

# Production Management (ME-419)

## Module 2 – Demand Management

### Forecasting Methods – Qualitative

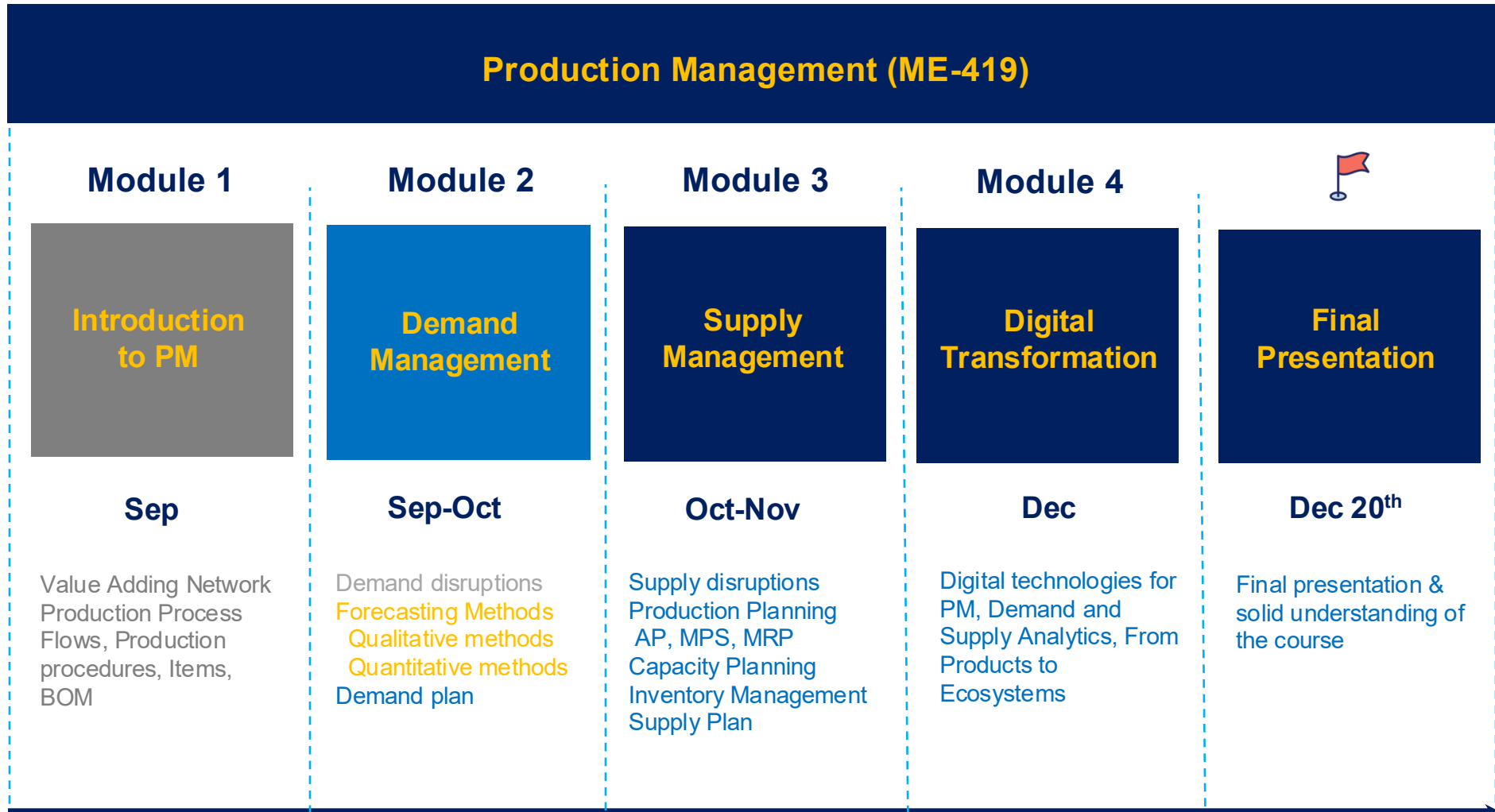
Amin Kaboli

Week 4 – Session 1&2 – Oct 03<sup>rd</sup>, 2024

# Course Framework



**Business plan**  
Strategic plan  
Financial plan



# Demand Management – Forecasting Steps



Demand forecast  
at the item and  
aggregate levels



**Goal:** What is the purpose of the forecast (Type of products, Granularity, Horizon)



**Data:** Obtain, clean, and analyze appropriate data



**Method:** Select a forecasting method (Qualitative vs Quantitative)



**Forecast:** Make the forecast



**Performance:** Monitor the forecast errors

# Forecasting Methods – Qualitative & Quantitative



Forecasting  
Methods



Qualitative  
methods



Quantitative  
methods



Executive  
opinions



Salesforce  
opinions



Customer  
surveys



Delphi  
method



Causal  
models



Time  
series



Machine  
Learning

# Demand Forecast – Step 3: Methods (Comparing)



## Quantitative methods



## Qualitative methods

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### Characteristics

Based on mathematics; and past data

Based on human judgement, opinions, subjective, and nonmathematical

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### Strengths

Consistent and objective; able to consider much information and data at one time

Can incorporate latest changes in the environment and “inside information”

---

### Weaknesses

Often quantifiable data are not available. Only as good as the data on which they are based.

Can bias the forecast and reduce forecast accuracy

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# Demand Management – Forecasting Steps



Demand forecast  
at the item and  
aggregate levels



**Goal:** What is the purpose of the forecast (Type of products, Granularity, Horizon)



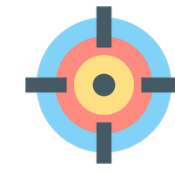
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**Forecast:** Make the forecast



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# Forecasting Methods – Qualitative & Quantitative



Forecasting  
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# Demand Forecast – Step 3: Methods (Comparing)



## Quantitative methods



## Qualitative methods

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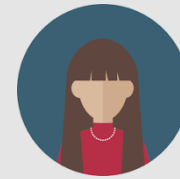
# Forecasting Methods – Quantitative Methods



Forecasting Methods



Qualitative methods



Executive opinions



Salesforce opinions



Customer surveys



Delphi method



Quantitative methods



Causal models



Time series



Machine Learning

# Comparing Quantitative Methods



Causal models



Time series



Machine Learning

**Ability to consider numerous variables and data sources**

Needs substantial effort

Smoothly incorporates multiple variables and data sources thanks to the high level of automation

**Volume of manual work**

High

Low

**Amount of data required**

Small

Large

**Maintenance complexity**

Low

High

**Technology requirements**

Low

High

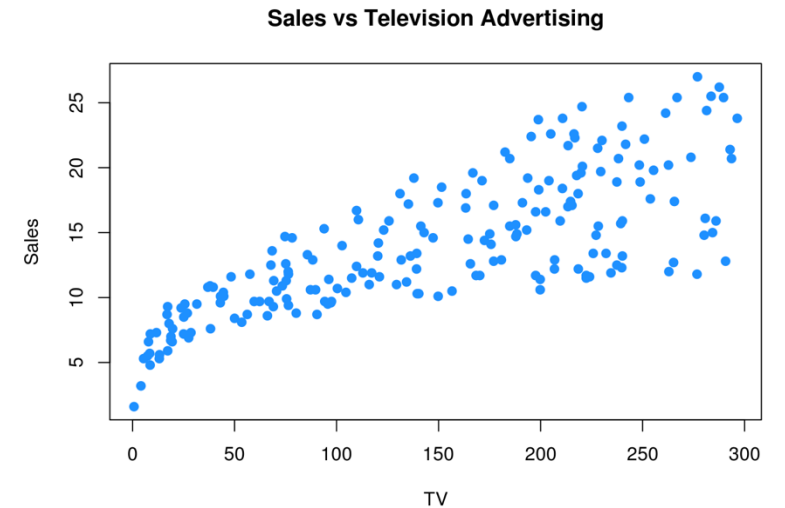
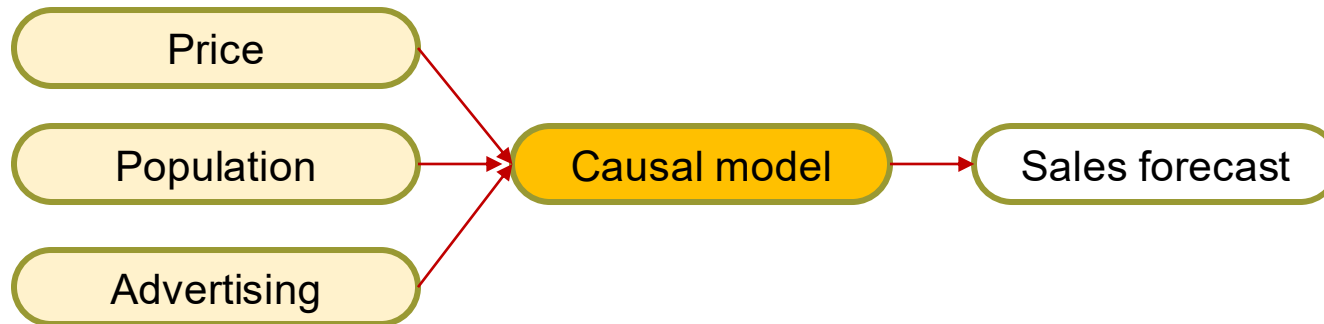
**Best fit**

Mid/long-term planning  
Established products  
Stable demand

Short/mid-term planning  
New products  
Volatile demand scenarios

# Demand Forecast – Causal Model

$$\text{Sales forecast} = \mathbf{f}(\text{Price, Population, Advertising, ...}) + \text{Constant}$$



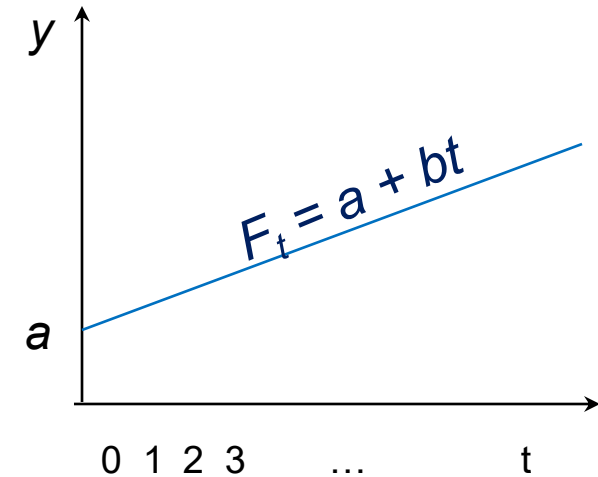
# Demand Forecast – Step 3: Method (Causal Model - Trend)

This model is used to develop forecasts when trend is present:

$$F_t = a + bt$$

$$b = \frac{n \sum ty - \sum t \sum y}{n \sum t^2 - (\sum t)^2} \quad a = \frac{\sum y - b \sum t}{n}$$

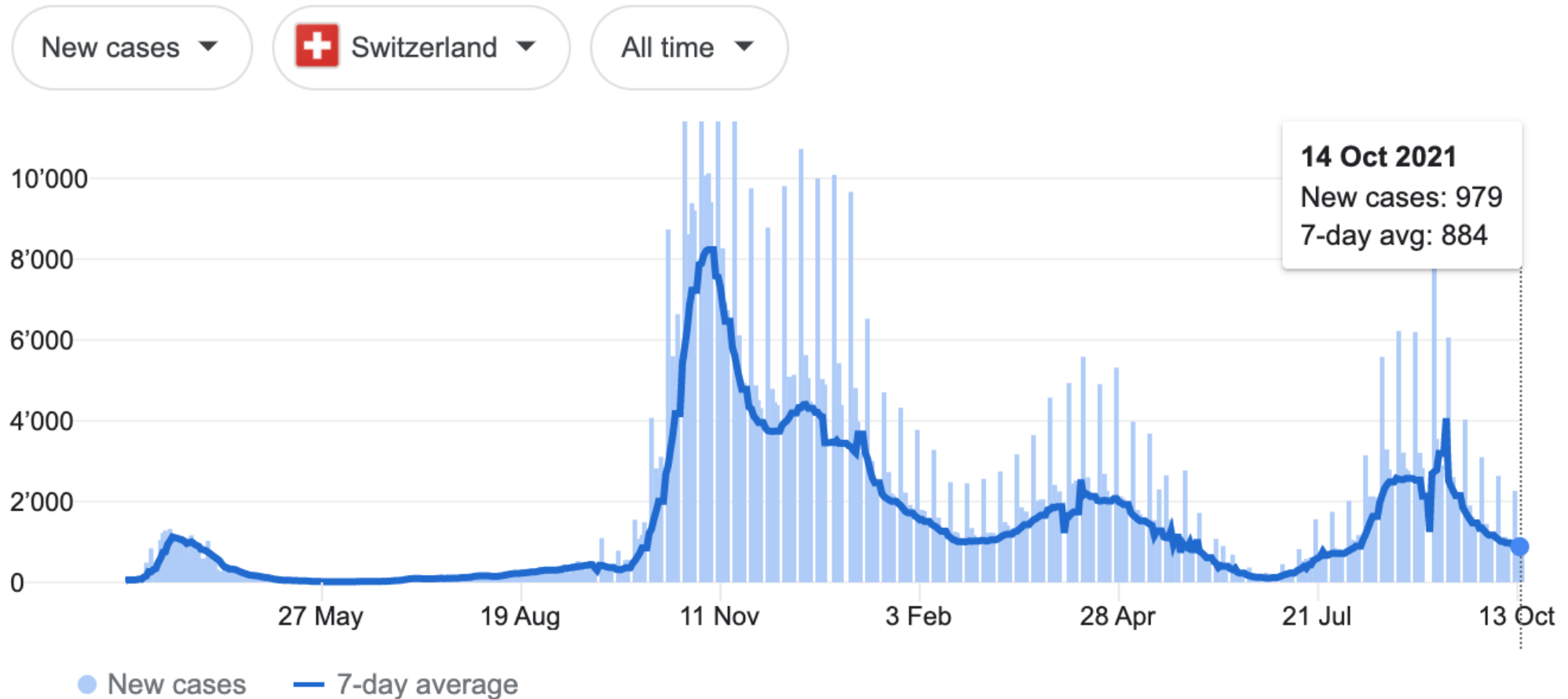
- $F_t$ : demand forecast for period  $t$
- $a$ : value of  $F_t$  at  $t = 0$ , which is the  $y$  intercept
- $b$ : slope of the line
- $t$ : specified number of time periods from  $t = 0$



# Time Series

- **A time-series is a set of observations on a quantitative variable collected over time.**
- In other words: **Time-series data are historical data in chronological order**, with only one value per time period (day, week, month, quarter, year, ...).
- Examples of historical data on:
  - Sales of iPhone
  - Stock
  - Interest rates
  - Customer engagements
  - Weather forecast, earthquake prediction, ...
- Businesses are often very interested in forecasting time series variables. Why?

