# Time Series Decomposition

## Introducing classical models (Additive, Multiplicative)

TADA S2 - 2022.11.05
Hyungjin Kim

# Time Series Decomposition

## What does 'decomposition' mean?

One approach to time series analysis is based on smoothing past data
in order to separate the **underlying pattern** in the data series from randomness

can be projected into the future and used as the **forecast**

can be broken down into **sub patterns** to identify **the component factors**

# Decomposition

# Time Series Decomposition

## Components

### Systematic

Level Trend Seasonality

### Non-Systematic

Noise

A combination of these components
= A series

$$y_t = f(S_t, T_t, R_t)$$

where,

- $y_t$ = data at period t
- $T_t$ = trend-cycle components at period t
- $S_t$ = seasonal component at period t
- $R_t$ = remainder(Noise) components at period t

# Time Series Decomposition

## Classical Decomposition Models

assume that the **seasonal component is constant** from year to year

***How to combine these components?***

**Additive**

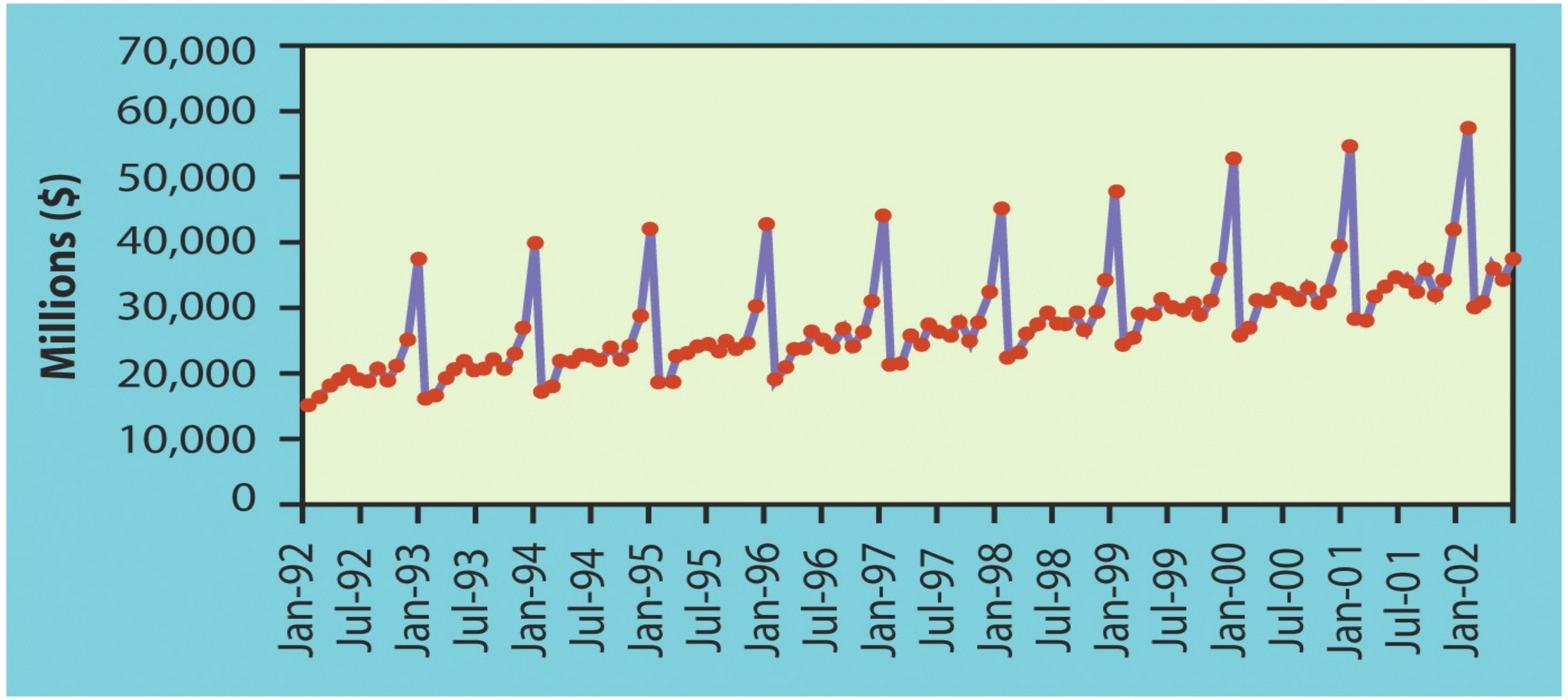
$y_t = S_t + T_t + R_t$

**Multiplicative**

$y_t = S_t * T_t * R_t$

# Additive Decomposition

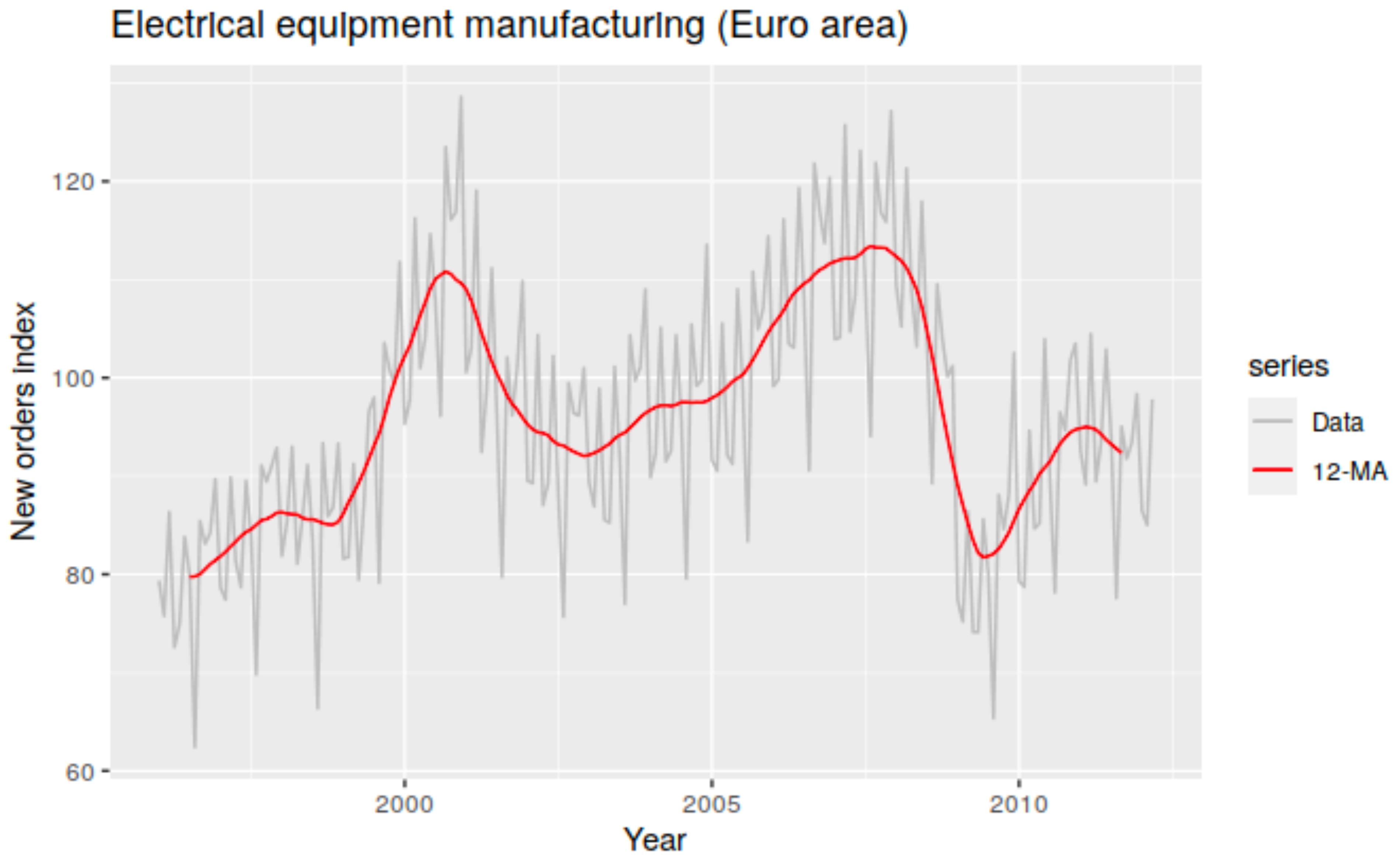
**Time series data is a function of the sum of its components**




Appropriate if the magnitude of the seasonal fluctuation **does not vary** with the level of the series

