EC07-Prévision & Planification – Forecast and Planning – Methodology for forecasting process

2025-2026

DIENG Coumba

Syllabus 2025-2026

FICHE EC- EC07-PrevPlan		
Contenu de cours	Les méthodes de prévision (3hC, 3hTD, 3,25hTP) : Les principales étapes du processus de prévision de la demande Les méthodes de base de la prévision de la demande, LES, HOLT, Winters Les critères pour comparer différentes méthodes de prévision La démarche de réalisation d'un plan industriel et commercial La notion de Consommation Moyenne Journalière TD : Les données techniques articles, clients et fournisseurs TP : L'élaboration d'un PDP à partir d'un PIC	La planification et l'ordonnacement (3hC, 3hTD, 6,5hTP) : Les méthodes de regroupement, en fonction des besoins, semaines... Flux de production, les différents type d'ateliers, repérage et mesure des flux Le calcul de besoins nets La planification des ordres de production, d'achat et de sous-traitance L'ordonnancement de la production par les capacités, la théorie des files d'attente, l'algorythme de Jonhsonl La gestion par les contraintes TD : Les données techniques de production TP : Le lancement de fabrication dans l'atelier avec une solution de MES et la mise en place d'un système de management visuel Kanban et Heijunka pour piloter la réactivité
Responsable	Philippe RAGOT	

Evaluation	DS	TP	Projet	Cours	Soutenances	Autre				
Nombre d'évaluations	1	3	0	0	0	0				
Coefficient de l'évaluation	3	3	0	0	0	0				
Détail de l'évaluation	DS : 1 QCM, possibilité de contrôle en cours + 3 TP évalués									

Volume horaire (en heures)				Projet		E-Learning				
	CM	TD	TP	Encadré	Autonome	Encadré	Autonome	DS	TOTAL	Travail Perso
	6	6	9,75	0	0	0	0	1,5	23,25	31,75
dt en anglais	6	6	9,75	0	0	0	0		21,75	
dt en allemand	0	0	0	0	0	0	0		0	
Laboratoires nécessaires										
Nombre de groupes	1	2	4	2		1		1		
Chronopédagogie	Les TP ne peuvent pas commencer avant le dernier cours de TD, en raison du contenu technique abordé lors de la session. TP avec Astrée Software									

Distribution	Distribution vue étudiant								Distribution vue enseignant							
Enseignants	CM	TD	TP	Pe	Pa	E-Le	E-La	TOTAL	CM_e	TD_e	TP_e	Pe_e	Pa_e	E-Le_e	E-La_e	TOTAL
ARNAUD Mathieu	0	0	3,25	0	0	0	0	3,25	0	0	13	0	0	0	0	13
COLIN Victor	0	0	3,25	0	0	0	0	3,25	0	0	13	0	0	0	0	13
DIENG Coumba	6	6	3,25	0	0	0	0	15,25	6	12	13	0	0	0	0	31

Learning agreement

- Your active participation is highly expected.
- Thanks for warning now in case you must answer your phone for imperial personal or professional reasons. If not, many thanks for turning them off and leaving them.

Course overview

Lesson 1

- Introduction
- Vocabulary
- Basics sales forecast

Lesson 2

- Tool : Sales & Operations Planning

Lesson 3

- Tool : Manufacturing Planning and Scheduling

Lesson 4

- Net requirement
- MRP
- KANBAN

TD 1 & 2 & 3 & 4

- Parameter and forecast with an ERP tool with Ms. DIENG
- PIC and PDP establishment
- Forecasting with Excel

TP 1

- Forecast and ERP tool with Ms. DIENG

TP 2

- KANBAN with M. ARNAUD

TP 3

- MES with AstreeSofware
- COLIN Victor

Table of contents

References & Objectives

Objectives:

- Experience the complexity of forecasting
- Gain vocabulary on the industrial forecasting field
- Establish a Sales and Operations Planning
- Establish a Manufacturing Planning and Scheduling for manufacturing
- Manage an industrial context, with a focus on its main challenges : reactivity to satisfy the customer needs, good level of stocks and quality of forecasting.

References :

- "Gestion de production" - A. COURTOIS, C. MARTIN-BONNEFOUS et M. PILLET – Editions d'Organisation at your disposal on SholarVox. Chapter on Kanban method.
- "La planification industrielle" – Technique de l'ingénieur, available on Moodle
- Méthode Delphi par Sébastien CROCHEMORE Ingénieur de l'École nationale supérieure des industries agroalimentaires Responsable VET Propriétés physiques et sensorielles. Extract at your disposal on Moddle.
- Forecasting with Seasonality Dr. Ron Lembke at your disposal on Moodle.
- « Comment sécuriser nos approvisionnements stratégiques » report from La Fabrique de l'industrie at your disposal on Moodle.

References

« Le métier de l'ingénieur consiste à poser, étudier et résoudre de manière performante et innovante des problèmes souvent complexes de création, de conception, de réalisation, de mise en œuvre et de contrôle de produits, de systèmes ou de services – éventuellement leur financement et leur commercialisation – au sein d'une organisation le plus souvent compétitive. Il intègre les préoccupations de protection de l'Homme, de la société et de ses valeurs, de la vie et de l'environnement, et plus généralement du bien-être collectif. L'activité de l'ingénieur mobilise des ressources humaines et des moyens techniques et financiers. Elle contribue à la création, au développement, à la compétitivité et à la pérennité des entreprises et des organisations, dans un cadre international. Elle s'exerce dans les secteurs privés, publics et associatifs, dans l'industrie et les services, le bâtiment et les travaux publics ainsi que dans l'agroalimentaire au sens large. Dans les faits il y aurait lieu de parler au pluriel de « métiers » d'ingénieur.»

CTI

Abreviations FR/ENG

CBN	Calcul de Besoin Net
GPAO	Gestion de Production Assistée par Ordinateur
PDP	Programme Directeur de Production
PGI	Progiciel de Gestion Intégrée
PIC	Plan Industriel et Commercial

MRP	Material Requirement Schedule
CAMS	Computer Aided Manufacturing System
MPS	Master Production Schedule
ERP	Enterprise Resource Planning
S&OP	Sales and Operations Plan

Introduction – Planning - Budget - Forecast

Planification

- Planning provides a roadmap for a company's financial objectives, usually for the next three to five years.

Budgeting

- Budgeting details how the plan will be executed month by month, and covers elements such as **revenues, expenses, potential cash flow and debt reduction**. Traditionally, a company designates a fiscal year and draws up a budget for the year. The budget may be adjusted based on actual revenues or compared to actual financial statements to determine how close they are to the budget target or exceed it.

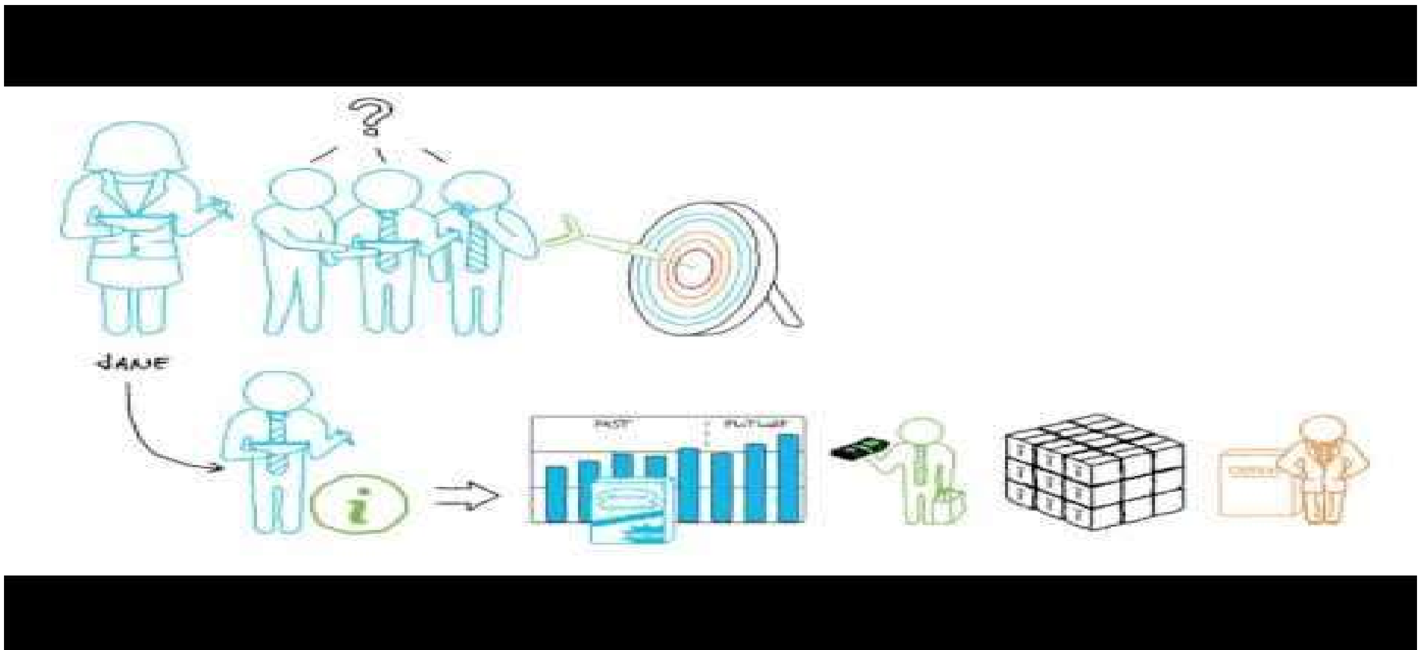
Forecasting

- Forecasts are based on historical data and current market conditions. They help **predict** how much revenue an organization can expect to earn over the **coming months or years**. Forecasts are usually updated when new information becomes available.

The process is usually managed by a CFO and the finance department. However, the definition can be extended to include all areas of organizational planning, such as financial planning and analysis, supply chain planning, sales planning, workforce planning, and marketing planning.

CFO = Chief Financial Officer = Directeur financier, souvent le n° 2 des entreprises

Introduction – Budget & Forecast (5min)



https://www.youtube.com/watch?v=FL2NcGYQ_Vc

Introduction - Differences between Planning and forecasting

- Forecasting :
  - Covers a wider scope and involves more uncertainty than planning.
  - Aims to capture external factors that can affect the organization, such as market trends, customer behavior, or competitor actions.
  - Considers multiple possible outcomes and their probabilities.
  - Relies on mathematical, commercial, and geopolitical tools.

- Planning :
  - More specific and more controllable.
  - Focuses on internal factors that can be managed, such as goals, actions, and resources.
  - Defines a single or a few preferred outcomes and the steps needed to achieve them.
  - Mainly uses technical tools.

Introduction - Similarities between Planning and forecasting

- Planning & forecasting
  - They aim to improve your performance, efficiency, and effectiveness.
  - They follow a similar process of collecting data, analyzing information, generating alternatives, and evaluating options.
  - Forecasting provides the inputs and constraints for planning.
  - Planning provides the feedback and adjustments for forecasting.

- For example, you can use forecasting to estimate the demand for your product or service, and then use planning to determine how much inventory, staff, or budget you need. You can also use planning to set your sales target or growth rate, and then use forecasting to assess the feasibility and risk of your plan.

Introduction - Purposes

- To ensure maximum efficiency, a company produces exactly what customers want and only buys what is needed for that production.

This ideal situation is only possible if production and purchasing start exactly when a customer order is received.

- To reduce the risk of producing the wrong goods or having stock shortages, companies rely on forecasting to predict demand.

Forecasts can be short-, medium-, or long-term, depending on the planning horizon.

Now imagine for a plane manufacturer, producing planes composed of nearly a millions parts

Example of production based on planification.

Example of production based on forecasting

Introduction - Purposes

The Great Depression Era (1930s):

- Modern economic forecasting began as a response to the economic crisis of the 1930s (Great Depression). New statistical methods were developed to help companies better predict future trends. Consulting firms also appeared to assist businesses in using these predictive tools.

Early 2000s – The Data Explosion:

- With the rise of digital technology, companies gained access to vast amounts of operational data and external information, such as weather conditions, social media sentiment, and economic indicators. This data abundance required more advanced software tools to analyze and use forecasts effectively.

Today – Continuous Planning and Rolling Forecasts:

- Many organizations still rely on traditional annual plans and budgets; a management method developed over 100 years ago. However, in today's fast-changing, competitive environment, companies understand that plans and forecasts must be updated regularly to reflect current realities. Continuous planning and rolling forecasts—updated quarterly or monthly—allow managers to detect trends early and make more agile decisions on pricing, product offerings, investments, and staffing.

Introduction - Purposes

Forecast are made to take **decisions:**

When companies adopt data and analytics in conjunction with well-established planning and forecasting best practices, they improve strategic decision-making and can be rewarded with more accurate plans and faster forecasts.

A good forecasts allow you to :

- ✓ Make more confident **strategic decisions** based on solid data rather than assumptions or guesses.
- ✓ **Quickly update plans and forecasts** to respond to emerging risks and opportunities.
- ✓ **Detect potential risks early** enough to address issues before they grow.
- ✓ Develop a **precise budget for growth**, with confidence in the available spending capacity.
- ✓ **Identify and analyze** the effects of changes as they happen.
- ✓ Strengthen the **connection** between **operational and financial** planning.
- ✓ **Attract new customers** by considering the Amazon Effect*, even in B2B markets.

Introduction - *The Amazon Effect*

The Amazon Effect refers to the impact that online, eCommerce, and digital marketplaces have had on traditional business models. This impact is driven by changes in shopping habits, customer expectations, and the competitive landscape of the industry. As online shopping and eCommerce continue to grow in popularity, many traditional businesses that rely solely on physical stores have struggled to compete with these digital platforms.