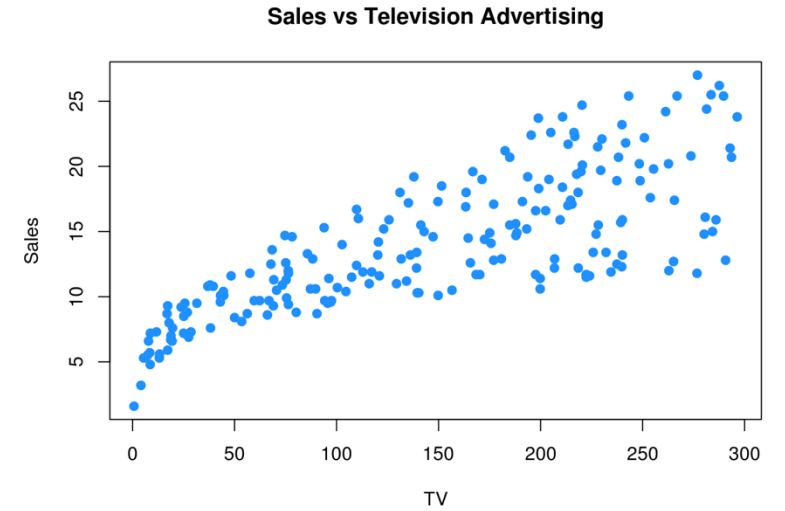
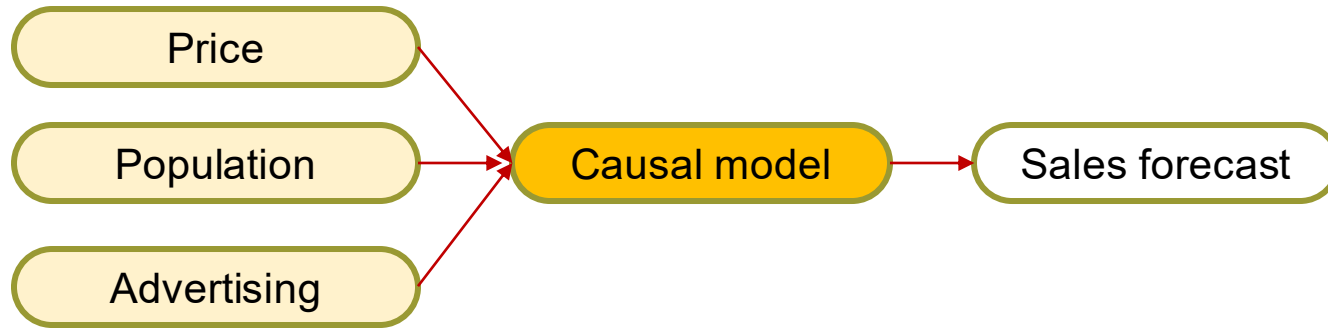
# Time Series – COVID in Switzerland



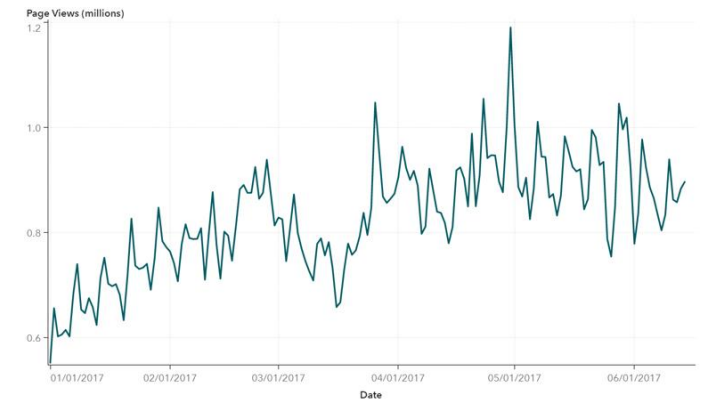
Source: Google,

# Demand Forecast – Causal Model vs Time Series

- **Causal models**



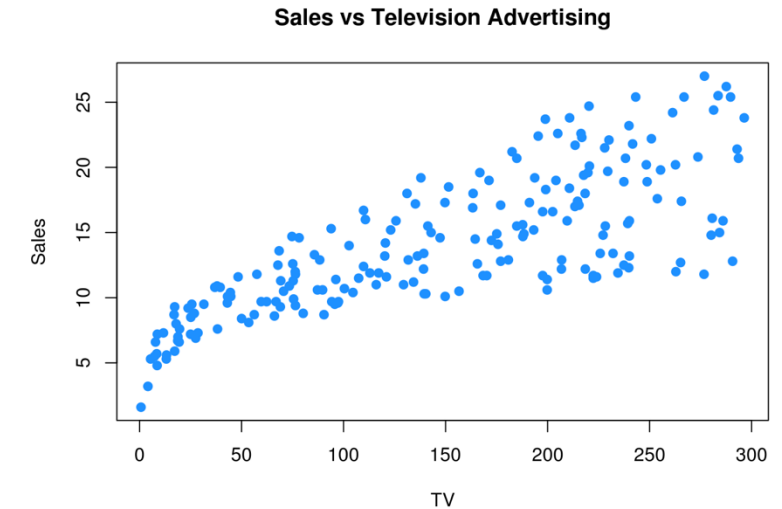
- **Time series models**



# Demand Forecast – Causal Model vs Time Series

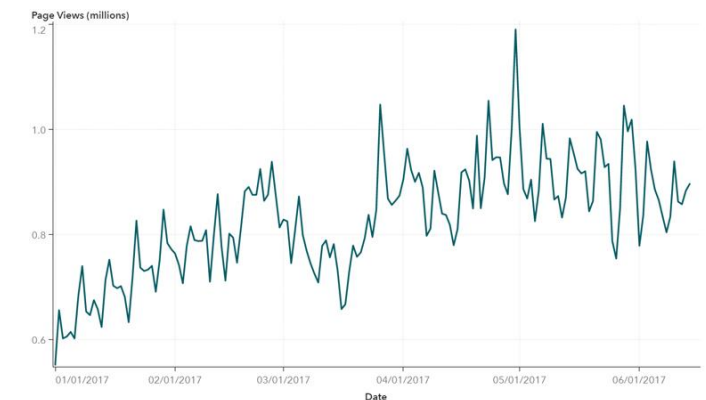
- **Causal models**

- **Regression** analysis useful in short-term forecasting with low accuracy.
- Often, **independent variables** are not available to build a regression model of a time series variable.

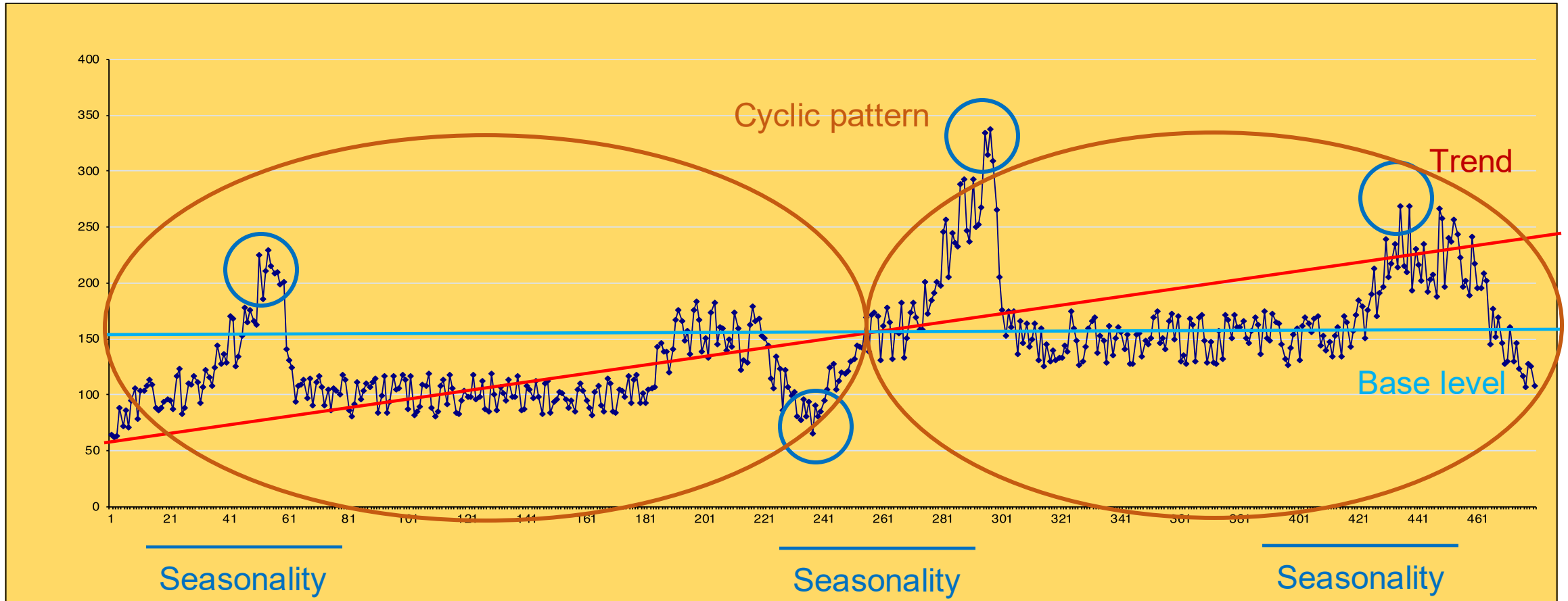


- **Time series models**

- In time series analysis, we analyze the **past behavior** of a variable in order **to predict its future behavior**.
- Our focus in this module is on time series methods for forecasting.



# Demand Forecast – Time Series



**Trends:** Pattern in which data exhibit increasing or decreasing values over time.  
**Seasonality:** Any pattern that repeats regularly and is constant in length.

# Time series – Analysis & Definitions

**Base level:** Pattern in which data values fluctuate around a constant mean

**Trend:** Pattern in which data exhibit increasing or decreasing values over time

**Seasonality:** Any pattern that regularly repeats itself and is constant in length.

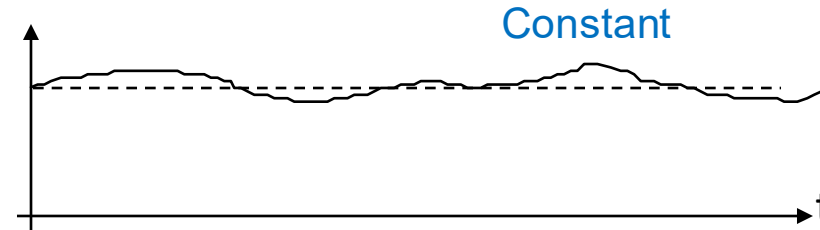
**Cycles:** Data patterns created by economic fluctuations.

# Time Series Models

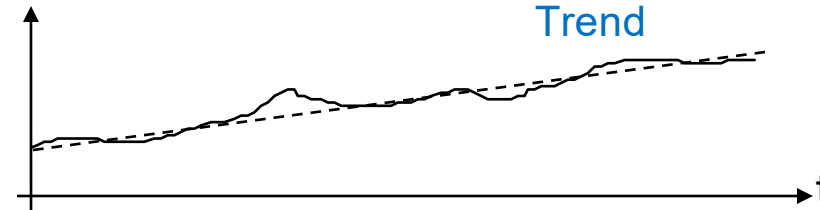


Time  
Series

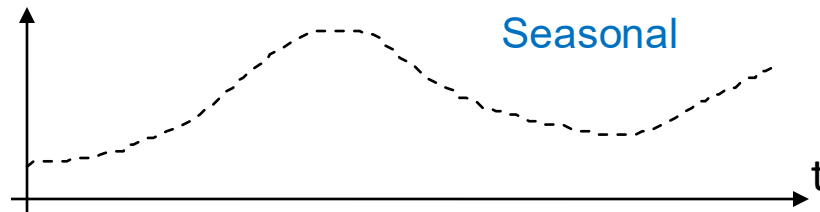
**Stationary**



**Trend**



**Trend  
+  
Seasonality**



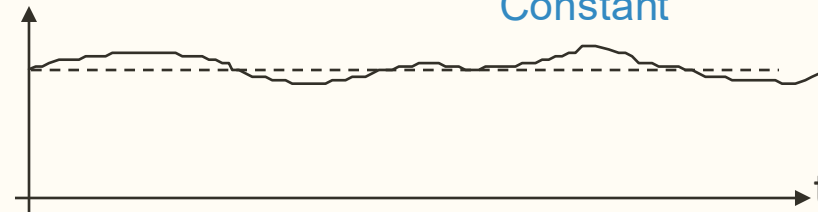
# Time Series Models



Time Series

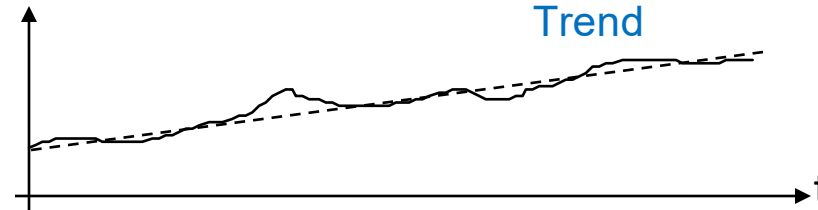
**Stationary**

Constant



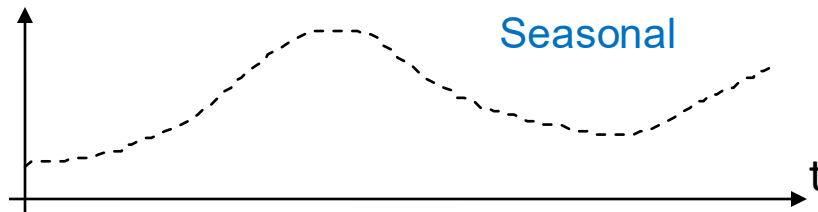
**Trend**

Trend



**Trend  
+  
Seasonality**

Seasonal



# Time Series – Stationary

**Data = Pattern + Random fluctuation**

# Time Series – Stationary

Data = Pattern + Random fluctuation

$$\mathcal{Y} = F(\mathcal{B}, \mathcal{T}, \mathcal{S}) + \mathcal{R}$$

- No trend and seasonal component, thus:

$$\mathcal{Y} = F(\mathcal{B}) + \mathcal{R}$$

- What are the models to forecast trend patterns in data?
  - Stationary models

# Summary – Time Series – Stationary Models

1) Naïve:

$$F_{t+1} = Y_t$$

2) Simple mean:

$$F_{t+1} = \Sigma Y_t / n$$

3) Simple moving average:

$$F_{t+1} = \Sigma Y_t / n \quad \text{or} \quad F_{t+1} = \frac{1}{p} \sum_{i=0}^{p-1} [Y_{t-i}]$$