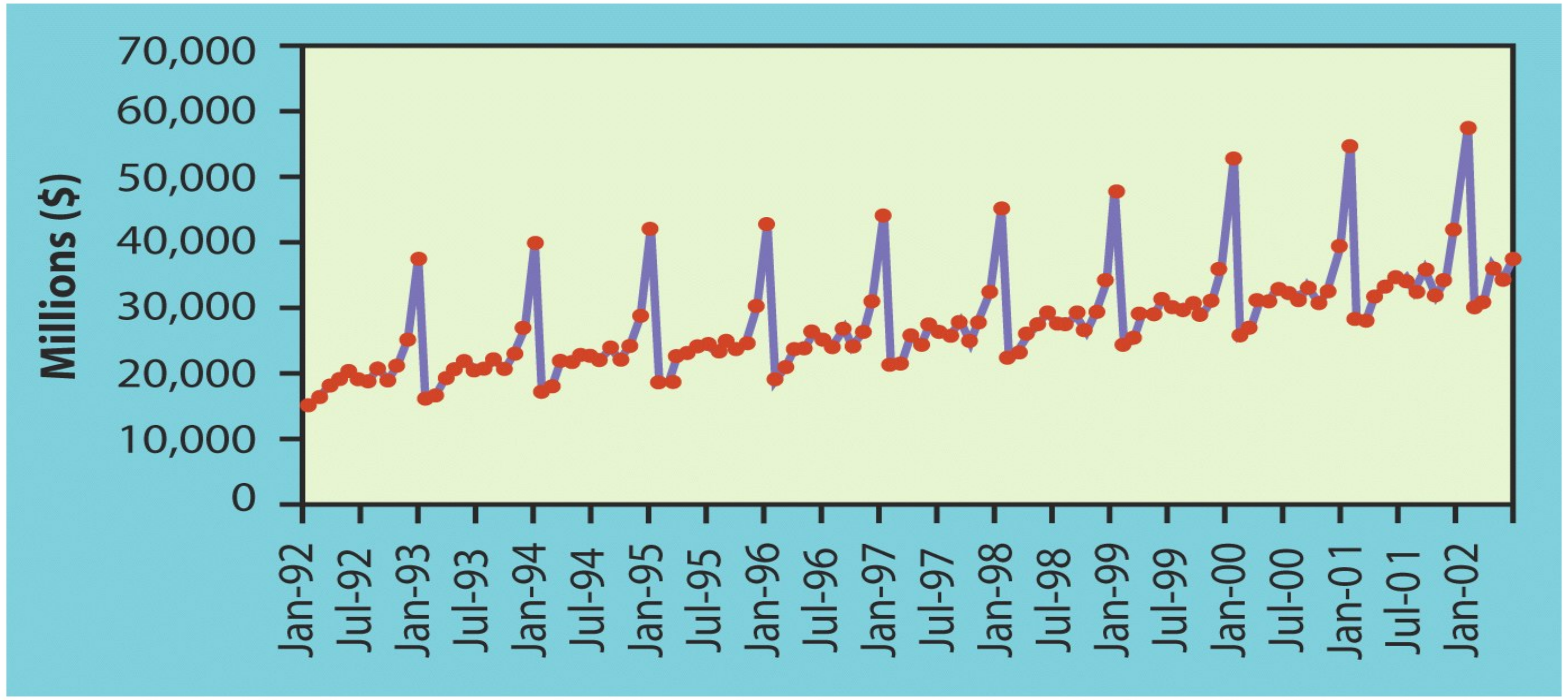
**Step 1.**

Compute trend-cycle($T_t$) using MA(Moving Average)



# Additive Decomposition

**Time series data is a function of the sum of its components**




Appropriate if the magnitude of the seasonal fluctuation **does not vary** with the level of the series

**Step 1.**
Compute trend-cycle($T_t$) using MA(Moving Average)

If period(m) is an **odd** num: m - MA
If period(m) is an **even** num: 2 * m - MA