This phenomenon has caused **significant disruptions in traditional demand forecasting processes.** Whereas supply chain planners once only needed to manage inventory levels at a few central sites, they now must accurately **manage inventory and stock reserves across hundreds of smaller distribution centers.**
This complexity **increases risks and potential losses.** Consequently, demand planning professionals rely more than ever on cloud-connected supply chain solutions to gain real-time insights and data, enabling them to manage their more fragmented and dynamic inventory effectively.

Introduction - Purposes

Without effective demand forecasting, companies' risk :

- Holding unnecessary and costly excess inventory
- Missing opportunities because they fail to anticipate customer needs, preferences, and buying intentions
- Managing resources (workforce, equipment, components) in a completely chaotic way

Introduction - Level scope for industries

Strategic planning focuses on **achieving the long-term objectives** set by the company's overall strategy. Its purpose is to ensure that the organization aligns its resources and actions to satisfy market needs and gain a competitive advantage.

Entering new markets, launching major product lines, or investing in new production capacity.

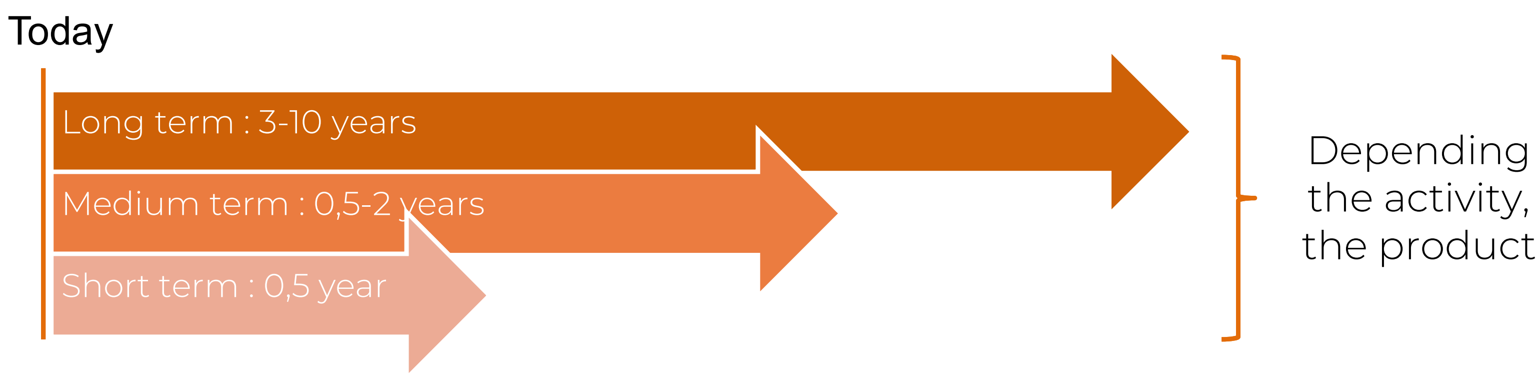
Tactical planning **translates strategic goals into medium-term actions**. It involves allocating resources, setting intermediate targets, and defining how to reach strategic objectives effectively. The main focus is balancing supply and demand while optimizing costs and resources.

Establishing a Sales and Operations Plan (S&OP), setting production targets per quarter, managing workforce levels.

Operational **planning deals with short-term actions and detailed schedules**. It organizes daily or weekly activities to implement tactical plans efficiently. Its goal is to ensure smooth operations, respect deadlines, and adapt quickly to unforeseen changes.

Scheduling machine use, assigning workers to shifts, ordering raw materials for the coming week.

Introduction - Temporal scope for industries

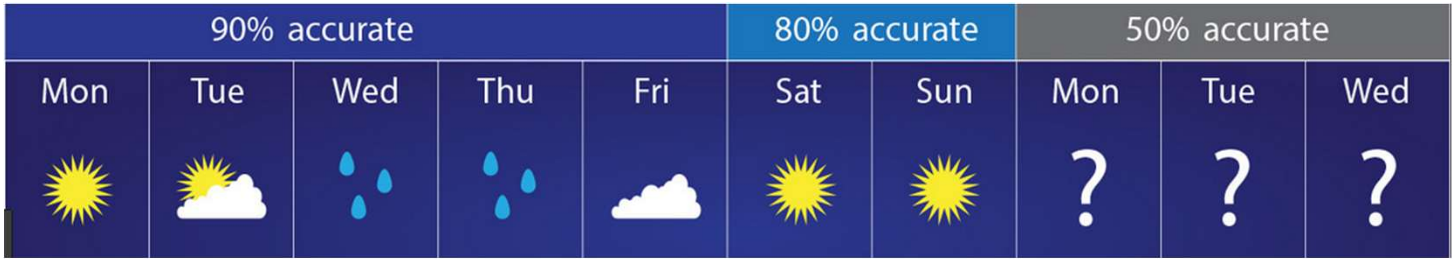


Long term forecasting is done for the strategic level of the company

Medium term forecasting is done for managing manufacturing and supply capacity

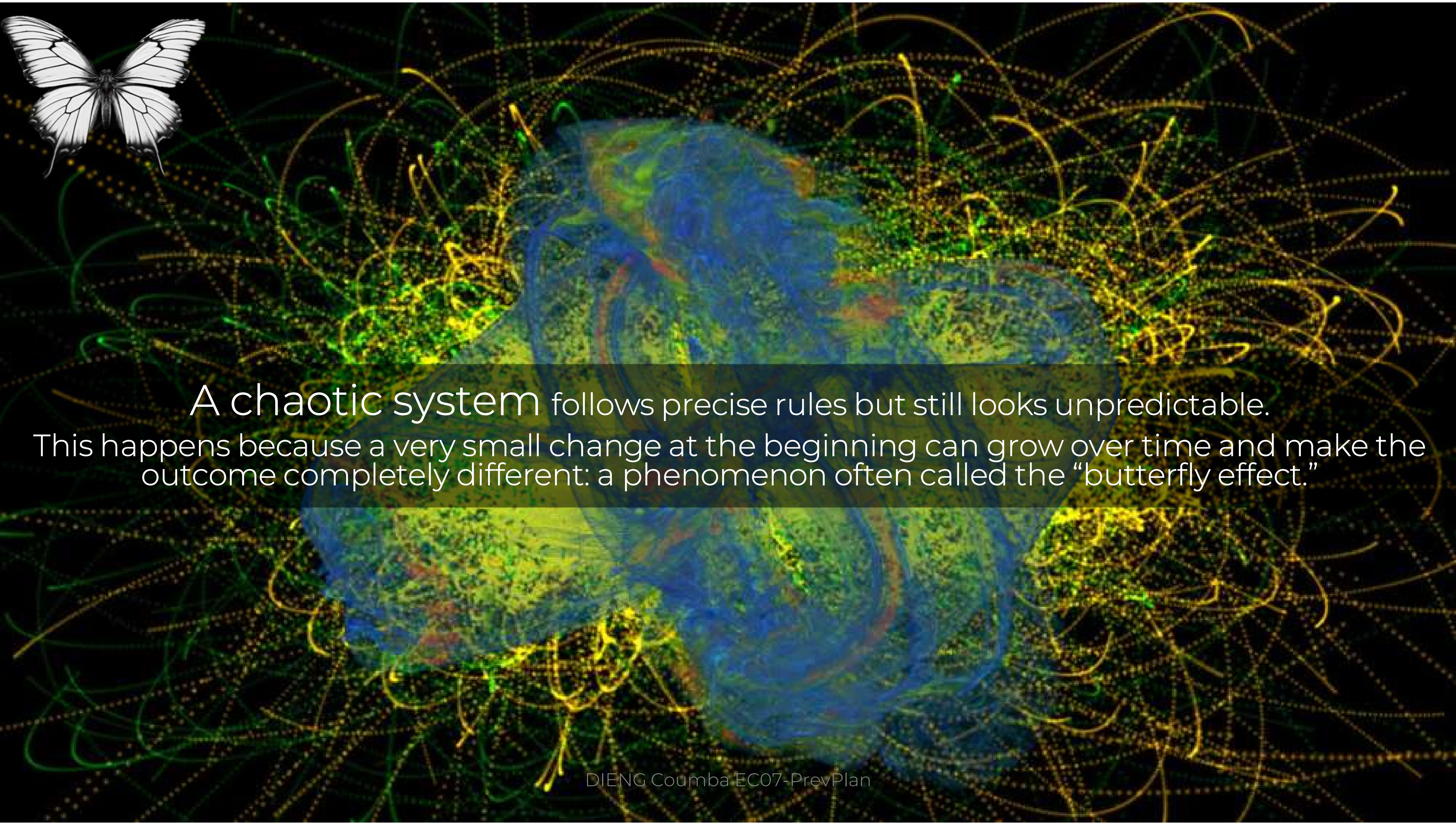
Short term forecasting is done for operational management of manufacturing

Introduction - Purposes



Weather forecast is useful to plan and adapt
your activities, your clothes, the heat of your home etc...

Sales forecasting is important for a company to plan and adapt
its strategy, activity, resources


A chaotic system follows precise rules but still looks unpredictable.
This happens because a very small change at the beginning can grow over time and make the outcome completely different: a phenomenon often called the “butterfly effect.”
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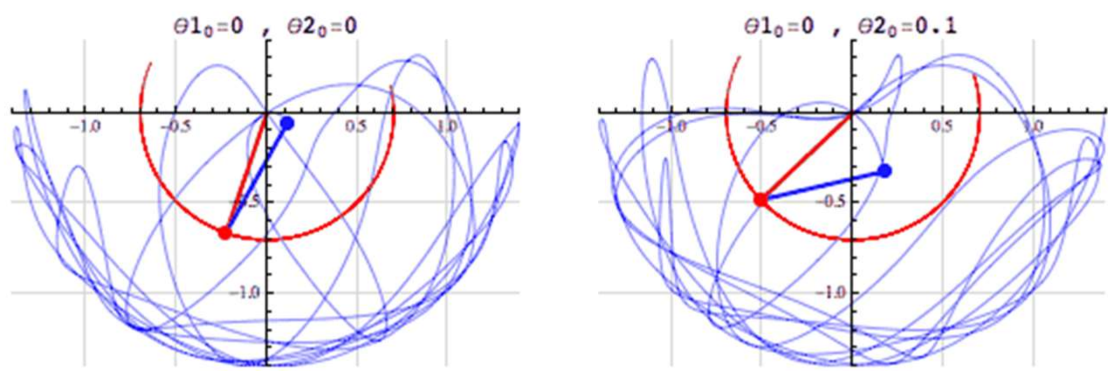
Introduction - Chaotic system

In the past, physics could describe complex systems like gases or liquids by using statistical mechanics, which works well for many particles at equilibrium.

However, in the late 19th century, scientists found that simple systems can also generate very complex, unpredictable behavior if they are chaotic.

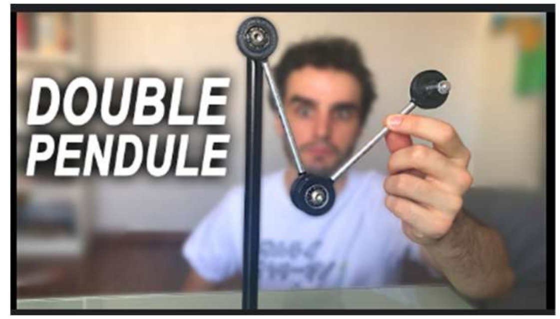
<u>Key Characteristics:</u>

- **Small causes** can create huge and unexpected effects (the "butterfly effect").
- **Similar causes** do not always lead to similar effects.
- **Long-term** prediction becomes impossible.
- Chaos can appear even in simple systems with only a **few variables.**



<u>Double pendulum</u>

Introduction - Chaotic system



We do not live in a fully predictable world.
Some systems, although deterministic, behave chaotically.
A dynamic system is said to be chaotic if, within part of its phase space, it simultaneously shows:

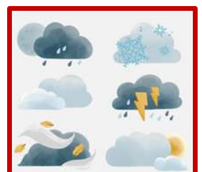
- Sensitivity to initial conditions (tiny differences at the start lead to very different outcomes),
- Recurrence or mixing (trajectories return and spread across the phase space in a complex way).

<u>"Unchaotic" system :</u>

Tides : can be predicted precisely thanks to the Moon's cycles.

Eclipses : can be calculated centuries in advance.

Planet positions : follow stable orbital laws.



<u>Chaotic systems:</u>

Weather: tiny changes in conditions can completely change the forecast.

Double pendulum: a slight push makes the motion unpredictable.

Billiards: a small error changes the whole trajectory.

Bullwhip effect-Effet coup de fouet

The Bullwhip Effect refers to the phenomenon where **small fluctuations in customer demand** cause **increasingly larger variations** in orders and inventory levels up the supply chain.

