the accurate forecast? How meaningful?
  - I use the weather forecast to know when to mow my lawn. Is that high stakes? Health models for vaccine production?
  - A company forecasting supply / demand might pay a lot for an accurate forecast since so many other aspects of the business are dependent on supply / demand; interdependence.
  - Is the forecast a high-value input to another forecast or decision process?

- #### PHIVE - EVALUATION
- Point forecasts are largely meaningless; interval forecasts are best.
  - A forecast without continuously **evaluating** its effectiveness and then adjusting as necessary is just fiddling around.
  - It is very common for forecasters to never go back and evaluate the forecast performance! Iterative review and adjustment almost always makes forecasting more accurate.

\* Interpolation vs extrapolation

\* Regressions vs Forecasting

\* How long into the future are we looking to forecast? (Horizon)

\* Quantitative VS Qualitative

↳ e.g. launching product for the first time

No prior data to aid forecasting