**Step 2.**
Calculate the detrended series ($y_t$ - $T_t$)

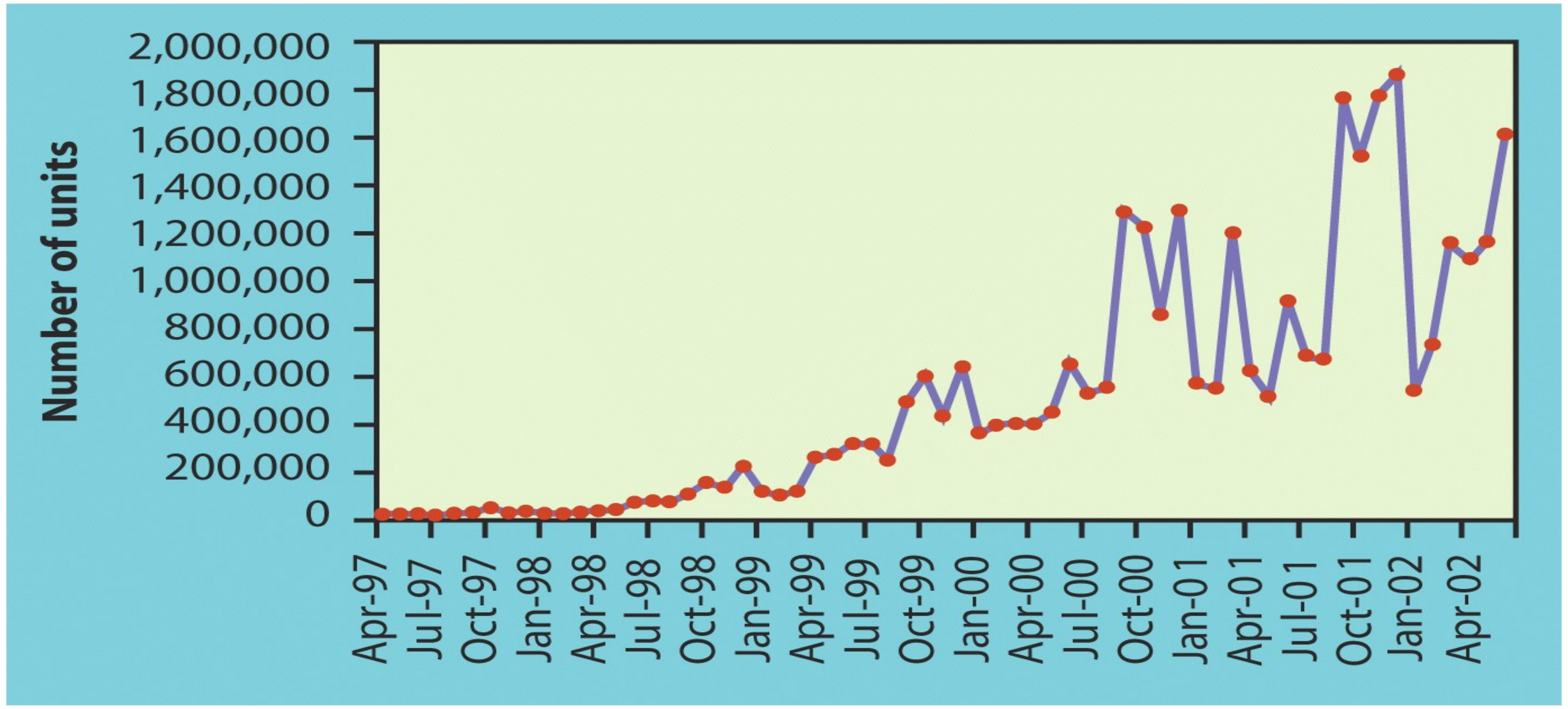
**Step 3.**
To estimate the seasonal component($S_t$),
**simply average the detrended values** for that season

+) adjust values so that they add to zero

**Step 4.**
Calculate the remainder($R_t$) by subtracting $S_t$, $T_t$

# Multiplicative Decomposition

**Time series data is a function of the product of its components**




Frequently used if the amplitude of the seasonality is **proportional** (increase or decrease) to level of series e.g. economic series

**Step 1.**
Compute trend-cycle($T_t$) using MA(Moving Average)

If period(m) is an **odd** num: m - MA
If period(m) is an **even** num: 2 * m - MA