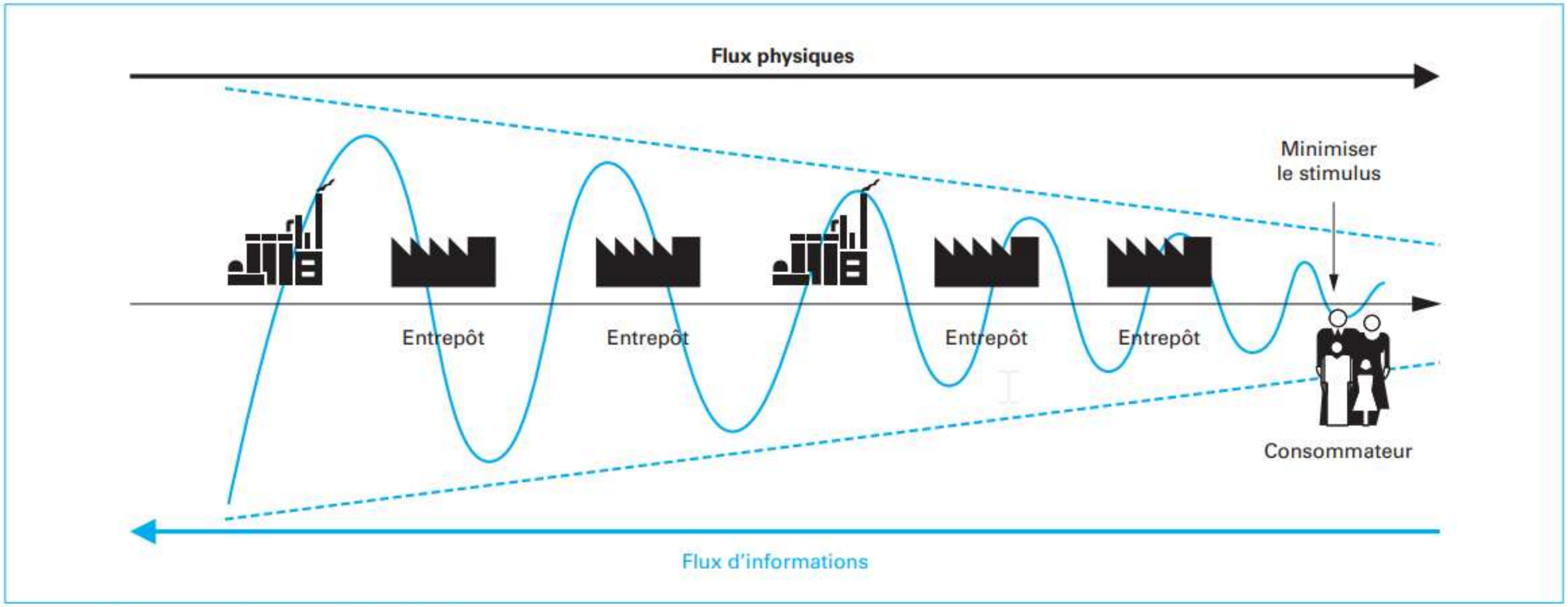


Figure 6 – Effet coup de fouet et sa minimisation

Introduction – Long temporal scope for industries

Report written by INSP and Ecole des Mines School, published by “La Fabrique de l’industrie”.

- Public institutions and industries responsibilities in the national strategic supply ;
- How forecasting strategic supply, at a national scale, is complex ;

- The Covid-19 crisis has highlighted the dependence of our production capacity and industrial supplies on production outside France.
  - It is not the first break in supply chain that France, but a global awareness from national population need to be pointed out.
  - Strong supply pressure from with the current economic recovery (wood, semiconductor, medicines).

- This will affect you in your career, (read part I, II and III)

Introduction – Long temporal scope for industries

Criteria for assessing the vulnerabilities of each link in the chain

- Macroeconomic factors characterizing the market, such as the level of import dependency, the geographical concentration of imports or the existence of national anti-competitive practices.
- Microeconomic factors characterizing the competitive environment and individual companies: concentration of the number of companies, industrial reliability (depending in particular on the players' mastery of the industrial process) or the environmental and social risks of industrial activity.
- Technical-economic factors linked to the characteristics of alternatives to the current production circuit: recyclability, substitutability, stockability or the time required to develop new production capacities. development of new production capacities.

ANALYSE	CRITÈRES
Macroéconomique (marchés)	Taux de dépendance aux importations
	Concentration géographique des importations
	Caractère déficitaire du marché
	Distorsion de concurrence (politiques commerciales / industrielles)
Economie industrielle (acteurs)	Concentration des entreprises fournisseurs (nombre et part)
	Concentration de l'actionnariat ou de sa nationalité
	Fiabilité industrielle
	Risques sociaux et environnementaux
Technico-économique (alternatives)	Recyclabilité
	Substituabilité
	Transportabilité et stockabilité
	Temps de développement de nouvelles capacités de production

Introduction - Level scope for industries

- Macro-Level Demand Forecasting considers general economic conditions, external forces, and other general influences that may disrupt or affect the business. These factors help inform businesses of regional and global risks or opportunities and raise awareness of general cultural and business changes.

- Micro-level demand forecasting can be specific to a particular product, region, or customer segment. Micro-level forecasts are particularly suitable for one-time or unexpected market fluctuations that could lead to a sudden spike or drop in demand.
  - For example, if experts predict a heat wave in New York and your business manufactures portable air conditioners, it may be worth taking the risk to preemptively increase your reserve inventory in that region.

Introduction : Profiles of sales

There are several typical profiles of sales, with an impact on the choice of forecasting methodology:

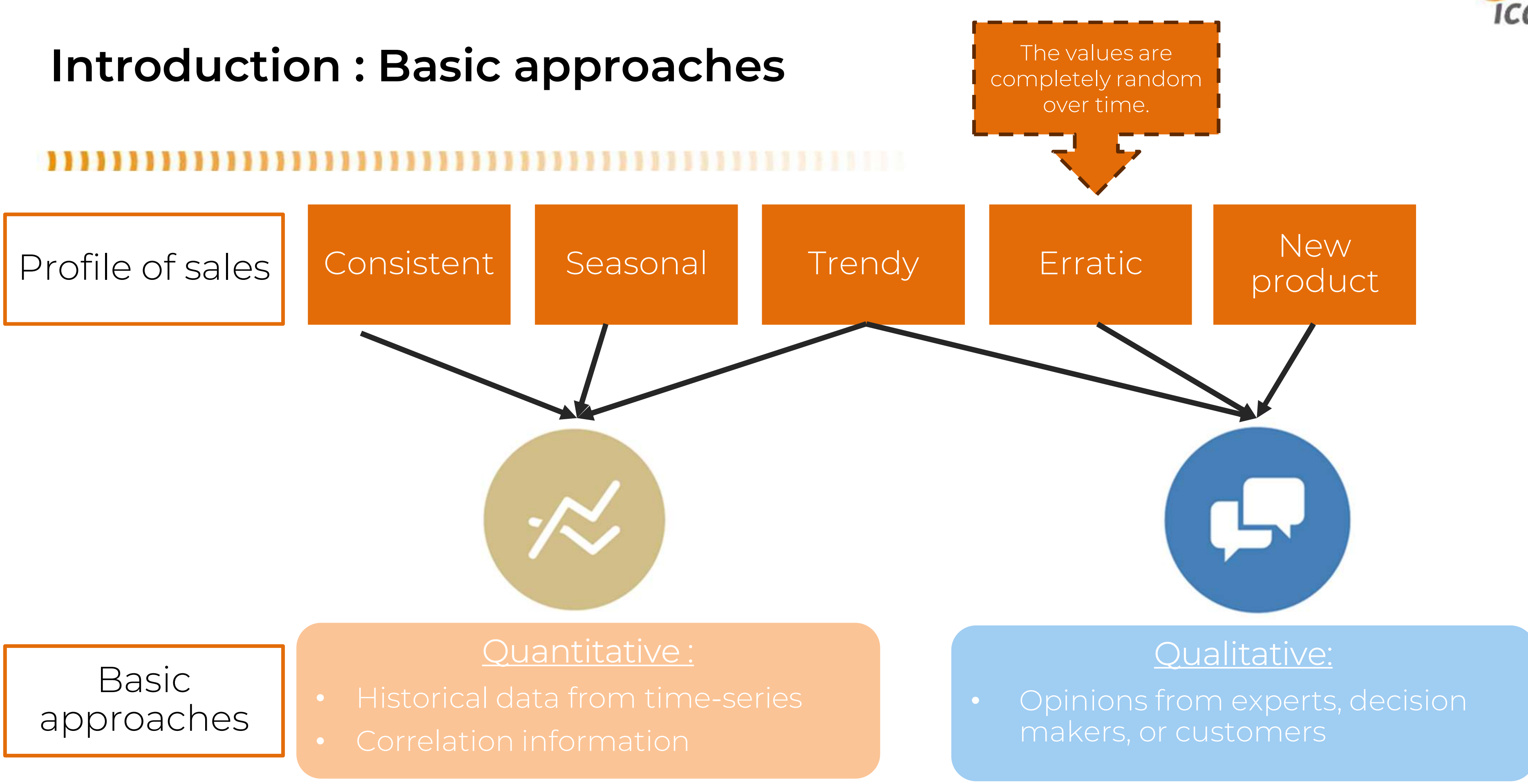
Constant demand :
It oscillates statistically around a constant average value over time, the average of D = f (t) is a horizontal line

Seasonal demand :
It exhibits significantly greater variations, up and down, on a periodic basis. It can be a peak in demand in winter (related to snow for example) or in summer (holidays), but it can also be more subtle seasonal variations (small electrical tools with peaks on Father's Day and at Christmas)
Natural seasons or not

Demand with trend :
There is oscillation around an increasing or decreasing value in time, D = f (t) is a straight line with positive or negative slope

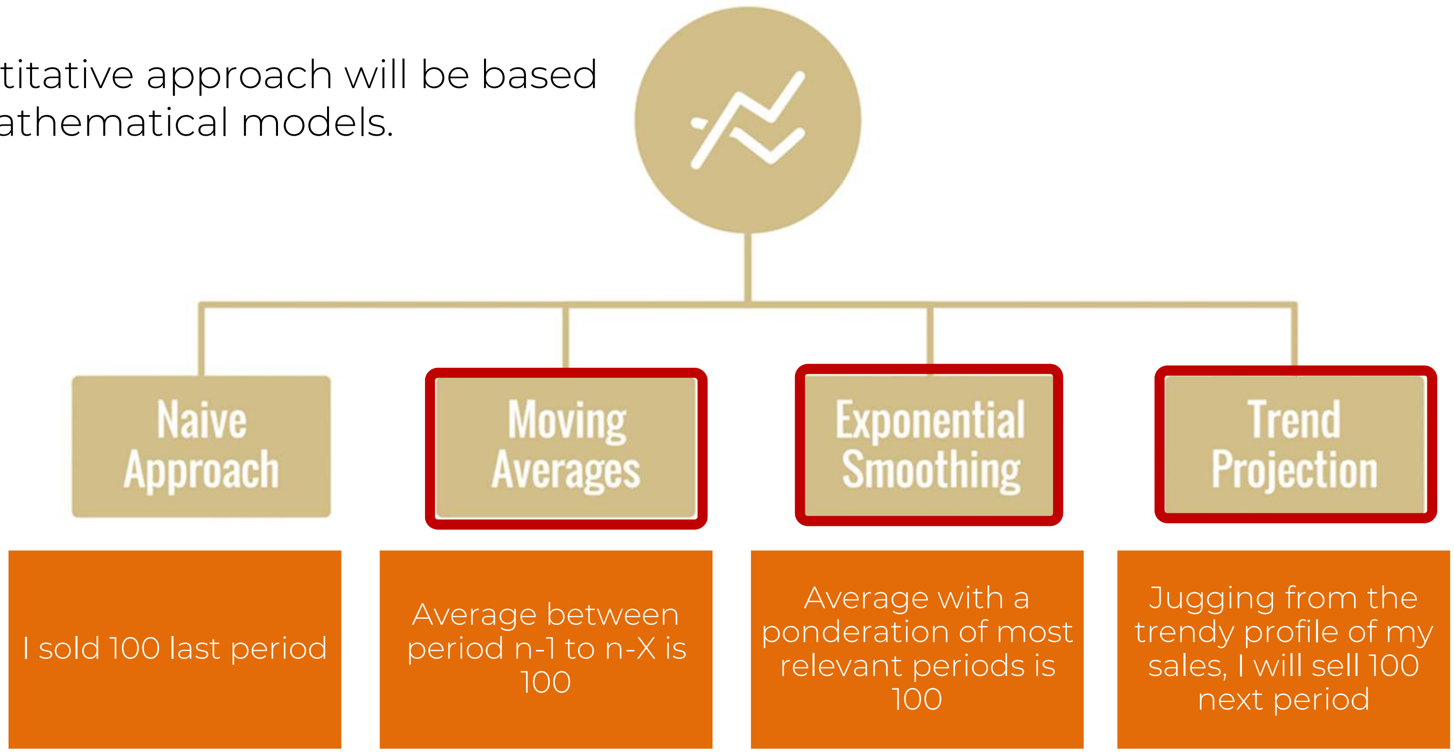
Seasonal and trending demand :
The peaks and troughs are arranged around a non-horizontal line