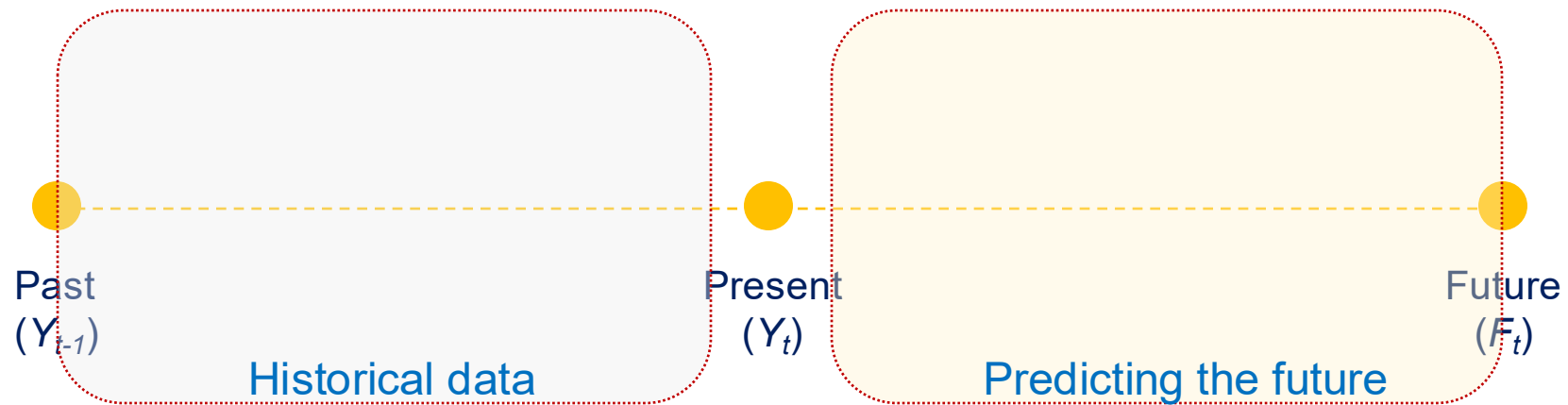
4) Weighted moving average:

$$F_{t+1} = \Sigma w_t * Y_t$$

5) Exponential Smoothing

$$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t$$

# Reminder: The Science of Predicting The Future



**Assumption:** The future will be the same as the **past!**

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$

# Quantitative Method – Stationary; Naïve

Forecast in period  $t+1$  = Actual demand of period  $t$

$$F_{t+1} = Y_t$$

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$

# Quantitative Method – Stationary; Simple Mean

Forecast in period  $t+1$  = Sum (Actual demand of period  $t$ ) /  $n$

$$F_{t+1} = \Sigma Y_t / n$$

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$
- $n$  : number of periods or data points to be averaged

# Quantitative Method – Stationary; Simple Moving Average

Forecast in period  $t+1$  = Sum (Actual demand of period  $t$ ) /  $n$

$$F_{t+1} = \Sigma Y_t / n$$

$$F_{t+1} = Y_t + Y_{t-1} + Y_{t-2} + \dots + Y_{t-n} / n$$

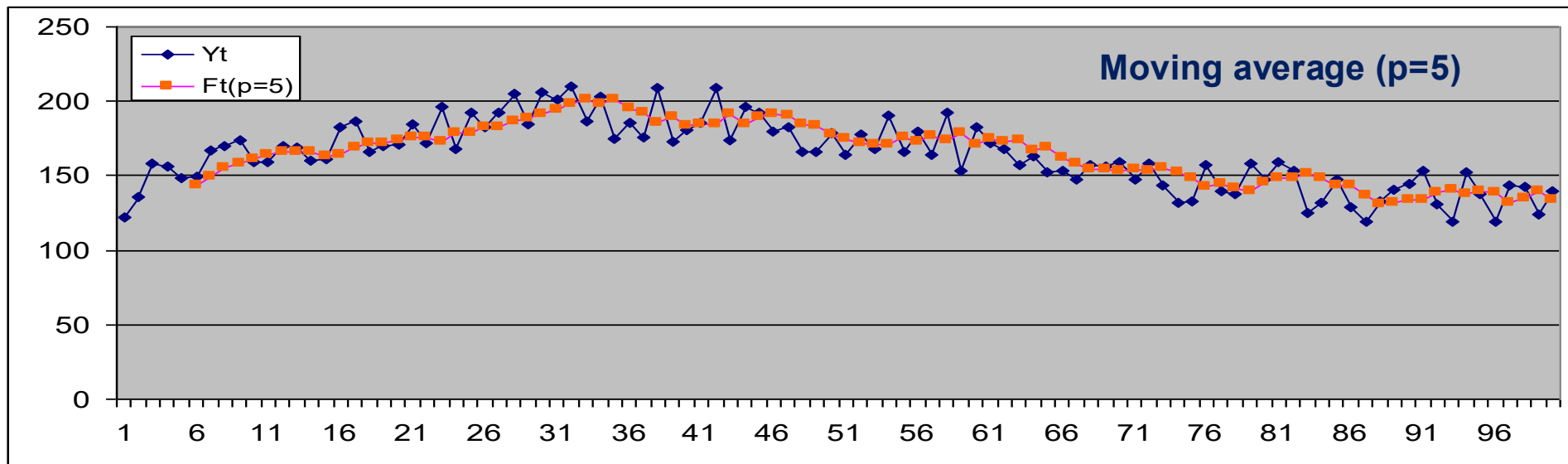
- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$
- $n$  : number of periods or data points used in the moving average

# Quantitative Method – Stationary; Simple Moving Average

- $F_t$  : demand forecast for period  $t$
  - $Y_t$  : actual demand for period  $t$
- $p = 1$  : Naive model

$$F_{t+1} = \frac{1}{p} \sum_{i=0}^{p-1} [Y_{t-i}]$$

$p$ : order of moving average = number of periods taken into account



# Quantitative Method – Stationary; Weighted Moving Average

Forecast in period  $t+1$  = Sum (Weights \* (Actual demand of period  $t$ )) /  $n$

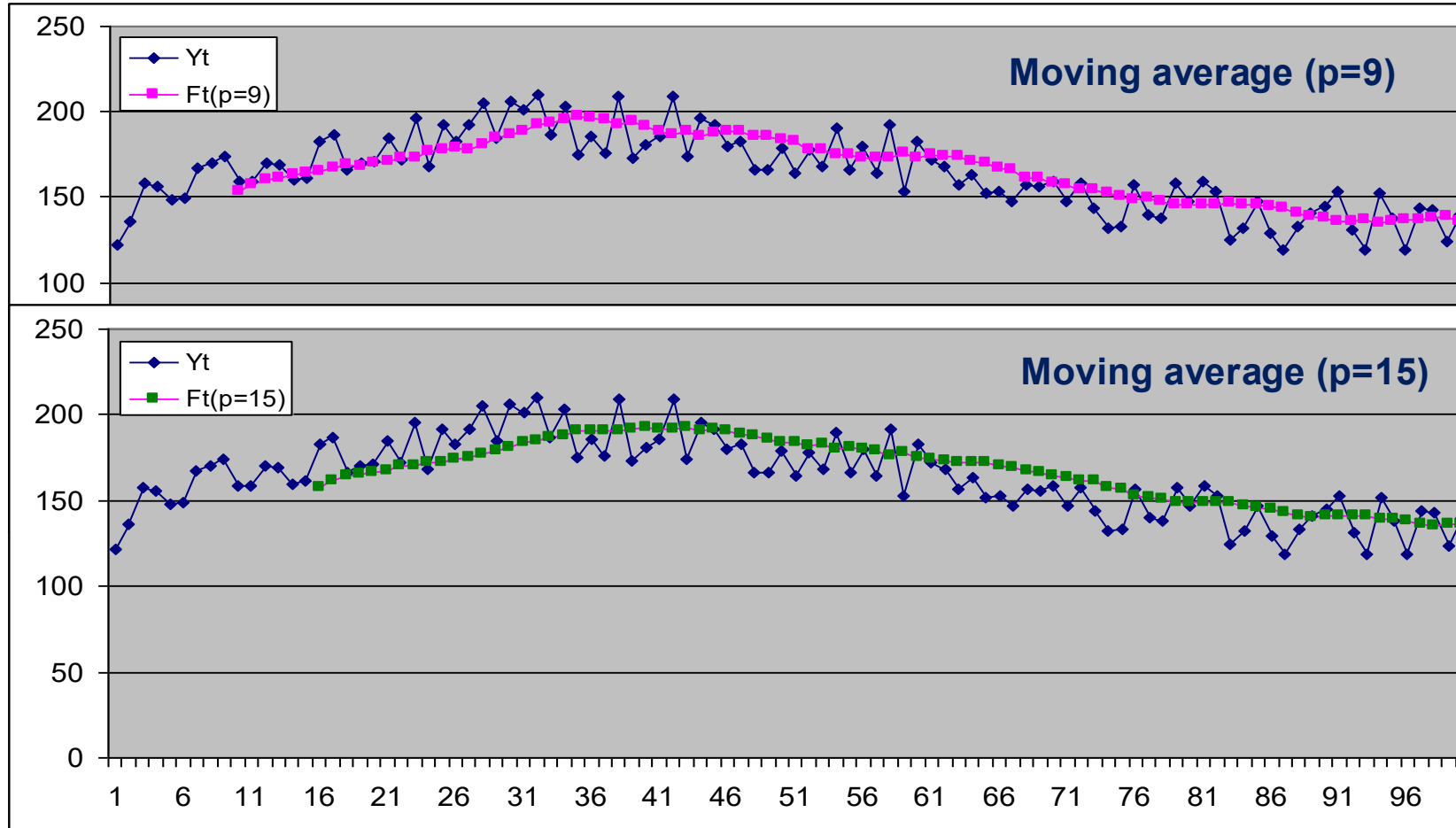
$$F_{t+1} = \sum w_t * Y_t$$

$$F_{t+1} = w_1 Y_1 + w_2 Y_2 + \dots + w_t Y_t$$

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$
- $w_t$  : weight placed on the actual value in period  $t$

# Quantitative Method – Stationary; Moving Average

$$F_{t+1} = \frac{1}{p} \sum_{i=0}^{p-1} [Y_{t-i}] \quad p: \text{order of moving average} = \text{number of periods taken into account}$$



# Quantitative Method – Stationary; Averaging

## Exercise 1



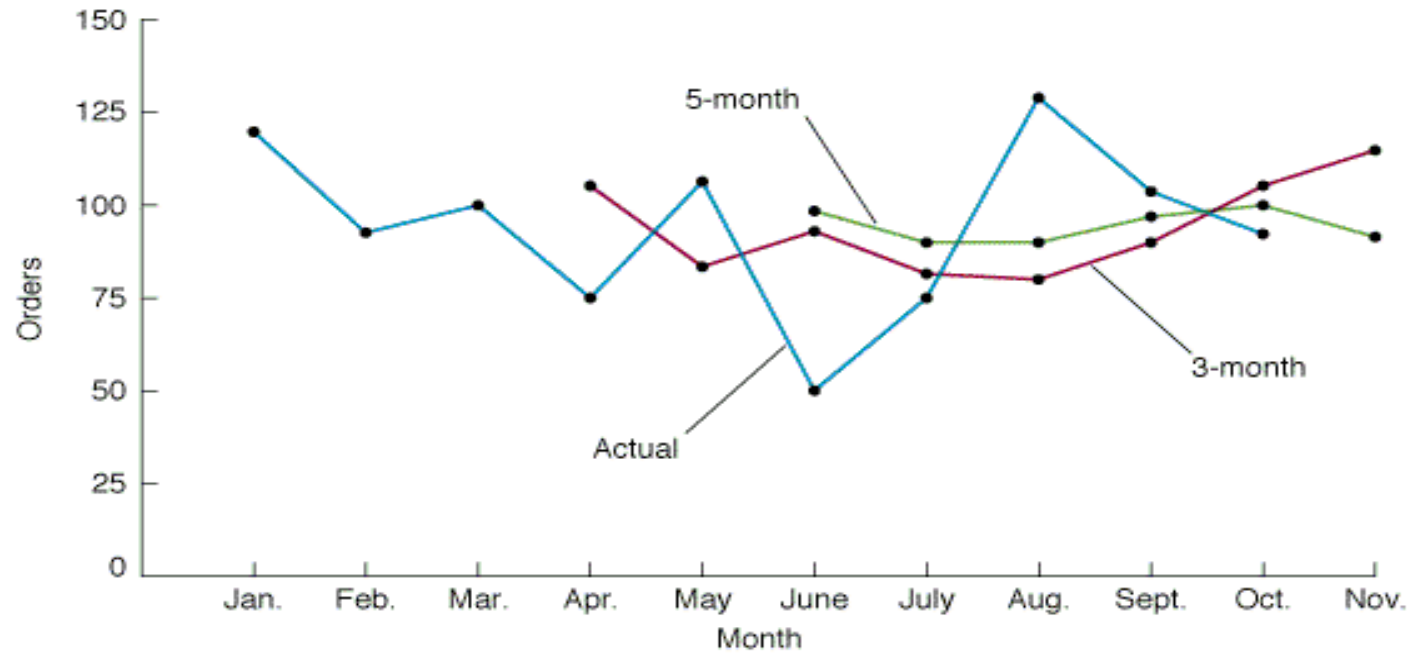
Complete the exercise in Excel (file on Moodle)