**Step 2.**
Calculate the detrended series ($y_t$ / $T_t$)

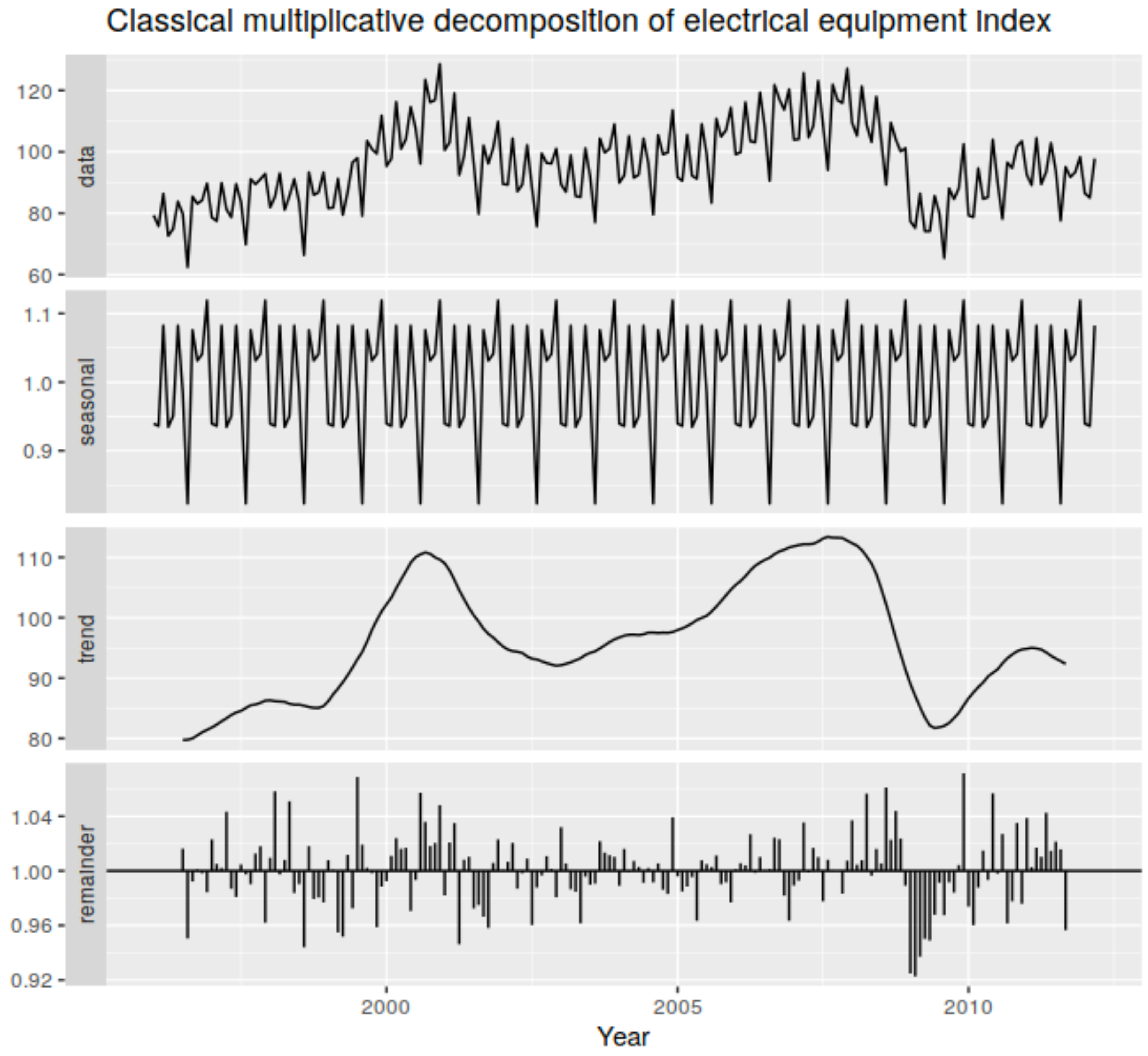
**Step 3.**
To estimate the seasonal component($S_t$),
**simply average the detrended values** for that season

+) adjust values so that they add to m (average = 1)

**Step 4.**
Calculate the remainder($R_t$) by dividing out $S_t$, $T_t$

# Multiplicative Decomposition

**Time series data is a function of the product of its components**




**Step 1.**
Compute trend-cycle($T_t$) using MA(Moving Average)

If period(m) is an **odd** num: m - MA
If period(m) is an **even** num: 2 * m - MA

**Step 2.**
Calculate the detrended series ($y_t$ / $T_t$)

**Step 3.**
To estimate the seasonal component($S_t$),
**simply average the detrended values** for that season

+) adjust values so that they add to m (average = 1)

**Step 4.**
Calculate the remainder($R_t$) by dividing out $S_t$, $T_t$

# Time Series Decomposition

## Problems of classical models

The estimate of the trend-cycle is **unavailable for the first few & last few observations**
= no estimate of the remainder component for the same time period

The trend-cycle estimate trends to **over-smooth** rapid rises and falls in the data
= cause a large remainder component

The basic assumption (seasonal component is constant throughout the entire series)
might **not be suitable for longer periods**.

***Uses alternative models like X11, STL***

# References


- https://yoongaemii.github.io/seasonal_decomposition/
- https://math.unm.edu/~lil/Stat581/6-decomposition.pdf
- https://towardsdatascience.com/different-types-of-time-series-decomposition-396c09f92693
- http://web.vu.lt/mif/a.buteikis/wp-content/uploads/2019/02/Lecture_03.pdf
- https://otexts.com/fpp2/classical-decomposition.html

# Thank You 💙