Introduction : Basic approaches



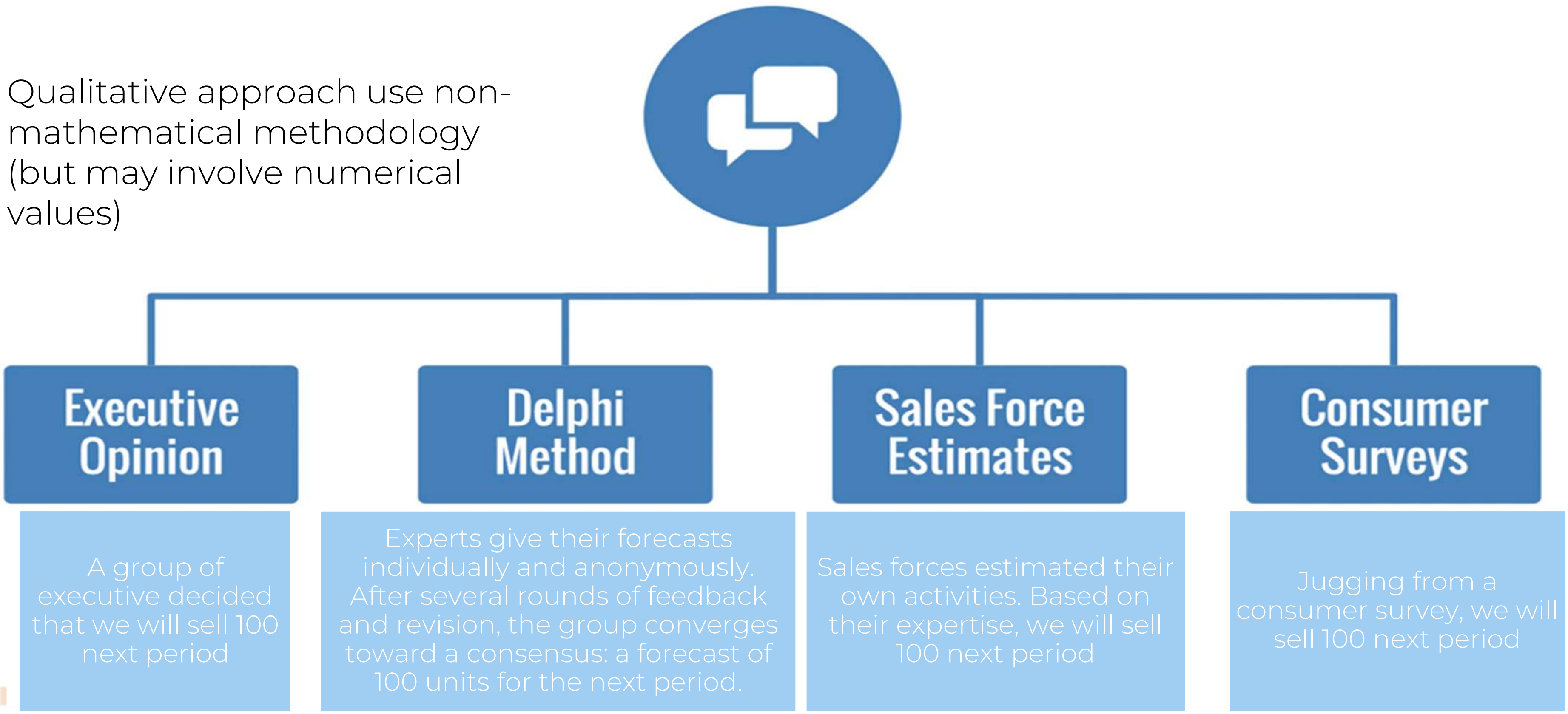
Introduction : Basic approaches

- Quantitative approach will be based on mathematical models.



Introduction : Basic approaches

- Qualitative approach use non-mathematical methodology (but may involve numerical values)



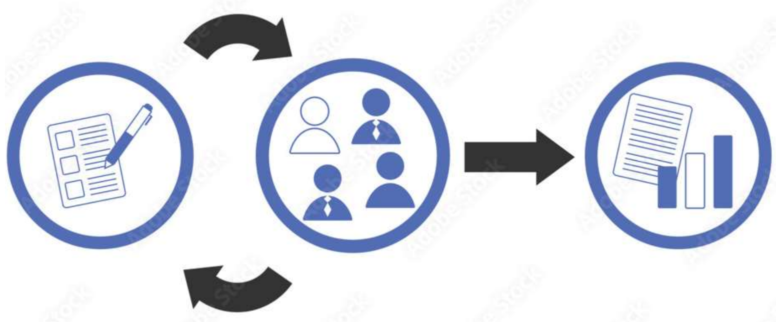
Introduction – Delphi method

The Delphi method is a structured communication method, developed as a forecasting method which relies on a panel of experts.

Delphi is based on the principle that forecasts (or decisions) from a structured group of individuals are more accurate than those from unstructured groups.

Introduction – Delphi method

The **experts answer questionnaires** in many rounds. After each round, a **facilitator** provides a **summary** of the experts' answers from the previous round as well as the reasons they provided for their judgments.



Thus, experts are encouraged to revise their earlier answers considering the replies of other members of their panel.
It is believed that **during this process the range of the answers will decrease**, and the group will converge towards the "correct" answer.

Introduction – Delphi method

1. Study scope definition

   A poorly defined issue may never lead to a consensus due to the potential existence of multiple solutions or a constantly evolving nature of the issue.

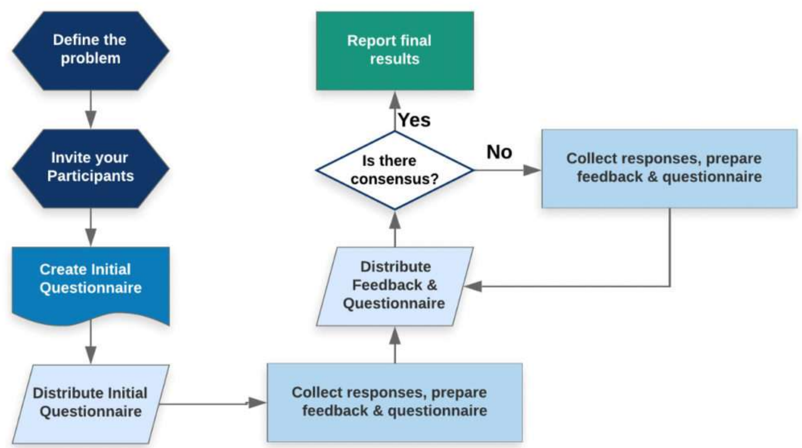
2. Research and formation of the expert panel.

   All individuals whose experiences and knowledge qualify them to anticipate the future development of the field of investigation.

   From different sector, educations...

3. Drafting and submission of the questionnaire.

4. Consultation rounds, data collection, and results processing.



Introduction – Delphi method

The Delphi method presents the following characteristics and features :

- Anonymity of experts, which assures free expression of opinions provided by the experts. This method helps to avoid social pressure from dominant or dogmatic individuals or even from the majority or minorities,
- Iteration—At any point, experts can change their opinions or judgments without fear of being exposed to public criticism,
- Controlled feedback—Experts are informed about views of other experts who participate in the study,
- Some form of statistical aggregation permits a quantitative analysis. Thus, though qualitative, the Delphi method can provide quantitative results.

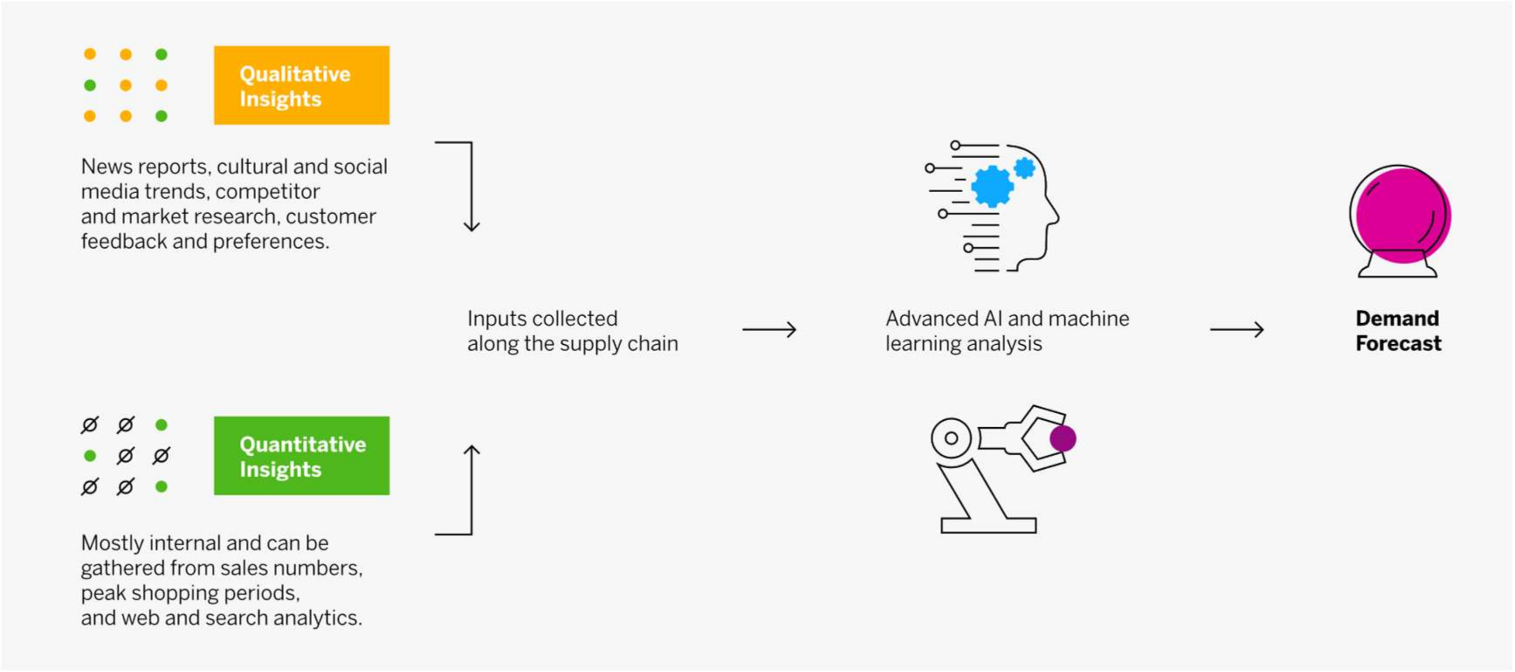
All of this with the aim of eliminating cognitive biases.

Introduction – Delphi method

Applications of the Delphi method:

- Management, economics, sciences, engineering, medicine, social sciences
- Estimate timelines (e.g. technology maturity)
- Predict events or scenarios (roadmaps)
- Assess feasibility and reduce risks
- Forecast market potential (sales, behavior changes)

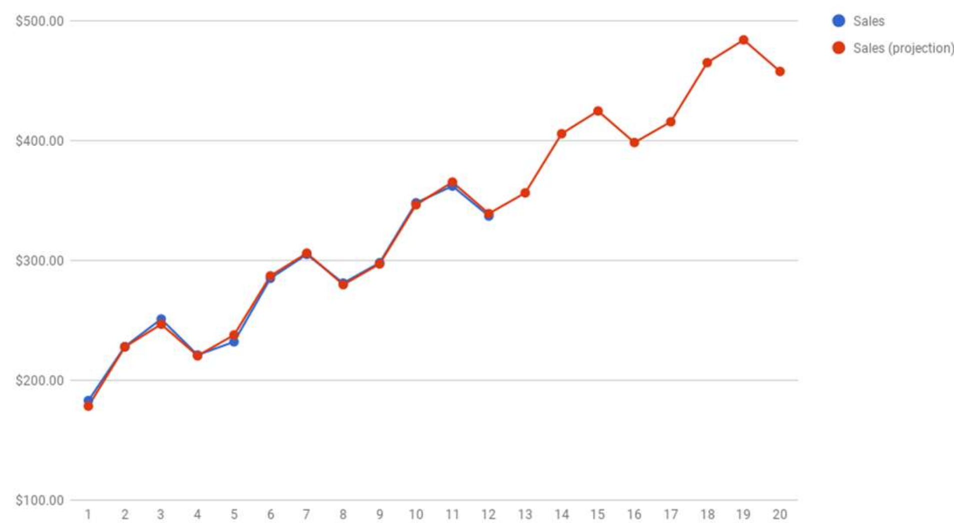
Introduction : Basic approaches



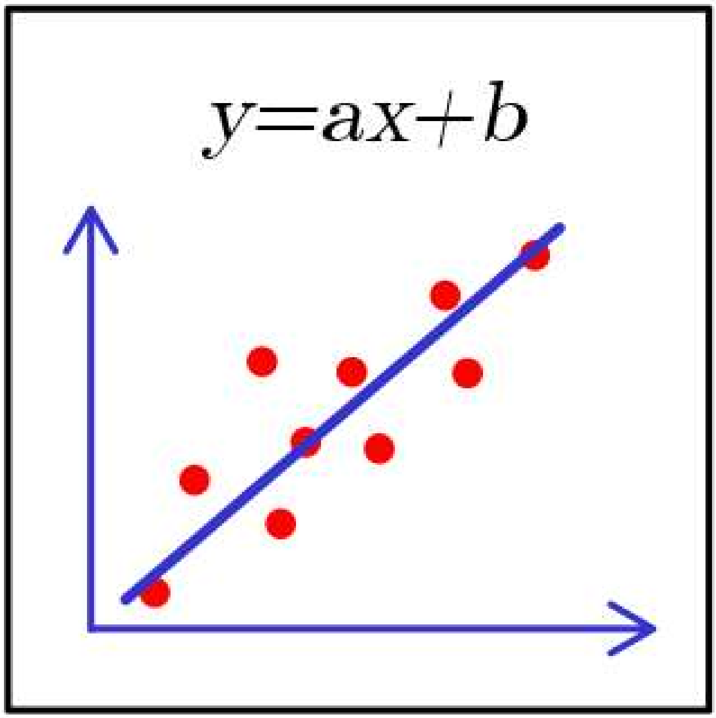
Introduction : Final purpose

Before creating a forecast, it’s essential to clarify a few key points to ensure it is useful, realistic and aligned with your objectives.

- What is the **purpose** of the forecast I’m about to do ?
- What is the **temporal scope** of the forecast I’m about to do ?
- How **accurate** the forecast I’m about to do should be ?
- How much time do I have to obtain them ?
- How much money do I have to obtain them ?