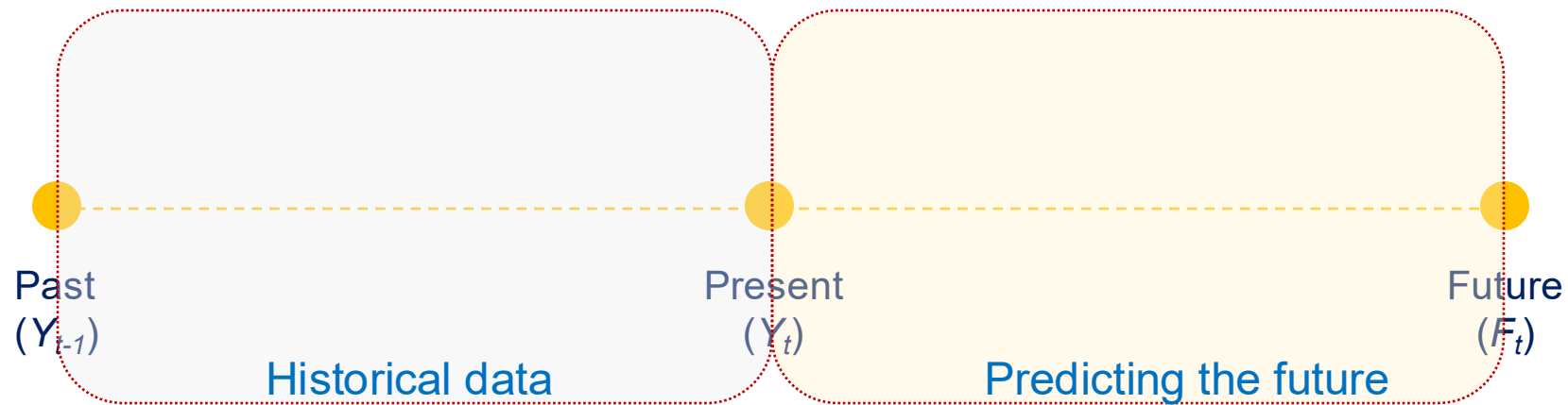
Bridge The Gap between Knowing & Doing

# Moving Average – Important Notes

- Suitable for relatively stable time series with NO trend or seasonal pattern
- A 3-period model ( $p=3$ ) will be more responsive to change
- The larger the “ $p$ ” the more stable the forecast
- The larger  $p$ , the slower reaction to actual changes



# The Science of Predicting The Future



**Assumption:** The future will be what happened in the **present and the past!**

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$

# Quantitative Method – Stationary; Exponential Smoothing

To make a forecast for the next period, you need three pieces of information:

$$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t$$

- 1) The current period's forecast ( $F_t$ )
- 2) The current period's actual demand ( $Y_t$ )
- 3) The value of a smoothing coefficient,  $\alpha$ , which varies between 0 and 1.

## Quantitative Method – Stationary; Exponential smoothing

$$F_{t+1} = F_t + \alpha(Y_t - F_t)$$

$$F_{t+1} = \alpha Y_t + (1 - \alpha)F_t$$

$$F_t = \alpha Y_{t-1} + (1 - \alpha)F_{t-1}$$

$$F_{t-1} = \alpha Y_{t-2} + (1 - \alpha)F_{t-2}$$

$$F_{t+1} = \alpha Y_t + (1 - \alpha)[\alpha Y_{t-1} + (1 - \alpha)(\alpha Y_{t-2} + (1 - \alpha)F_{t-2})]$$

$$F_{t+1} = \alpha[Y_t + (1 - \alpha)Y_{t-1} + (1 - \alpha)^2 Y_{t-2}] + (1 - \alpha)^3 F_{t-2}$$

$$F_{t+1} = \alpha \sum_{p=0}^{\infty} (1 - \alpha)^p Y_{t-p}$$

Infinite series of the actual values with exponentially decreasing importance.

# Quantitative Method – Stationary; Exponential smoothing

## Exercise 1



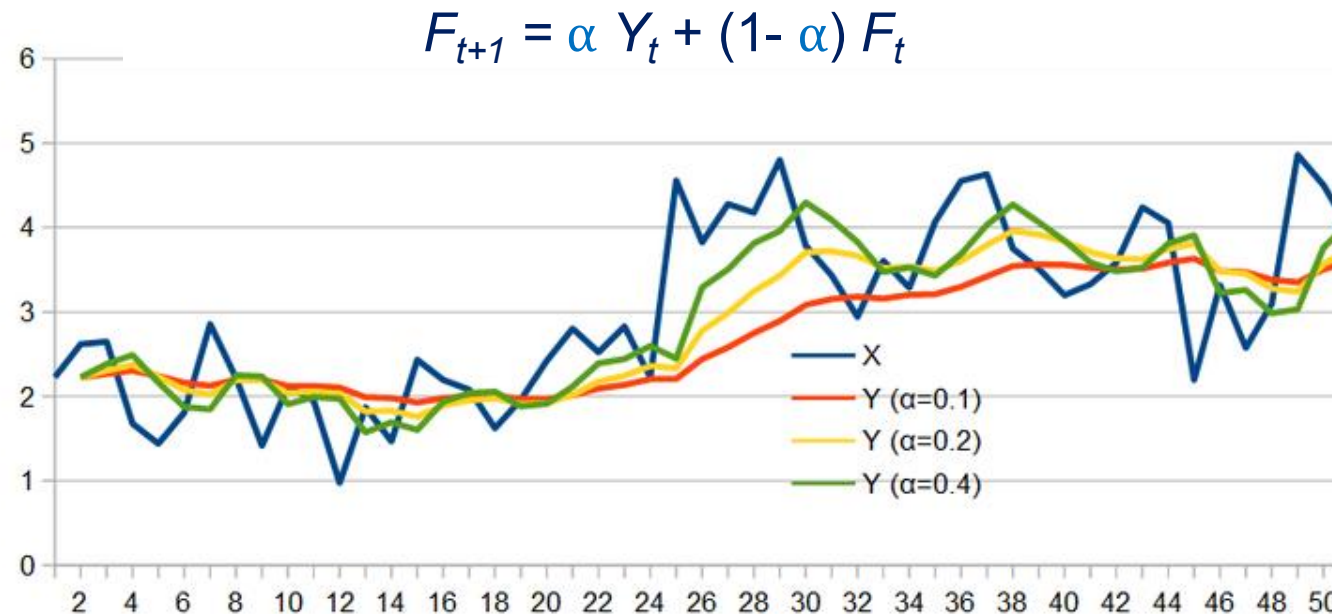
Complete the exercise in Excel (file on Moodle)



Bridge The Gap between Knowing & Doing

# Exponential Smoothing – Important Notes

- Suitable for relatively stable time series
- Does NOT do well when there is a **trend** in data
- Widely used model and it requires limited data
- The larger  $\alpha$ , the more responsive forecast
- The smaller  $\alpha$ , the smoother forecast



# Summary – Time Series – Stationary Models

1) Naïve:

$$F_{t+1} = Y_t$$

2) Simple mean:

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4) Weighted moving average:

$$F_{t+1} = \sum w_t * Y_t$$

5) Exponential Smoothing

$$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t$$

# Learning Points – Summary

- Demand forecasting steps
- Methods to forecast: qualitative and quantitative
- Different qualitative methods

# Assignment 4 – Tasks



5 min

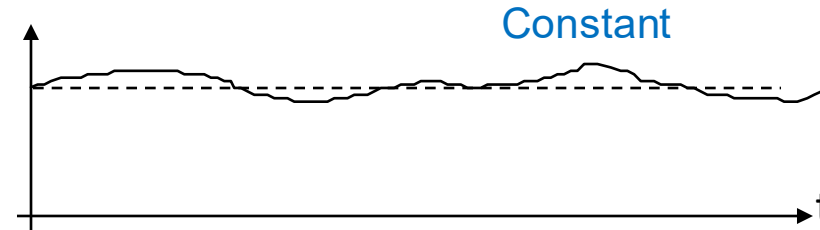
- 1) Upload exercise 1 (team submission)
- 2) Which forecasting model(s) — *for example, stationary models or Holt's method* — are most suitable for your case study at the product level?  
Explain your choice and justify why other models may not be appropriate.
- 3) Test whether there is seasonality in your dataset or not (use auto-correlation)

# Time Series Models

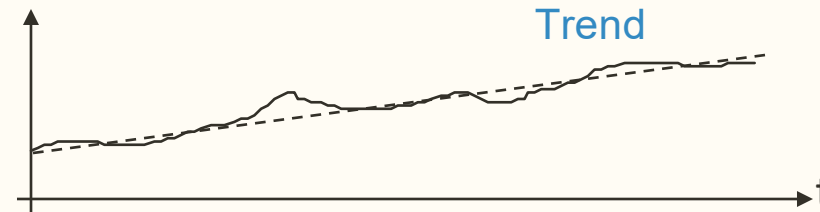


Time Series

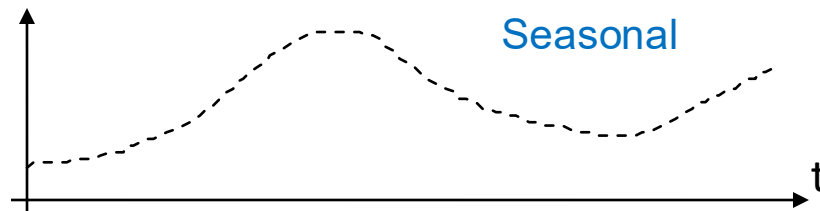
**Stationary**



**Trend**



**Trend  
+  
Seasonality**



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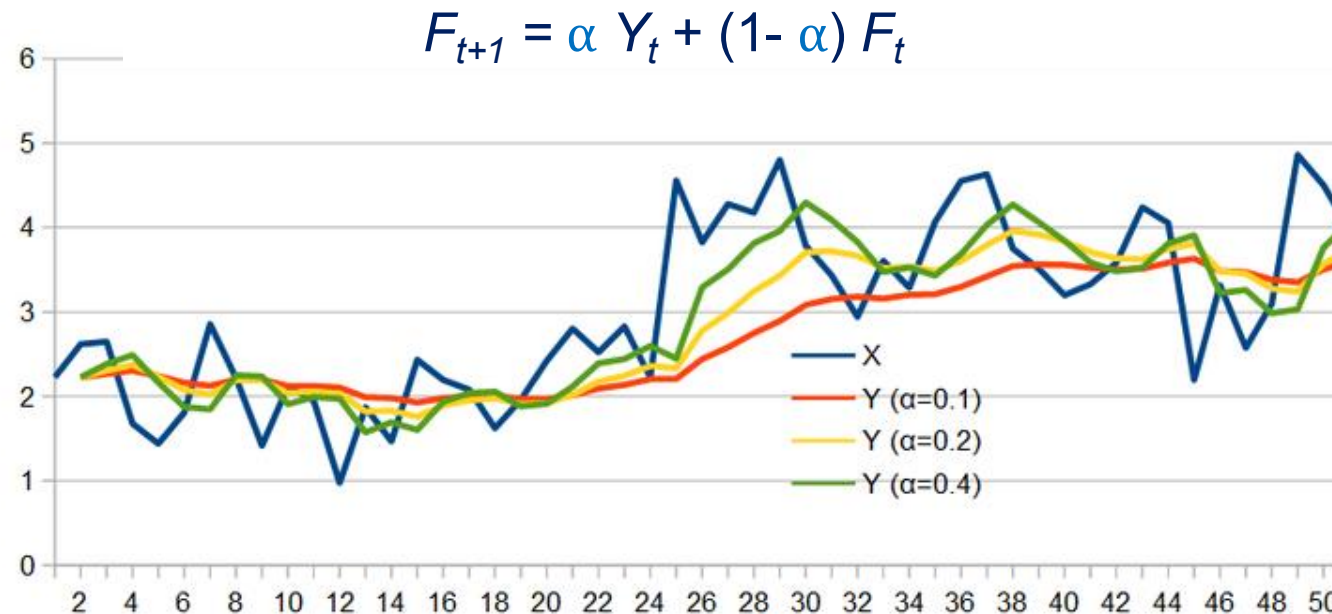
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# Exponential Smoothing – Important Notes

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- Widely used model and it requires limited data
- The larger  $\alpha$ , the more responsive forecast
- The smaller  $\alpha$ , the smoother forecast



# Time Series – Trend

Data = Pattern + Random fluctuation

$$\mathcal{Y} = F(\mathcal{B}, \mathcal{T}, \mathcal{S}) + \mathcal{R}$$

- No seasonal component, thus:

$$\mathcal{Y} = F(\mathcal{B}, \mathcal{T}) + \mathcal{R}$$

- What are the models to forecast trend patterns in data?
  - Linear trend line
  - Holt model (trend-adjusted exponential smoothing)

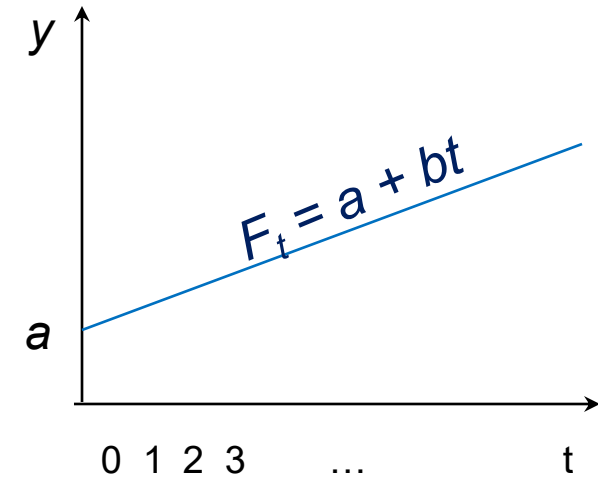
# Reminder: Demand Forecast – Causal Model

This model is used to develop forecasts when trend is present:

$$F_t = a + bt$$

$$b = \frac{n \sum ty - \sum t \sum y}{n \sum t^2 - (\sum t)^2} \quad a = \frac{\sum y - b \sum t}{n}$$

- $F_t$ : demand forecast for period  $t$
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- $b$ : slope of the line
- $t$ : specified number of time periods from  $t = 0$



## Problem - Time Series – Trend

ABB wants to forecast demand for a piece of pollution-control equipment. A review of past sales, as shown below, indicates that an increasing trend is present:

Month ( $t$ )	Actual demand ( $Y_t$ )	Month ( $t$ )	Actual demand ( $Y_t$ )
1	12	6	21
2	17	7	31
3	20	8	28
4	19	9	36
5	24	10	-

Smoothing constants are assigned the values of  $\alpha = 0.2$  and  $\beta = 0.4$ . The firm assumes the initial base level ( $B_1$ ) is 11 units and the trend over that period ( $T_1$ ) is 2 units. Define the forecast for month 1 to 10.