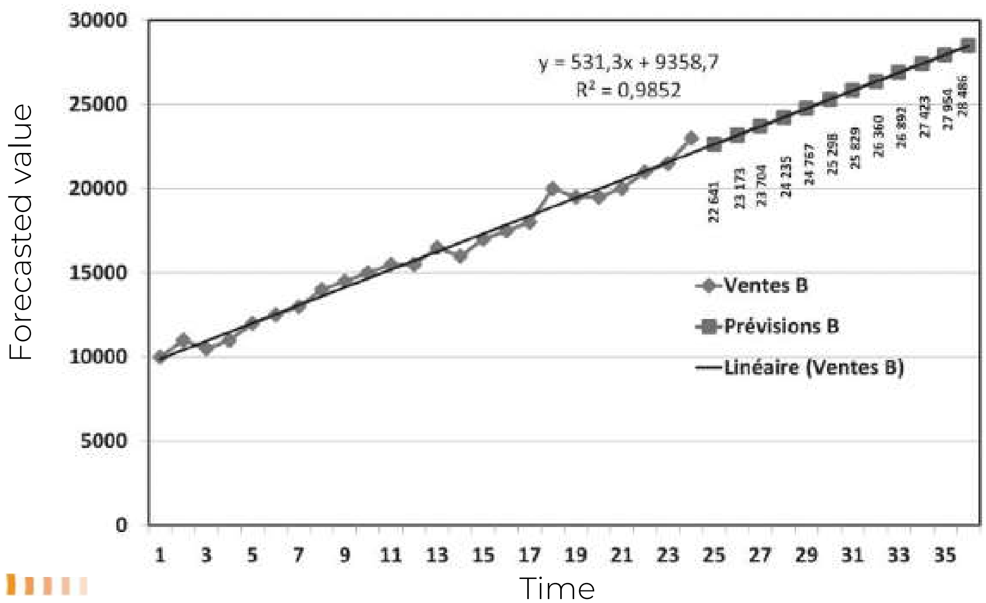
Linear regression



Linear regression

y = ax+b

First, we will define **the equation that best fits the scatter plot**. Linear regression is a statistical method used to model the relationship between a dependent variable and one or more independent variables by fitting a straight line through the data.



Least square calculations

(Calculs des moindres carrés)

$$a = \frac{\overline{x \times y} - \bar{x} \times \bar{y}}{\overline{x^2} - \bar{x}^2} = \frac{cov(X,Y)}{V(x)}$$

$$b = \bar{y} - a \times \bar{x}$$

$$\sigma = \sqrt{V} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

$$cov(X,Y) = \frac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)\left(Y_i - \bar{Y}\right)}{n-1}$$

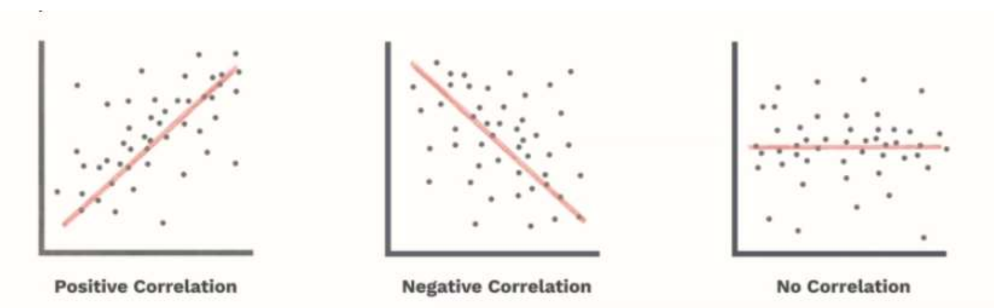
Linear regression

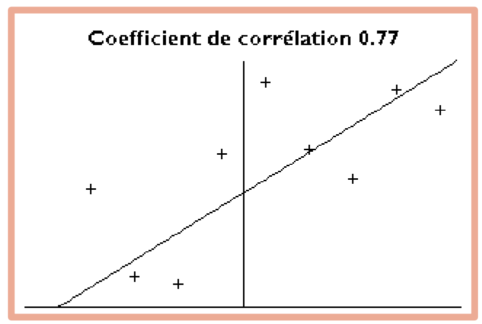
Corelation coefficient = r = [-1 ; 1]

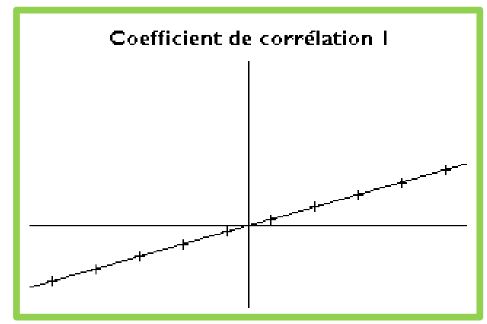
The closer r is to 1 or -1, the bigger the corelation is.

R^2 → is a percentage of corelation.

$$r = \frac{\mathrm{Cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{\sum_{i=1}^{N}(x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{N}(y_i - \bar{y})^2}}$$







Linear regression

Period	Nb of parts sold	X	X²	Y	Y²	XY	x-x̄	y-ȳ	(x-x̄)(y-ȳ)
Janvier	20 000	1	1	20 000	400000000	20000	-5,5	-1 500	8250
Février	21 000	2	4	21 000	441000000	42000	-4,5	-500	2250
Mars	19 000	3	9	19 000	361000000	57000	-3,5	-2 500	8750
Avril	22 000	4	16	22 000	484000000	88000	-2,5	500	-1250
Mai	23 000	5	25	23 000	529000000	115000	-1,5	1 500	-2250
Juin	22 000	6	36	22 000	484000000	132000	-0,5	500	-250
Juillet	20 000	7	49	20 000	400000000	140000	0,5	-1 500	-750
Août	16 000	8	64	16 000	256000000	128000	1,5	-5 500	-8250
Septembre	20 000	9	81	20 000	400000000	180000	2,5	-1 500	-3750
Octobre	23 000	10	100	23 000	529000000	230000	3,5	1 500	5250
Novembre	25 000	11	121	25 000	625000000	275000	4,5	3 500	15750
Décembre	27 000	12	144	27 000	729000000	324000	5,5	5 500	30250
Moyenne average		6,5	54,16667	21500	469833333	144250	Somme		54000
Ecart-type standard deviation		3,605551 28		2876,23491		93417,07 6			

$$a = \frac{\overline{x \times y} - \bar{x} \times \bar{y}}{\overline{x^2} - \bar{x}^2} = \frac{144\,250 - 6{,}5 * 21500}{54{,}16 - 6{,}5^2} = \frac{4500}{11{,}9} = 378$$

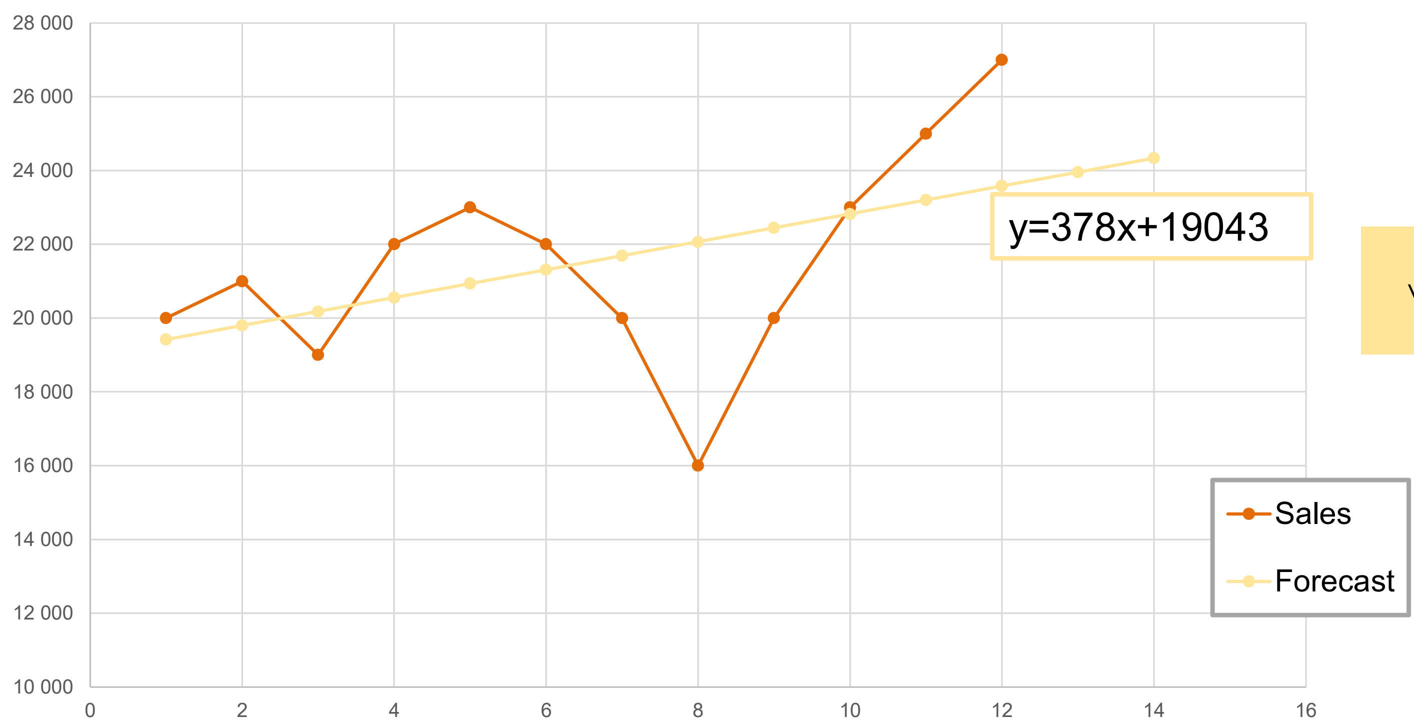
$$b = \bar{y} - a \times \bar{x} = 21500 - 6{,}5 * 378 = 19043$$

$$r = \frac{4909}{3{,}6 \times 2876{,}23} = 0{,}473$$

→ $R^2 = 0{,}22$

Or $$a = \frac{Cov(x;y)}{V(x)} = \frac{54000/11}{3{,}6^2} = \frac{4909}{12{,}96} = 378$$

Linear regression

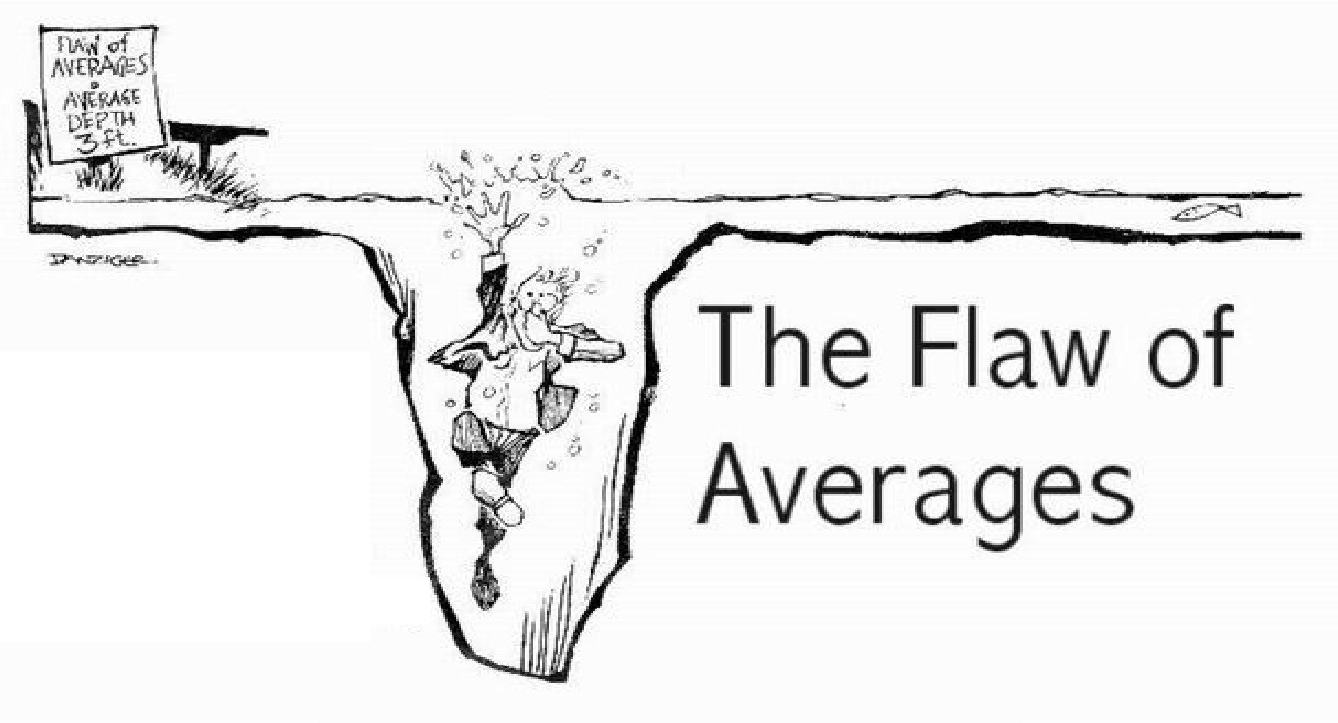


R^2 signify that 22% of the sales variability can be explain by my regression right

Linear regression

Strength	Weakness
• Quick calculations • Reliable with a trendy profile of sales	• It is just a projection (rely only on the past data). • Limited technical expertise

Moving averages methodology



Moving averages methodology

This methodology can be used to forecast sales and to <u>smooth</u> data before applying other methods

The forecast for a given period is estimated using the average of data from a fixed number of previous periods

- For example, to calculate August, we use sales from May to July.

$$Prevision_{August} = \left(Demand_{May} + Demand_{June} + Demand_{July}\right)/3$$

In this case the studied period is 3 months (n=3)

Moving averages methodology

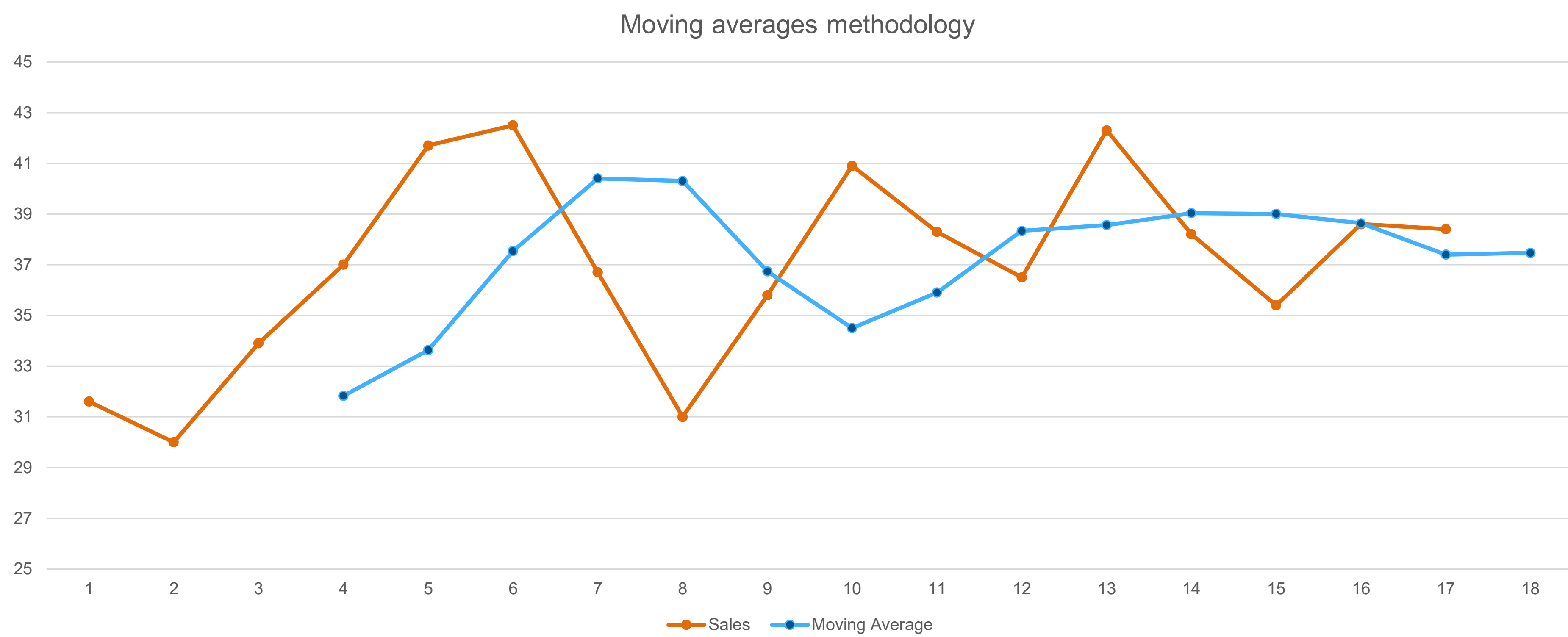
This methodology needs an important stock of data and lots of calculation

But it simple and not expensive

The problem is that methodology is waiting for data of previous periods to be able to calculate

Period	Sales	Moving Average
1	31,6	
2	30	
3	33,9	
4	37	31,8
5	41,7	33,6
6	42,5	37,5
7	36,7	40,4
8	31	40,3
9	35,8	36,7
10	40,9	34,5
11	38,3	35,9
12	36,5	38,3
13	42,3	38,6
14	38,2	39,0
15	35,4	39,0
16	38,6	38,6
17	38,4	37,4
18		37,5

Moving averages methodology



Moving averages methodology

Strength

- We can **weight some periods** if we consider that some months are more relevant than others.

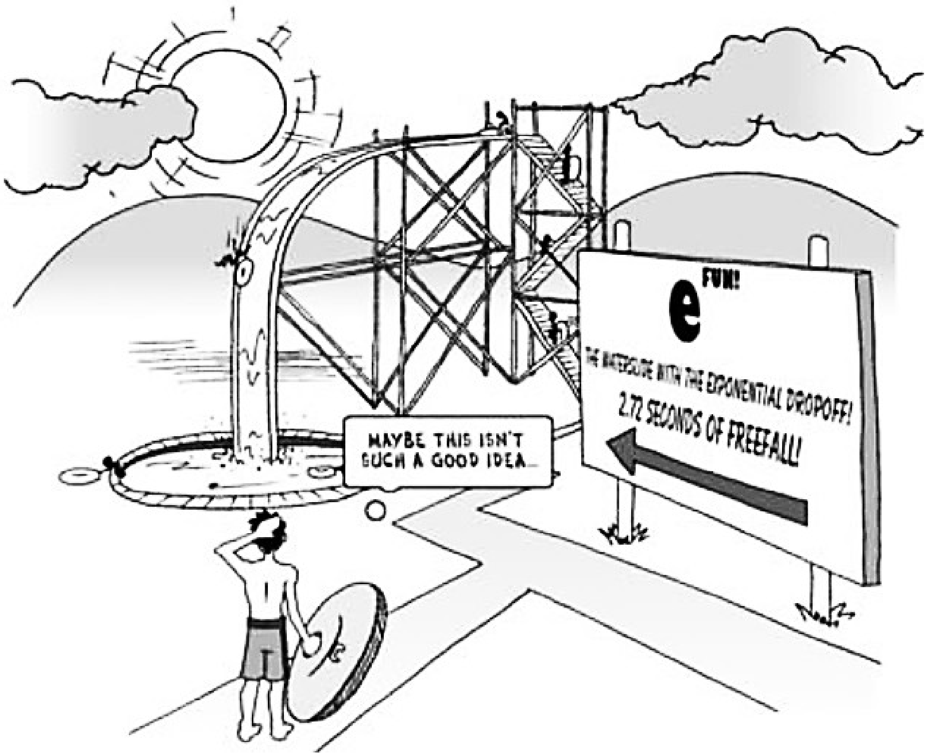
$$P_8 = \frac{(2D_5 + 3D_6 + 4D_7)}{(2+3+4)} = \frac{(2D_5 + 3D_6 + 4D_7)}{9}$$

- It is also possible to smooth data intended for other methods. This avoids introducing abnormal points that could disturb the demand estimates.
- Method of scaled averages is **a very simple method of forecasting** which consists of averaging the sales of the same month from several different years

Weakness

- It reacts slowly to sudden changes
- Rely only on the past data

Exponential smoothing methodology



Exponential smoothing methodology

This methodology is the most famous for forecasting products

The forecast for the period n is the n-1 period corrected proportionally with the difference between sales (D) and forecast (P) of the previous period

$$P_n = P_{n-1} + \propto (D_{n-1} - P_{n-1})$$ OU $$P_n = \propto D_{n-1} + (1 - \propto)\, P_{n-1}$$

In exponential smoothing, the alpha (α) coefficient is a *smoothing constant* between 0 and 1.
It controls how much weight is given to the most recent observation compared to the past forecast.

- **If α is close to 1,** $P_n = D_{n-1}$, the forecast reacts strongly to recent changes — it gives more importance to the newest data point.
 High α → reactive forecast : *when the demand changes quickly.*
- **If α is close to 0,** $P_n = P_{n-1}$,the forecast changes very slowly, because it gives more weight to the past values.
Low α → stable forecast : *when the demand is stable and you want a smoother forecast.*

Smoothing constant

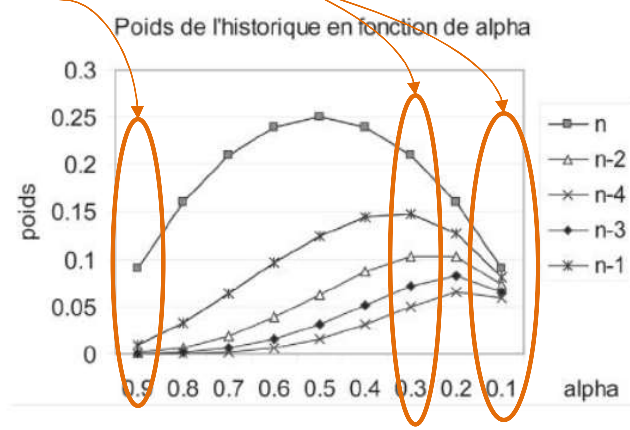
$$P_n = P_{n-1} + \alpha(D_{n-1} - P_{n-1}) = \alpha D_{n-1} + (1-\alpha)P_{n-1}$$

$$\text{or } P_{n-1} = P_{n-2} + \alpha(D_{n-2} - P_{n-2}) = \alpha D_{n-2} + (1-\alpha)P_{n-2}$$

$$\text{donc } P_n = \alpha D_{n-1} + \alpha(1-\alpha)D_{n-2} + (1-\alpha)^2 P_{n-2}$$

$$\boxed{P_n = \alpha D_{n-1} + \alpha(1-\alpha)D_{n-2} + \alpha(1-\alpha)^2 D_{n-3} + \ldots}$$

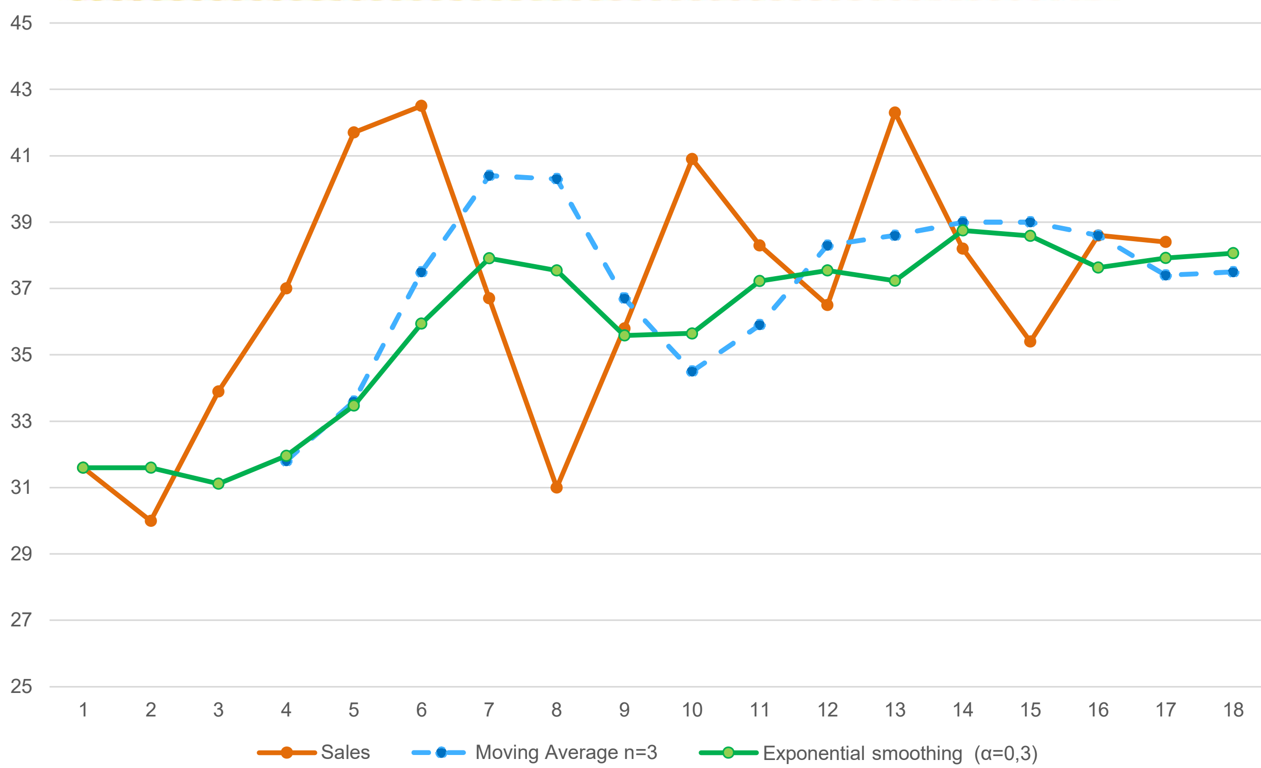
Période	n	n – 1	n – 2	n – 3	n – 4
Poids	α	$\alpha(1-\alpha)$	$\alpha(1-\alpha)^2$	$\alpha(1-\alpha)^3$	$\alpha(1-\alpha)^4$
α = 0,9	0,9	0,09	0,009	0,0009	0,00009
α = 0,3	0,3	0,21	0,147	0,1029	0,07203
α = 0,1	0,1	0,09	0,081	0,0729	0,06561



The exponential smoothing method therefore performs a weighted moving average where the coefficients assigned to past data are linked by an exponential decay law. In practice, the relationship between the coefficient $\boldsymbol{\alpha}$ and an N-period moving average is approximately given by