# Time Series – Trend (Holt Model)

An exponential smoothing model (with two smoothing equations) for data with trend:

Step 1) Forecast equation

$$F_{t+h} = B_t + hT_t \quad h = 1, 2, 3, \dots$$

Step 2) Level equation

$$B_t = \alpha Y_t + (1 - \alpha)(B_{t-1} + T_{t-1}) \quad 0 \leq \alpha \leq 1$$

Step 3) Trend equation

$$T_t = \beta(B_t - B_{t-1}) + (1 - \beta)T_{t-1} \quad 0 \leq \beta \leq 1$$

## Exercise 1 - Time Series – Trend (Holt Model)



7 min

Swiss Green is a lawn care company that uses exponential smoothing with trend to forecast monthly usage of its lawn care products. At the end of July the company desires to forecast demand of August. The trend through June has been 15 additional boxes of products sold per month.

Average demand have been 57 boxes per month. The demand for July was 62 boxes. The company uses  $\alpha = 0.2$  and  $\beta = 0.10$ . Make a forecast including trend for the month of August.

## Exercise 2 - Time Series – Trend (Holt Model)



10 min

ABB wants to forecast demand for a piece of pollution-control equipment. A review of past sales, as shown below, indicates that an increasing trend is present:

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1	12	6	21
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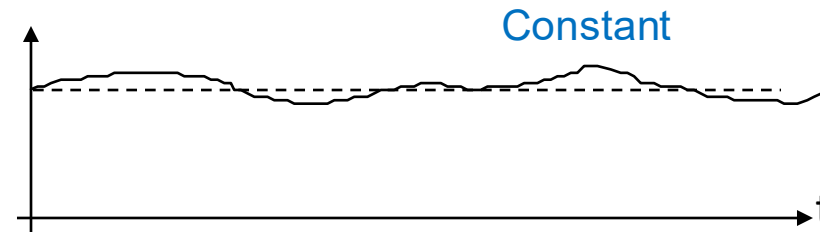
Smoothing constants are assigned the values of  $\alpha = 0.2$  and  $\beta = 0.4$ . The firm assumes the initial base level ( $B_1$ ) is 11 units and the trend over that period ( $T_1$ ) is 2 units. Use Holt model to define the forecast for month 1 to 10.

# Time Series Models

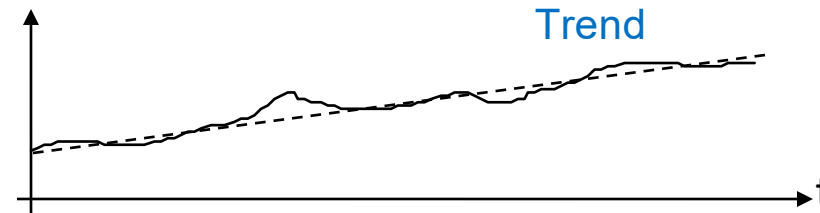


Time Series

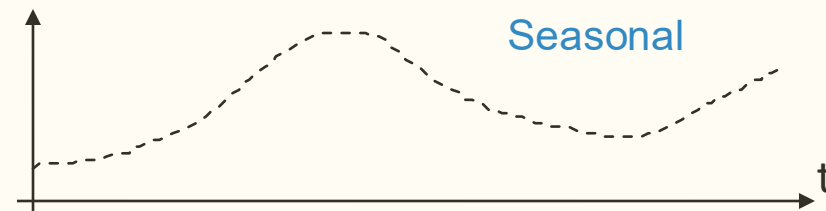
Stationary



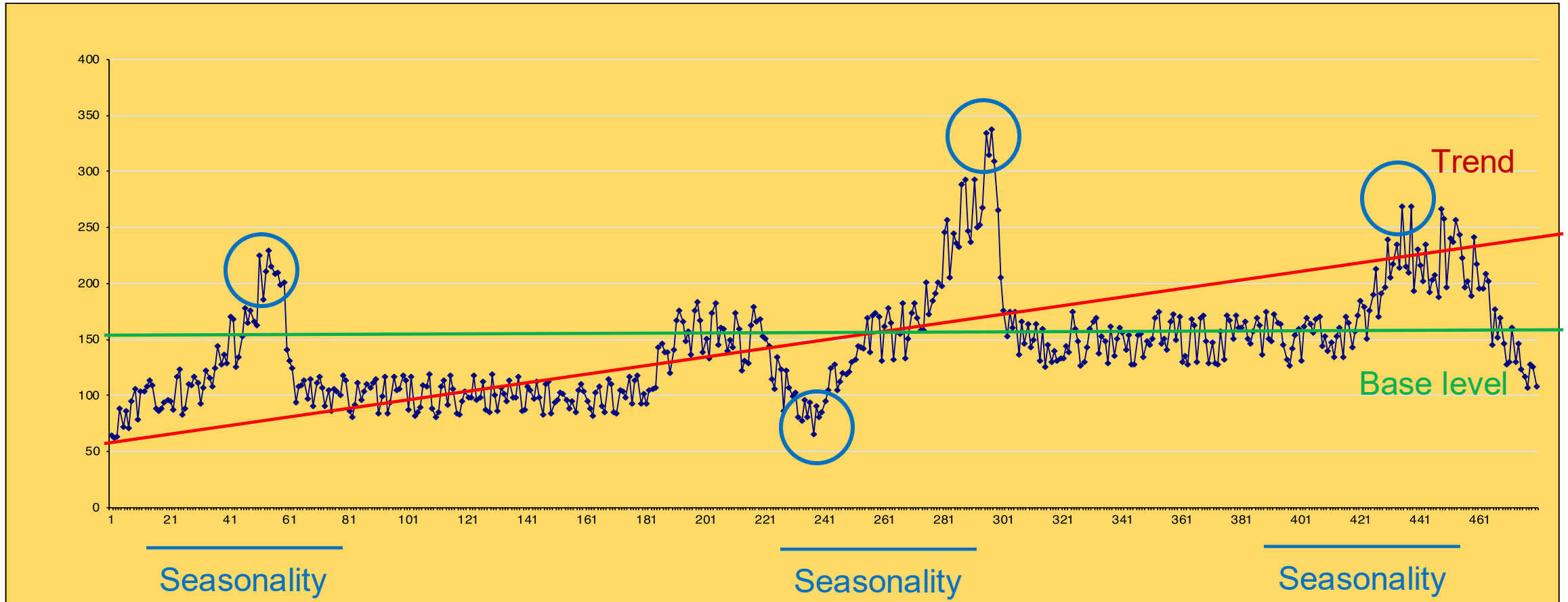
Trend



Trend + Seasonality

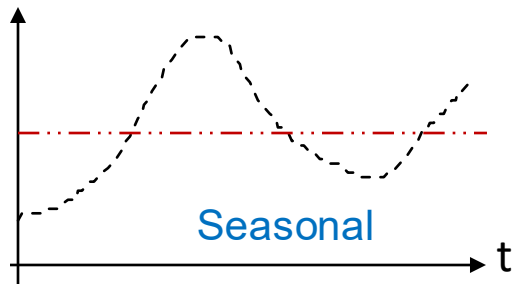


# Time series – Seasonality



**Seasonality:** Any pattern that regularly repeats itself and is constant in length.

# What Is Seasonality?



**Seasonality:** Regular repeating movements in series values that can be tied to recurring events

## Examples:

- Daily (2x rush hours of traffic)
- Weekly (Netflix views at weekends)
- Monthly (Salary payments)
- Any other regular recurring patterns

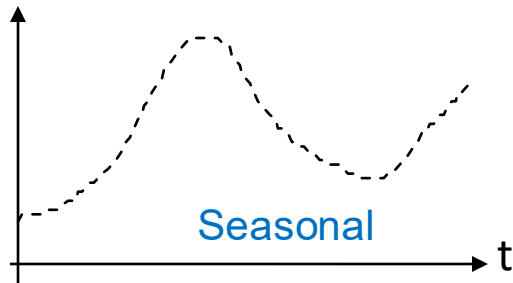
## Characteristics:

- The period is fixed and unchanging
- Series are influenced by seasonal factors (Additive, Multiplicative)

## Importance:

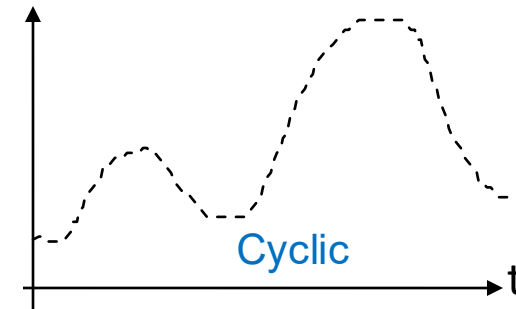
- In upfront planning; Capacity planning and scheduling (e.g: Retail)

# Time series – Seasonality vs Cyclic pattern



## Seasonality pattern

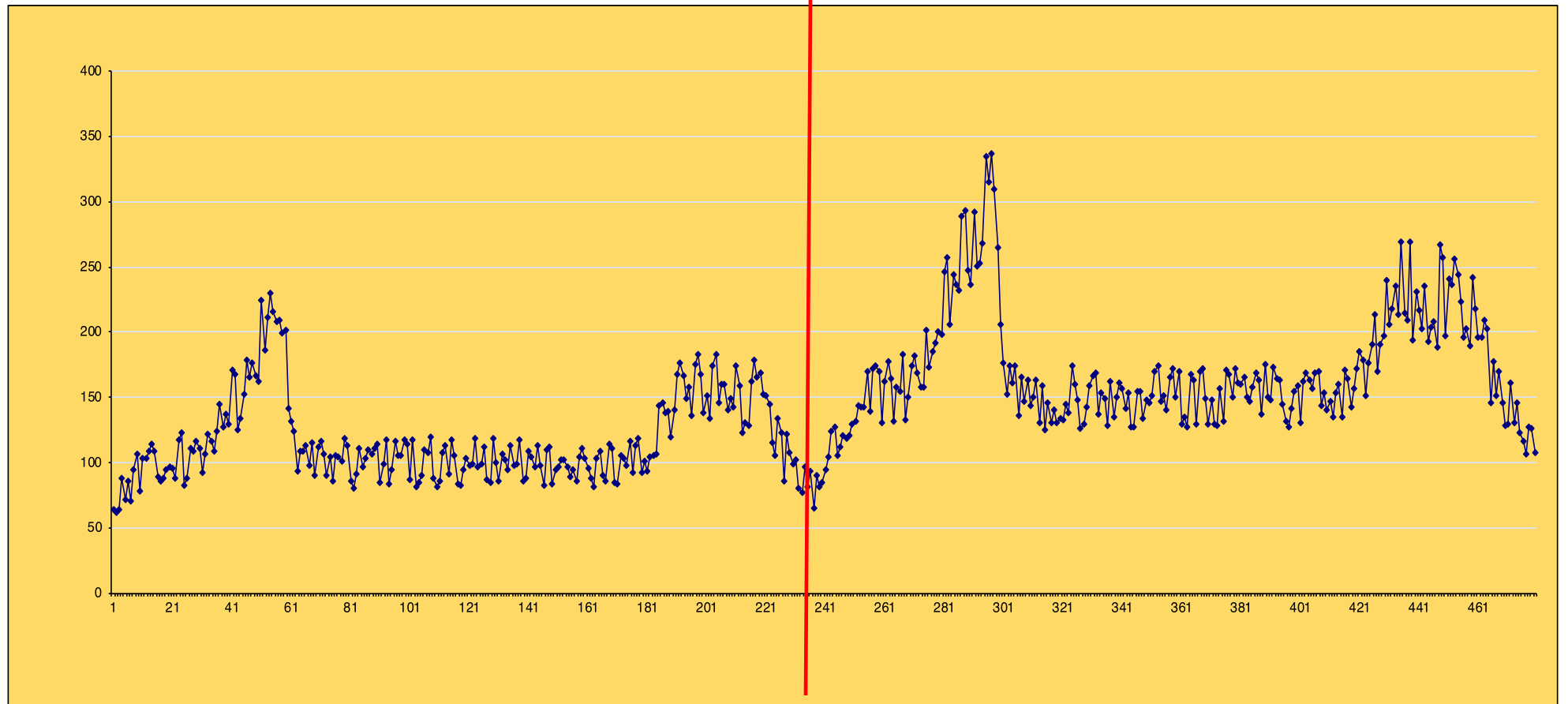
- The period is fixed and unchanging
- Series are influenced by seasonal factors
  - Day of the week/month
  - Week of the month
  - Quarter of the year



## Cyclic pattern

- The period is NOT fixed and changing
- Current cycle is unknown beforehand
  - Business cycles
  - Economic recession
  - Inflation