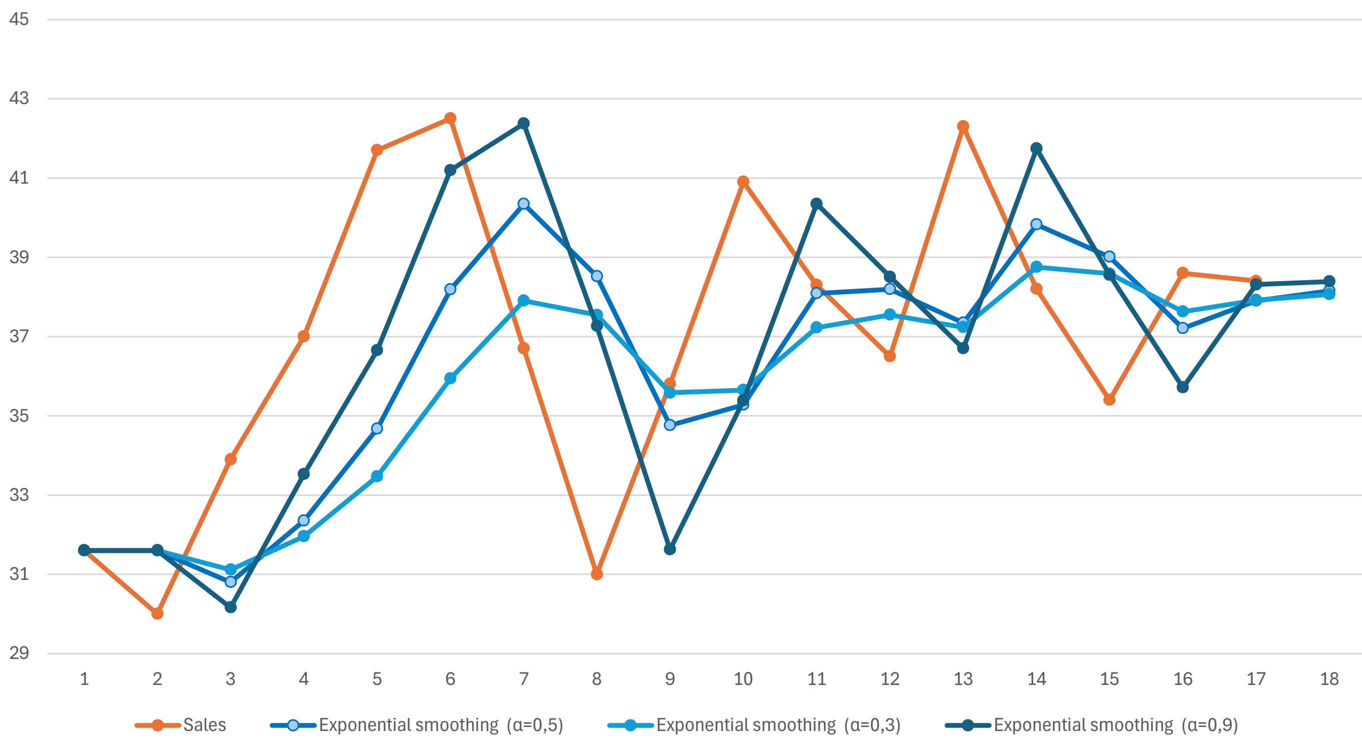
$\boldsymbol{\alpha} = 2/(N + 1)$.

Exponential smoothing methodology



Period	Sales	Moving Average n=3	Exponential smoothing (α=0,3)
1	31,6		31,6
2	30		31,6
3	33,9		31,1
4	37	31,8	32,0
5	41,7	33,6	33,5
6	42,5	37,5	35,9
7	36,7	40,4	37,9
8	31	40,3	37,5
9	35,8	36,7	35,6
10	40,9	34,5	35,6
11	38,3	35,9	37,2
12	36,5	38,3	37,5
13	42,3	38,6	37,2
14	38,2	39	38,8
15	35,4	39	38,6
16	38,6	38,6	37,6
17	38,4	37,4	37,9
18		37,5	38,1

Exponential smoothing methodology



Period	Sales	Exponential smoothing (α=0,3)	Exponential smoothing (α=0,5)	Exponential smoothing (α=0,9)
1	31,6	31,60	31,60	31,60
2	30	31,60	31,60	31,60
3	33,9	31,12	30,80	30,16
4	37	31,95	32,35	33,53
5	41,7	33,47	34,68	36,65
6	42,5	35,94	38,19	41,20
7	36,7	37,91	40,34	42,37
8	31	37,54	38,52	37,27
9	35,8	35,58	34,76	31,63
10	40,9	35,65	35,28	35,38
11	38,3	37,22	38,09	40,35
12	36,5	37,55	38,20	38,50
13	42,3	37,23	37,35	36,70
14	38,2	38,75	39,82	41,74
15	35,4	38,59	39,01	38,55
16	38,6	37,63	37,21	35,72
17	38,4	37,92	37,90	38,31
18		38,07	38,15	38,39

This methodology is a moving averages weighted where coefficients are managed by an exponential decreasing law

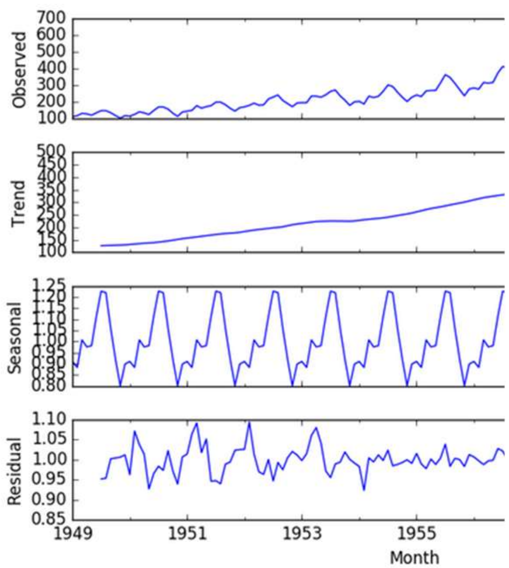
Exponential smoothing methodology

Strength	Weakness
• The coefficient α is defined empirically or in a more scientific way by the method of least squares. Its value is used to adjust the sensitivity of the system. This method is then highly adaptable for different businesses • We can estimate the Mean Absolute Deviation (MAD) of the error with this formula: $e = \frac{\sum(D_i - P_i)}{n}$ • This is an average that help to see if our model is correct or not	• The main limitation of this method is that it can only produce a forecast for the next period, making it suitable only for very short-term or broad forecasts.

Method by decomposition (1)

Method by decomposition

Decomposition is a forecasting method that breaks down a time series into several components, such as **trend, seasonality, and residuals**.
By analyzing these separate patterns, it becomes easier to understand and predict complex data over time."



The sales forecast can be explain with the formula :
$D_n = T_n \times S_n \times R_n$ → more frequently used
$or, D_n = T_n + S_n + R_n$
Where n is the term and D the demand

$\boldsymbol{T_n}$ is the trend, it gives the linear evolution of the demand : Medium term

$\boldsymbol{S_n}$ is the seasonal variation, it complete the information with cyclical evolution of the demand

$\boldsymbol{R_n}$ is the residual element, it add punctual information with consequences on the forecast (climate; epidemic, strike, new customer on the market)

Period	n	Demand
Jan-18	1	20 000
Feb-18	2	21 000
Mar-18	3	19 000
Apr-18	4	22 000
May-18	5	23 000
Jun-18	6	22 000
Jul-18	7	20 000
Aug-18	8	16 000
Sep-18	9	20 000
Oct-18	10	24 000
Nov-18	11	25 000
Dec-18	12	27 000
Jan-19	13	23 000
Feb-19	14	22 000
Mar-19	15	22 000
Apr-19	16	25 000
May-19	17	24 000
Jun-19	18	25 000
Jul-19	19	23 000
Aug-19	20	19 000
Sep-19	21	23 000
Oct-19	22	25 000
Nov-19	23	24 000
Dec-19	24	30 000

Method by decomposition

Evaluation of the trend T

The trend line is calculated by the method of least square

The function of the line is :

$$D = a \times n + b$$

$$a = \frac{N \sum nD_{n} - \sum n \sum D_n}{N \sum n^2 - (\sum n)^2}$$

$$b = \frac{\sum D_n}{N} - a \frac{\sum n}{N}$$

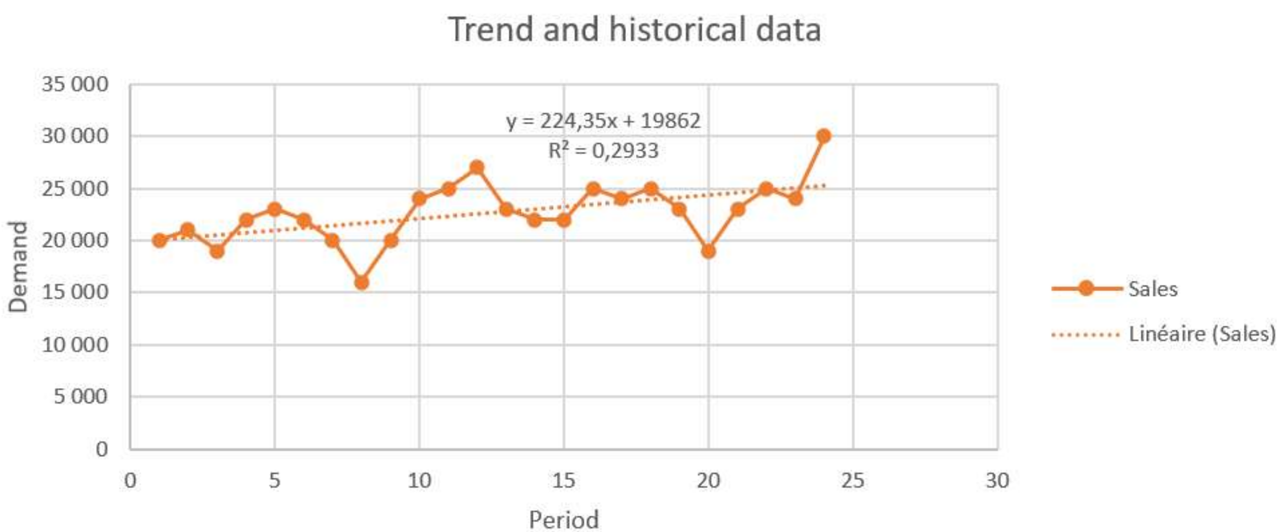
- Where N is the number of period of data

$$r = \frac{\mathrm{Cov}(X, Y)}{\sigma_X \sigma_Y}$$

Method by decomposition

Evaluation of the trend T

- D_t represent the forecast of sales depending on the trend
- n is the period consider
- The coefficient R^2 signify that 29% of the variability can be explain by D_t
- 78% are explained by seasonal variations or random characters, thus there are significant demand fluctuations around the trendline.



Method by decomposition

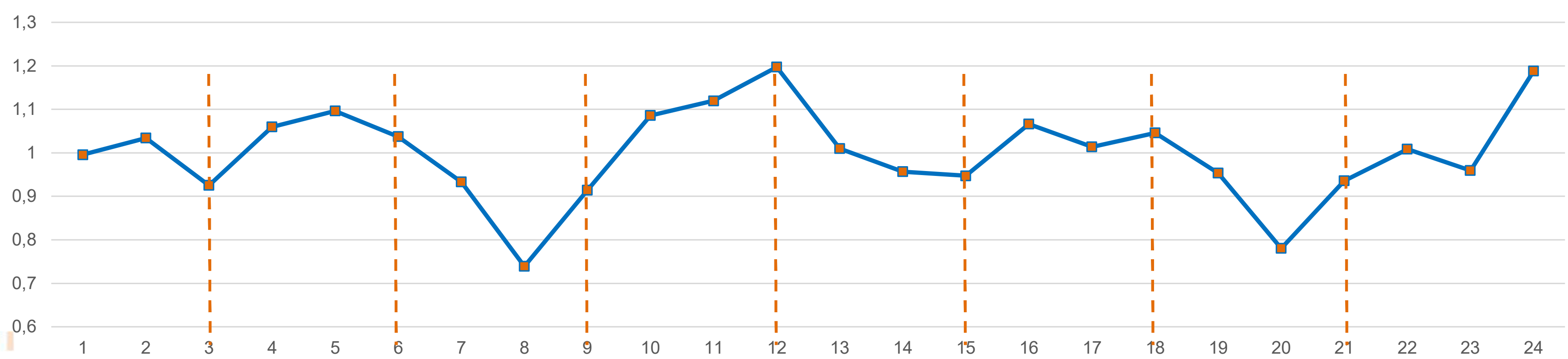
Seasonal variations: Seasons identification

Seasons are groups of periods (months, quarters, or weeks) that show similar demand behavior.

In general, when data are monthly, an annual seasonal pattern has a cycle of 12 periods (12 months).

Seasonal variations are expressed as coefficients representing the differences from the trend value during typical periods.

In our example, instead of using 12 individual months, we observe that the demand tends to repeat a pattern every 3 months (a quarter). Therefore, we consider a quarterly seasonal cycle with 4 seasons per year.



Seasonal variation – method 1

We first must calculate the global average of sales:

- $\frac{Total\ sales\ for\ the\ year\ 2018}{Number\ of\ months} = \frac{258\ 000}{12} = 21\ 500\ products/month$
- $\frac{Total\ sales\ for\ the\ year\ 2019}{Number\ of\ months} = \frac{285\ 000}{12} = 23\ 750\ products/month$

First quarter

- $\frac{Average\ of\ products\ for\ the\ Quarter}{Global\ average\ of\ sales} = \frac{20000}{21500} = 93\%$

Second quarter

- $\frac{Average\ of\ products\ for\ the\ Quarter}{Global\ average\ of\ sales} = \frac{22333}{21500} = 103{,}9\%$

If the calculated seasonal coefficient is greater than 100%, it indicates a period of high sales. If the calculated seasonal coefficient is less than 100%, we are in a period of low sales.