# Detecting Seasonality



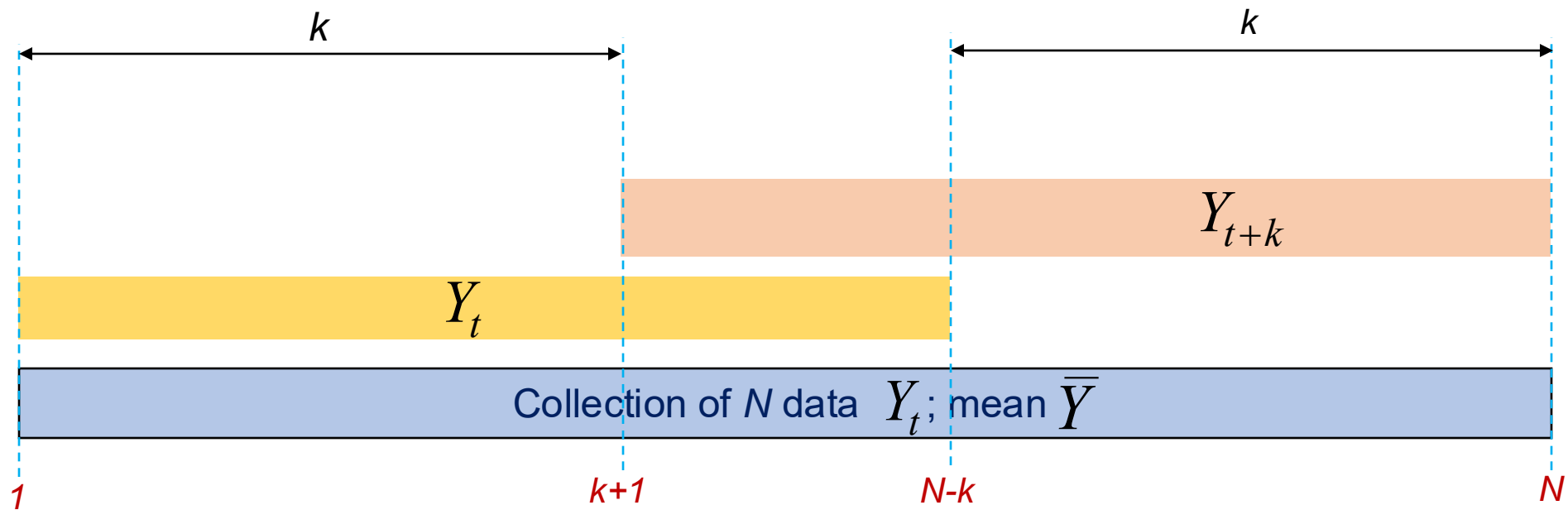
**Question:** Is it random or we have a real seasonal effect? – Autocorrelation Analysis Function (ACF)

# Autocorrelation Analysis Function (ACF)

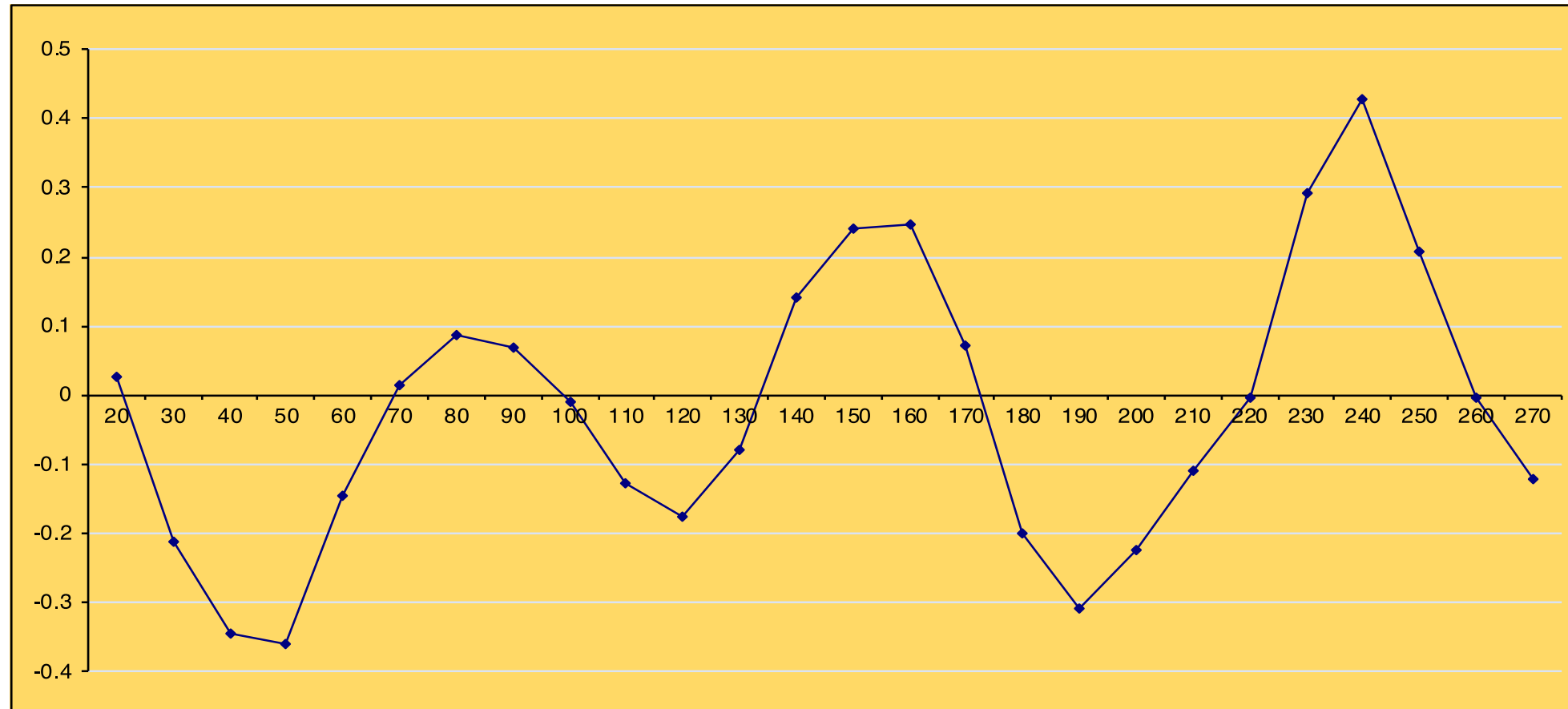
Auto-correlation coefficient  $r_k = f(k)$

$k$ : time lag (1, 2, 3, ..., N)

$$r_k = \frac{\sum_{t=1}^{N-k} (Y_t - \bar{Y})(Y_{t+k} - \bar{Y})}{\sum_{t=1}^N (Y_t - \bar{Y})^2}$$



# Autocorrelation Analysis Function (ACF)



# Exercise 1 - Time Series – Autocorrelation in Excel

Two following approaches;

$$r_k = \frac{\sum_{t=1}^{N-k} (Y_t - \bar{Y})(Y_{t+k} - \bar{Y})}{\sum_{t=1}^N (Y_t - \bar{Y})^2}$$

= build up the formula



= CORREL

# Learning Points – Summary

- Types of quantitative models
- Casual models vs Time series vs Machine learning
- Time series – stationary models
- Time series – trend
- Time series – Seasonality detection

# Assignment 4 – Tasks



5 min

- 1) Upload exercise 1 (team submission)
- 2) Which forecasting model(s) — *for example, stationary models or Holt's method* — are most suitable for your case study at the product level?  
Explain your choice and justify why other models may not be appropriate.
- 3) Test whether there is seasonality in your dataset or not (use auto-correlation)

# Forecasting Methods – Qualitative Methods



Forecasting Methods



Qualitative methods



Executive opinions



Salesforce opinions



Customer surveys



Delphi method



Quantitative methods



Causal models



Time series



Machine Learning

# Qualitative Method – Executive Opinions

**Senior Executive Level**



Finance



Operations



Marketing



R&D

**Developing long range plan**



New Product

# Qualitative Method – Salesforce Opinions

## Members of Sales & Customer Service



Sales manager



Sales staff



Customer Service



Sales staff

## Developing sales plan



Current product

# Qualitative Method – Consumer Surveys

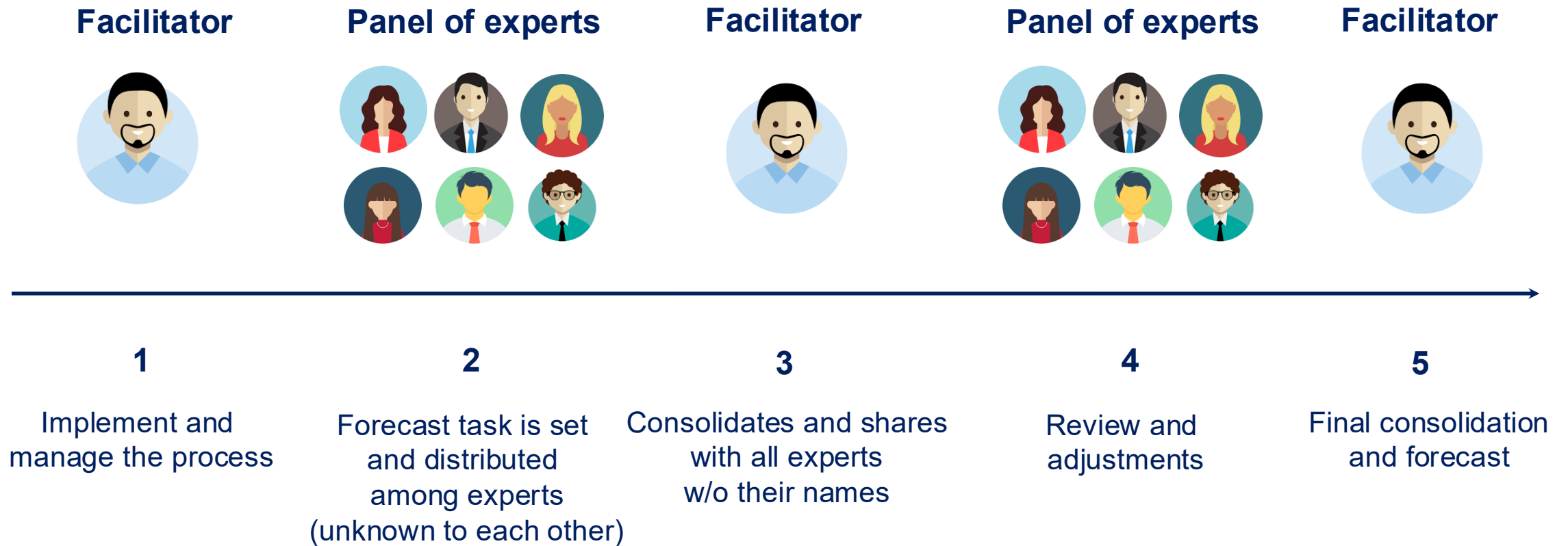


Survey



Art of constructing a survey,  
administer it, and  
correctly interpret the results

# Qualitative Method – Delphi Method



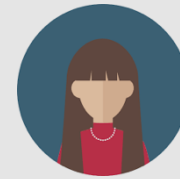
# Forecasting Methods – Qualitative Methods



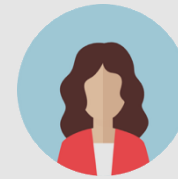
Forecasting  
Methods



Qualitative  
methods



Executive  
opinions



Salesforce  
opinions



Customer  
surveys



Delphi  
method



Quantitative  
methods



Causal  
models



Time  
series



Machine  
Learning

# Qualitative Method – Comparing Qualitative Methods



5 min

**Pros**

**Cons**

- 
1. Executive Opinion
  2. Salesforce Opinions
  3. Consumer Surveys
  4. Delphi Method

# Qualitative Methods

**What is the base for the qualitative method?**

# Qualitative Methods

**What is the base for the qualitative method?**

Observations, judgement, experience, ...

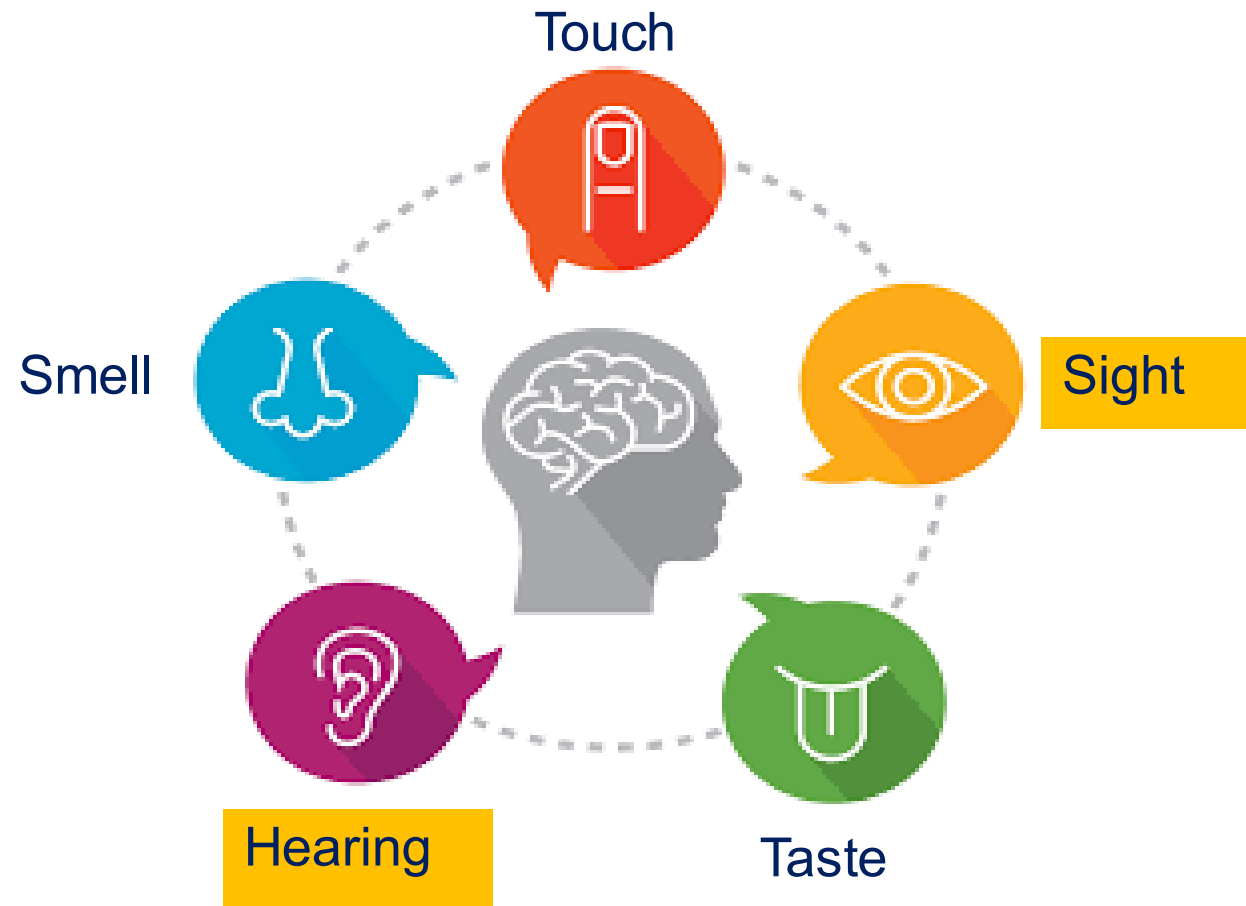
# Do We See The Same?



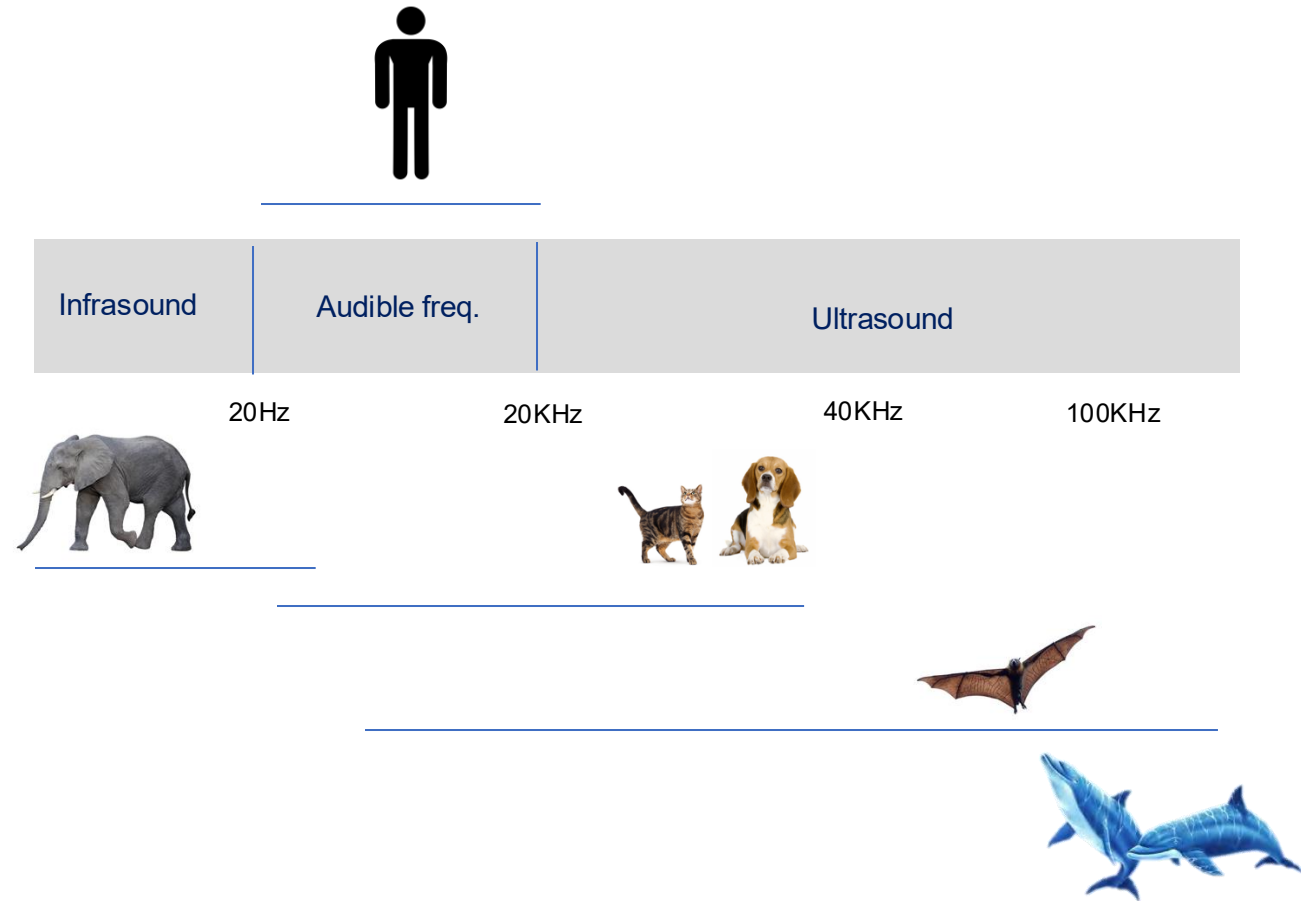
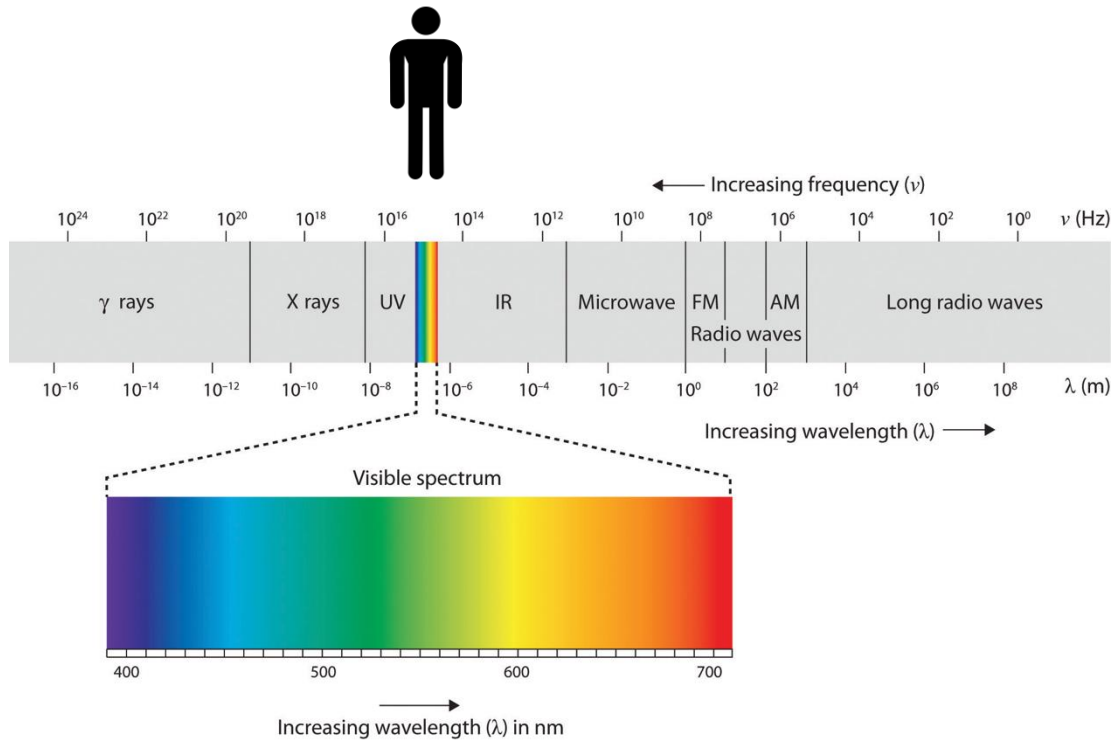
# Perception – Our Five Senses



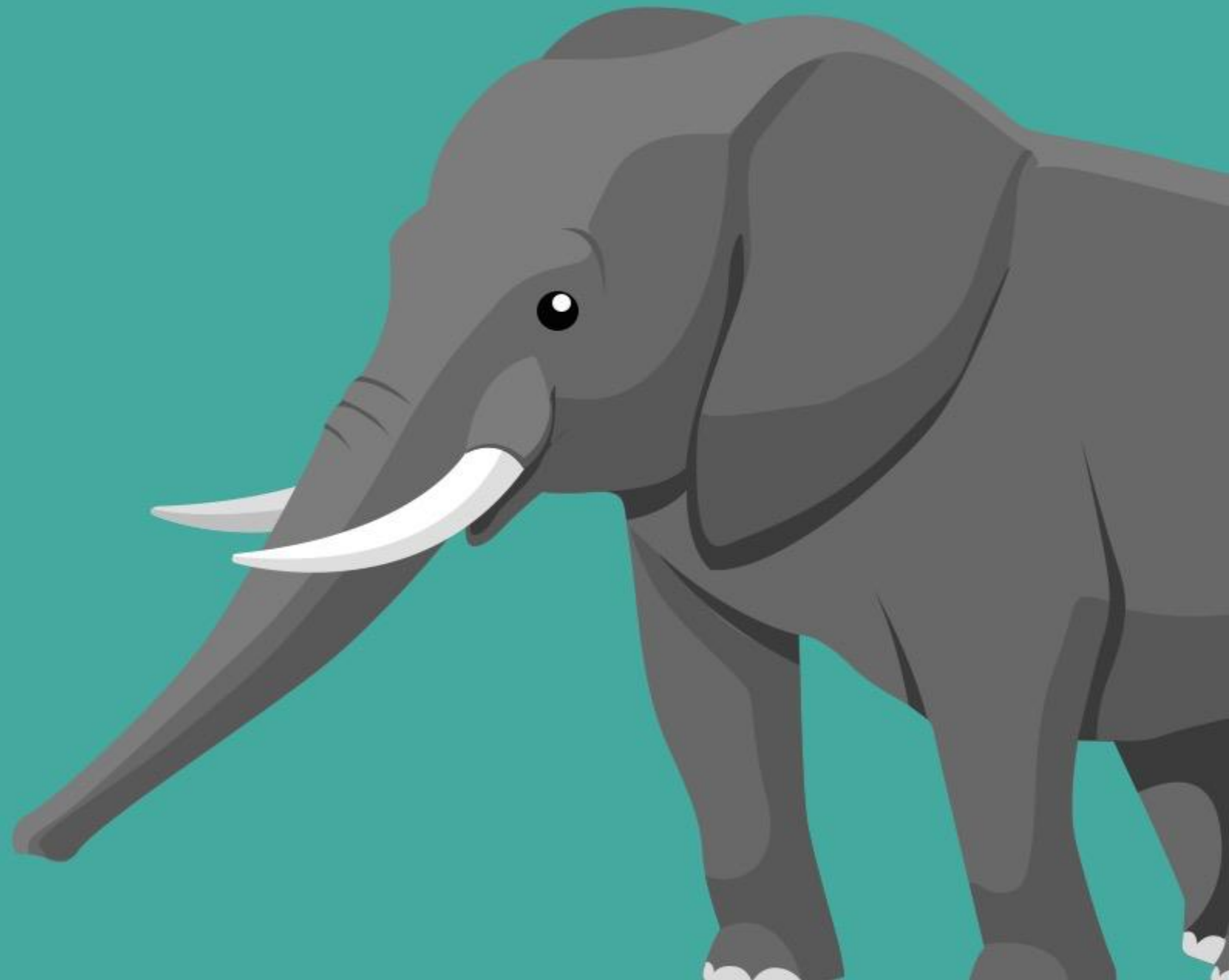
# Perception – Two Main Senses



# Perception Limitations – Sight and Hearing

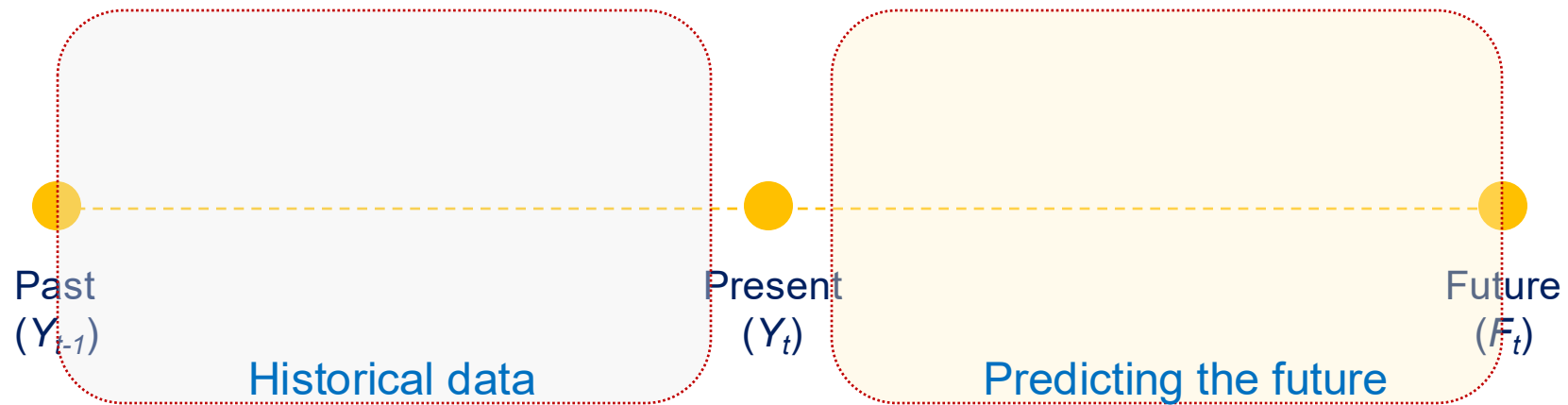


# ELEPHANT AND 6 BLIND MEN METAPHOR





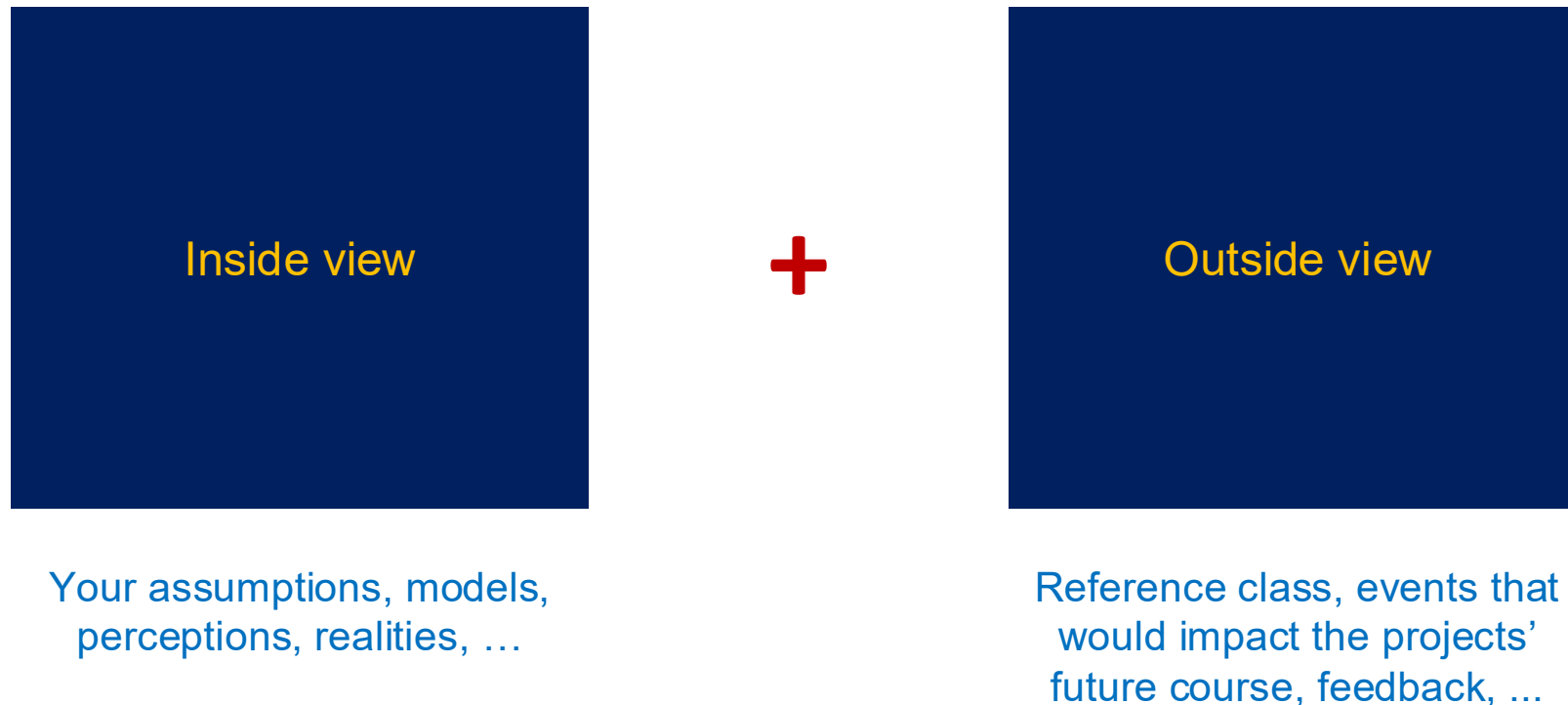
# Reminder: The Science of Predicting The Future



**Assumption:** The future will be the same as the **past!**

- $F_t$  : demand forecast for period  $t$
- $Y_t$  : actual demand for period  $t$

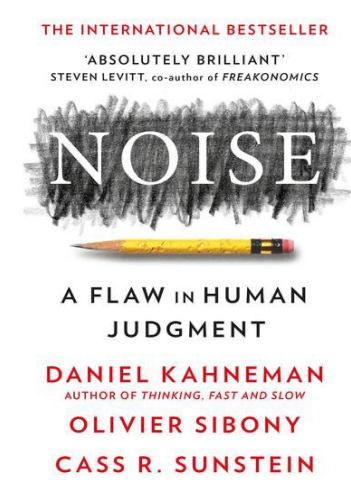
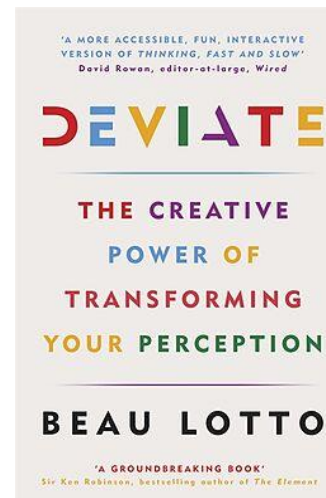
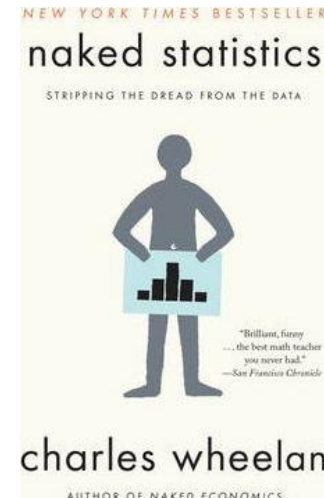
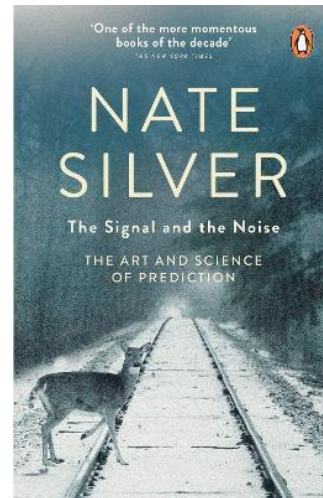
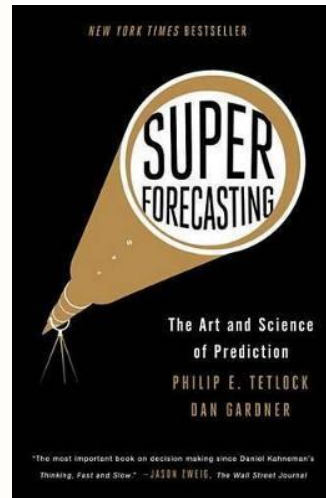
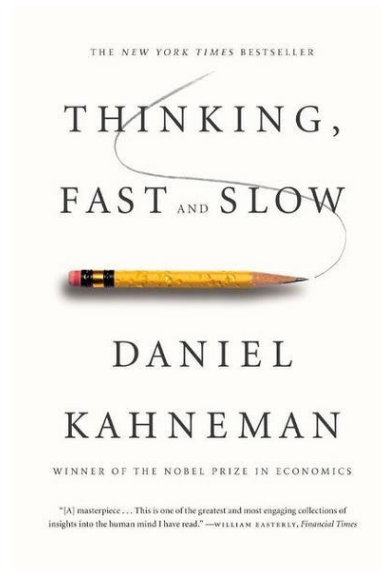
# Demand Management – Best Way To Forecast/Predict Future



## Sources:

1. Kahneman, D., & Lovallo, D. (2003). Delusions of success—How optimism undermines executive's decisions. *Harvard Business Review*, 81(7), 56-63.
2. Kahneman, D., & Lovallo, D. (1993). Timid choices and bold forecasts: A cognitive perspective on risk taking. *Management science*, 39(1), 17-31.

# Want to Know More? – Selected Books

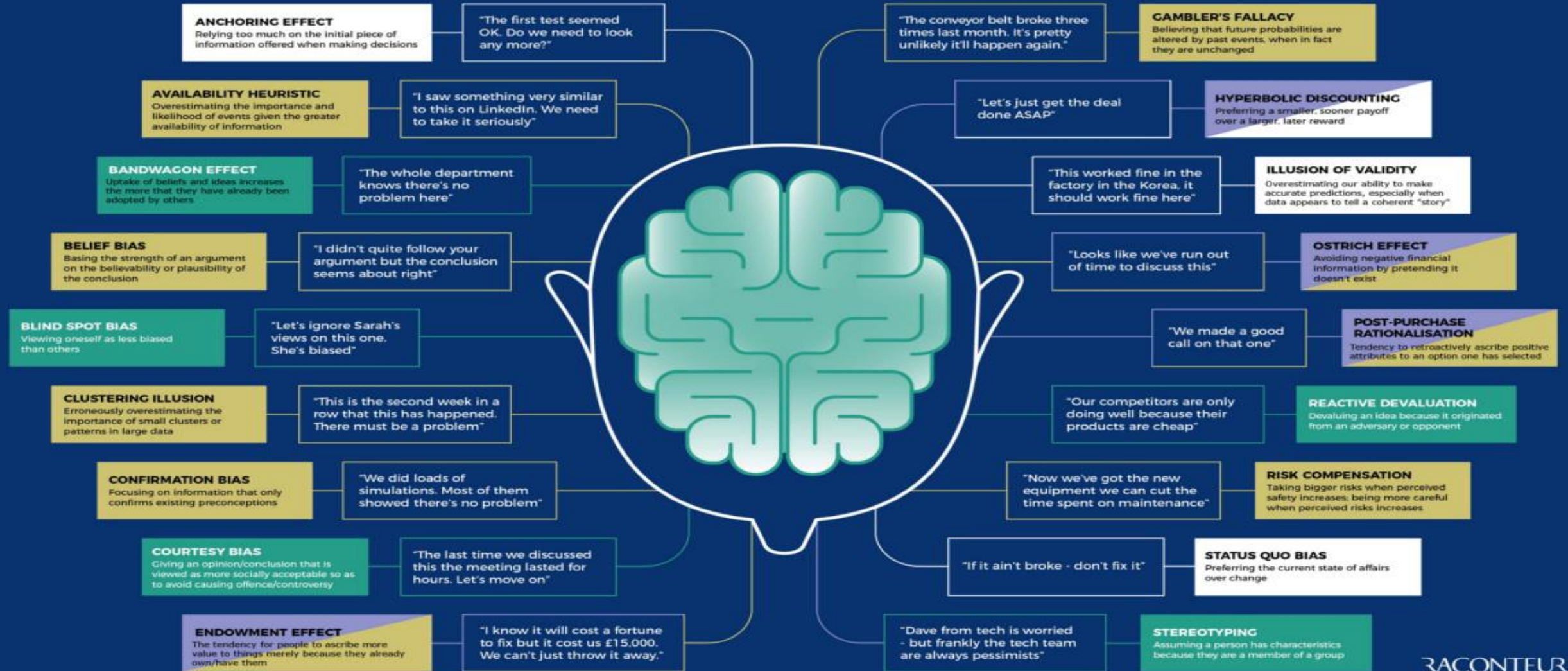


# Cognitive bias

● Social ● Financial ● Failure to estimate ● Short-termism

When it comes to assessing risk, humans often fail to make rational decisions because our brains take mental shortcuts that prevent us making the correct choice. Since the 1960s behavioural scientists and psychologists have been researching these failings, and have identified and labelled dozens of them. Here are some that can cause havoc when it comes to assessing risks in business

**ORIGIN**  
The notion of cognitive biases was first introduced by psychologists Amos Tversky and Daniel Kahneman in the early-1970s. Their research paper, 'Judgment Under Uncertainty: Heuristics and Biases', in the Science journal has provided the basis of almost all current theories of decision-making and heuristics. Professor Kahneman was awarded a Nobel Prize in 2002 after further developing the ideas and applying them to economics.



RACONTEUR

# Group Exercise – Judgement & Cognitive Biases



10 min



**Task1:** Define each of the judgment and cognitive biases can be related to what step(s) of Demand Forecast? Why?

**Task3:** What are the main judgment and cognitive biases that can be related to each qualitative method? Why?

**Exercise:** Define each of the judgement and cognitive biases can be related to what step(s) of Demand Forecast? Why?

**ONLY for groups of Matia & Théodora**

#	Judgement & Cognitive Biases	Step 1 Goal	Step 2 Data	Step 3 Method	Step 4 Forecast	Step 5 Performance	Why?
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

**Exercise:** What are the main judgement and cognitive biases that can be related to each qualitative method? Why?

**ONLY for groups of Norberto & Patrick**

#	Qualitative Methods	Judgement & Cognitive Biase(s)	Why?
1	Executive Opinions		
2	Salesforce Opinions		
3	Consumer Survey		
4	Delphi Method		

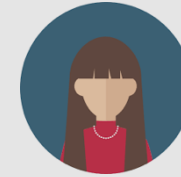
# Forecasting Methods – Quantitative Methods



Forecasting Methods



Qualitative methods



Executive opinions



Salesforce opinions



Customer surveys



Delphi method



Quantitative methods



Causal models



Time series



Machine Learning

# Learning Points – Summary

- Demand forecasting steps
- Methods to forecast: qualitative and quantitative
- Different qualitative methods

# Production Management (ME-419)

## Coaching Rooms

Amin Kaboli

Week 4 – Session 4 – Oct 03<sup>rd</sup>, 2024

# The Art of Giving and Receiving Effective Feedback



Feedback is a gift



Feedback/comments are  
always welcome

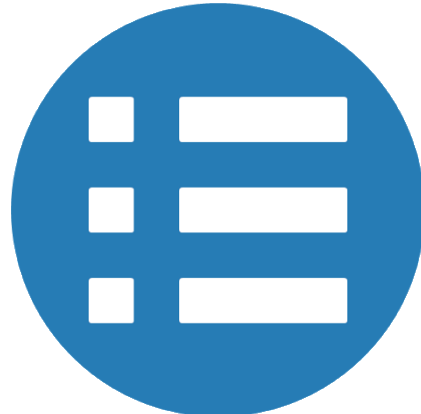
# Giving Effective Feedback



## Respectful

Ask for permission

May I share my observation



## Fact-based

Share facts/ your feelings

What I observed/felt is that ...



## Constructive

Stay focused on growth

What I suggest is that ...



## Concise

Be to-the-point and short

Max three key points



## Open

Be open to any reaction

I respect your feeling ...

# Receiving Effective Feedback



## Receive the gift

**Be open and receptive**

*I appreciate your feedback*



## Listen

**Listen to listen!**

The goal is to listen not to answer, no interruption (zip it)



## Understand

**Focus on THE message**

The goal is to understand, ask questions, clarify, repeat key points, ...



## Decide

**You always have a choice**

*Thank you, I have never seen it this way*  
OR  
*Thank you, let me reflect and get back to you?*



## Follow up

**Reach a common understanding**

There are many ways to follow up: revise the work, set up a meeting, ...