	Total needs	Seasons average	Seasonal Coefficient
2018 First Quarter	20 000+ 21 000+ 19000 = 60000	20000	93,0%
2018 Second Quarter	22 000+ 23 000+ 22 000 = 67000	22 333	103,9%
2018 Third Quarter	20 000+ 16 000+ 20 000 = 56 000	18 667	86,8%
2018 Fourth Quarter	23 000+ 25 000+ 27 000 =75000	25 333	116,3%
2019 First Quarter	23 000 + 22 000+ 22 000 = 67000	22 333	94%
2019 Second Quarter	74 000	24 667	103,9%
2019 Third Quarter	65 000	21 667	91,2%
2019 Fourth Quarter	79 000	26 333	110,9%

Result of the forecast – method 1

Past data :

Period	n	Sales	Period sales Average	Trend 224,35n+19862	Sn	Fn=Tn.Sn
Jan-18	1	20 000	20 000	20086,7	93,0%	18685,3
Feb-18	2	21 000		20311,0	93,0%	18894,0
Mar-18	3	19 000		20535,4	93,0%	19102,7
Apr-18	4	22 000	22 333	20759,7	103,9%	21564,4
May-18	5	23 000		20984,1	103,9%	21797,4
Jun-18	6	22 000		21208,4	103,9%	22030,4
Jul-18	7	20 000	18 667	21432,8	86,8%	18608,3
Aug-18	8	16 000		21657,1	86,8%	18803,1
Sep-18	9	20 000		21881,4	86,8%	18997,8
Oct-18	10	24 000	25 333	22105,8	117,8%	26047,1
Nov-18	11	25 000		22330,1	117,8%	26311,5
Dec-18	12	27 000		22554,5	117,8%	26575,8
Jan-19	13	23 000	22 333	22778,8	94,0%	21420,1
Feb-19	14	22 000		23003,2	94,0%	21631,1
Mar-19	15	22 000		23227,5	94,0%	21842,0
Apr-19	16	25 000	24 667	23451,9	103,9%	24357,0
May-19	17	24 000		23676,2	103,9%	24590,1
Jun-19	18	25 000		23900,6	103,9%	24823,1
Jul-19	19	23 000	21 667	24124,9	91,2%	22008,7
Aug-19	20	19 000		24349,3	91,2%	22213,4
Sep-19	21	23 000		24573,6	91,2%	22418,0
Oct-19	22	25 000	26 333	24798,0	110,9%	27495,3
Nov-19	23	24 000		25022,3	110,9%	27744,0
Dec-19	24	30 000		25246,7	110,9%	27992,8

Forecast

Period	n	Sales	Trend 224,35n+19862	Sn	Fn=Tn.Sn
Jan-20	25	X	25471,0	93,5%	23822,8
Feb-20	26	X	25695,4	93,5%	24032,7
Mar-20	27	X	25919,7	93,5%	24242,5
Apr-20	28	X	26144,1	103,9%	27155,3
May-20	29	X	26368,4	103,9%	27388,3
Jun-20	30	X	26592,8	103,9%	27621,3
Jul-20	31	X	26817,1	89,0%	23873,9
Aug-20	32	X	27041,4	89,0%	24073,6
Sep-20	33	X	27265,8	89,0%	24273,3

Sn = Average(Sn-1;Sn-2)

Residual elements

A time series can be represented as the combination of three main components:
Two main models exist:

•**Additive model**

$$Y_n = T_n + S_n + Rn$$

Residual:

$$R_n = Y_n - (T_n + Sn)$$

•**Multiplicative model**

$$Y_n = T_n \times S_n \times R_n$$

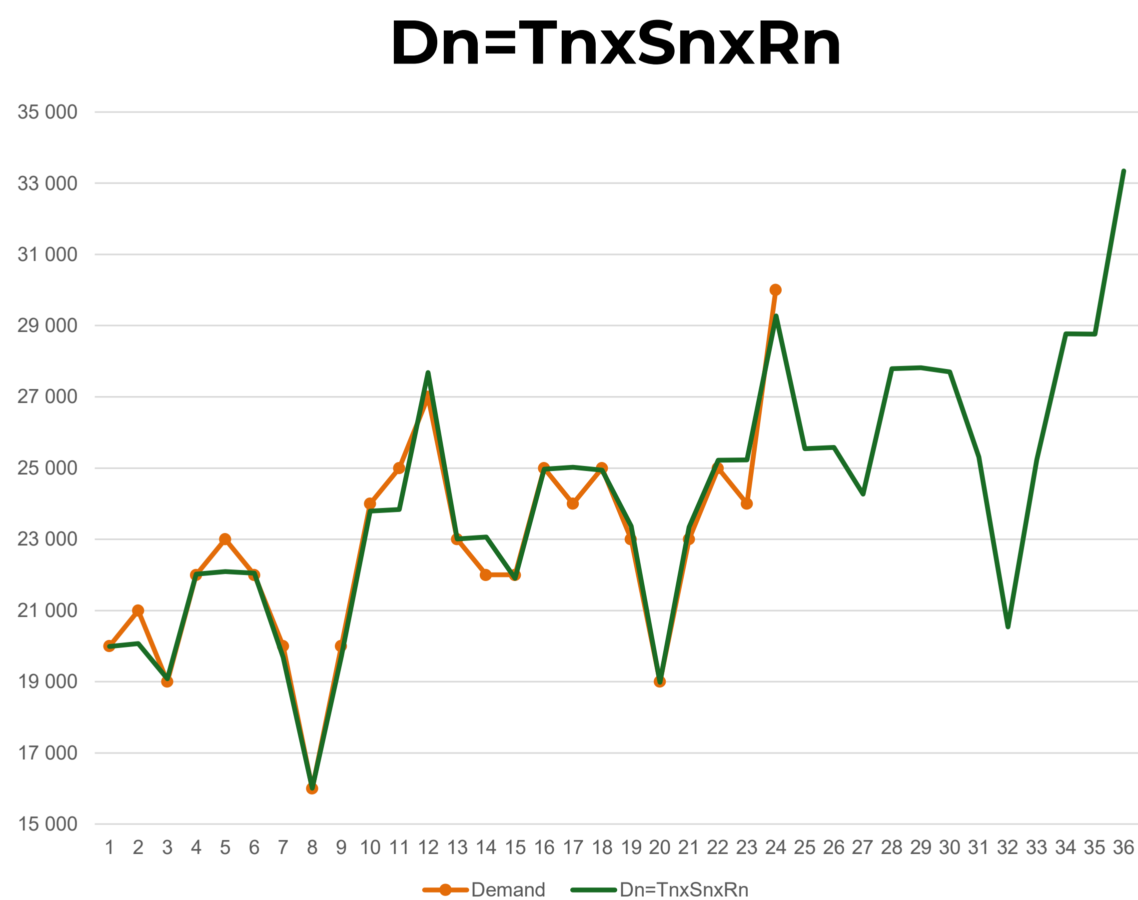
Residual:

$$R_n = \frac{Y_n}{T_n \times Sn}$$

Once trend and seasonality are estimated, the residual is obtained by subtracting (additive) or dividing (multiplicative).

Result of the forecast – method 1

Period	n	n²	Demand	n*Dn	Tn	annual average	Seasons average	Seasonal Coefficient Sn	Dn=TnxSn	AVERAGE residual (multiplicative methode)		Dn=TnxSnxRn
janv-18	1	1	20 000	20 000	20086,67	21 583	20 000	92,66%	18613,13	1,07	1,07	19 992,99
Feb-18	2	4	21 000	42 000	20311,01				18821,02	1,12	1,07	20 071,01
mars-18	3	9	19 000	57 000	20535,36				19028,91	1,00	1,00	19 083,26
Apr-18	4	16	22 000	88 000	20759,71		22 333	103,47%	21481,09	1,02	1,03	22 024,06
May-18	5	25	23 000	115 000	20984,06				21713,23	1,06	1,02	22 096,11
juin-18	6	36	22 000	132 000	21208,41				21945,38	1,00	1,00	22 050,90
juil-18	7	49	20 000	140 000	21432,75		18 667	86,49%	18536,44	1,08	1,06	19 685,67
Aug-18	8	64	16 000	128 000	21657,10				18730,47	0,85	0,85	16 010,46
sept-18	9	81	20 000	180 000	21881,45				18924,50	1,06	1,04	19 707,88
oct-18	10	100	24 000	240 000	22105,80		25 333	117,37%	25946,57	0,92	0,92	23 795,92
nov-18	11	121	25 000	275 000	22330,14				26209,90	0,95	0,91	23 836,44
Dec-18	12	144	27 000	324 000	22554,49				26473,23	1,02	1,05	27 685,74
janv-19	13	169	23 000	299 000	22778,84	23 750	22 333	94,04%	21420,10	1,07	1,07	23 008,06
Feb-19	14	196	22 000	308 000	23003,19				21631,07	1,02	1,07	23 067,69
mars-19	15	225	22 000	330 000	23227,54				21842,03	1,01	1,00	21 904,43
Apr-19	16	256	25 000	400 000	23451,88		24 667	103,86%	24357,04	1,03	1,03	24 972,71
May-19	17	289	24 000	408 000	23676,23				24590,05	0,98	1,02	25 023,65
juin-19	18	324	25 000	450 000	23900,58				24823,06	1,01	1,00	24 942,42
juil-19	19	361	23 000	437 000	24124,93		21 667	91,23%	22008,71	1,05	1,06	23 373,21
Aug-19	20	400	19 000	380 000	24349,28				22213,37	0,86	0,85	18 987,59
sept-19	21	441	23 000	483 000	24573,62				22418,04	1,03	1,04	23 346,04
oct-19	22	484	25 000	550 000	24797,97		26 333	110,88%	27495,29	0,91	0,92	25 216,27
nov-19	23	529	24 000	552 000	25022,32				27744,04	0,87	0,91	25 231,66
Dec-19	24	576	30 000	720 000	25246,67				27992,80	1,07	1,05	29 274,90
janv-20	25				25471,01			93,35%	23777,09		1,07	25 539,78
févr-20	26				25695,36				23986,52		1,07	25 579,57
mars-20	27				25919,71				24195,94		1,00	24 265,06
avr-20	28				26144,06			103,67%	27102,83		1,03	27 787,91
mai-20	29				26368,41				27335,41		1,02	27 817,42
juin-20	30				26592,75				27567,98		1,00	27 700,55
juil-20	31				26817,10			88,86%	23828,95		1,06	25 306,31
août-20	32				27041,45				24028,30		0,85	20 538,95
sept-20	33				27265,80				24227,65		1,04	25 230,56
oct-20	34				27490,14			114,13%	31373,36		0,92	28 772,89
nov-20	35				27714,49				31629,40		0,91	28 765,18
déc-20	36				27938,84				31885,44		1,05	33 345,84



Method by decomposition – method 2

It is necessary to determine the seasons. To do this, consider two consecutive months (M1 and M2): if, in the historical data, the sales of M1 are alaways lower or always higher than the sales of M2, then M1 and M2 are not in the same season. Otherwise, M1 and M2 can be grouped into the same season. Seasons are thus composed of months that exhibit similar sales patterns.

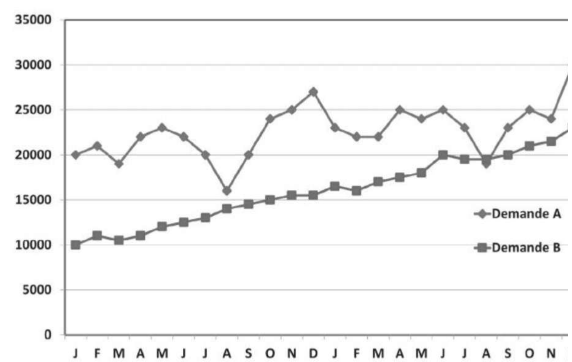
Année 2018	J F M	A M J	J	A	S	O N	D
Demande totale	60 000	67 000	20 000	16 000	20 000	52 000	27 000
Moyenne	20 000	22 333	20 000	16 000	20 000	26 000	27 000
Mois central	2	5	7	8	9	10,5	12
Valeur tendance	20 311,0	20 984,1	21 432,8	21 657,1	21 881,4	22 218,0	22 554,5
Coefficient	98,5 %	106,4 %	93,3 %	73,9 %	91,4 %	117,0 %	119,7 %

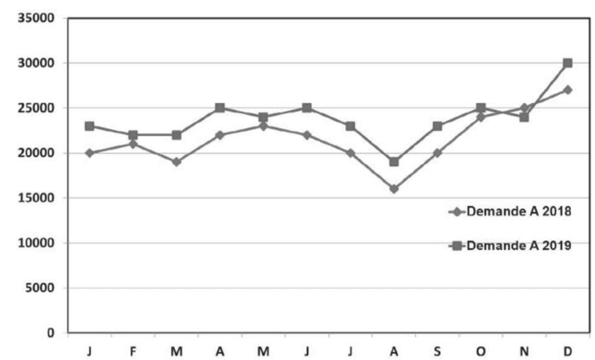
Année 2019	J F M	A M J	J	A	S	O N	D
Demande totale	67 000	74 000	23 000	19 000	23 000	49 000	30 000
Moyenne	22 333	24 667	23 000	19 000	23 000	24 500	30 000
Mois central	14	17	19	20	21	22,5	24
Valeur tendance	23 003,2	23 676,2	24 124,9	24 349,3	24 573,6	24 910,1	25 246,7
Coefficient	97,1 %	104,2 %	95,3 %	78,0 %	93,6 %	98,4 %	118,8 %

Pour le futur	J F M	A M J	J	A	S	O N	D
Coefficient	97,8 %	105,3 %	94,3 %	76,0 %	92,5 %	107,7 %	119,3 %

But we could have chosen different seasons :

Instead of dividing by the average sales year here we define a central value



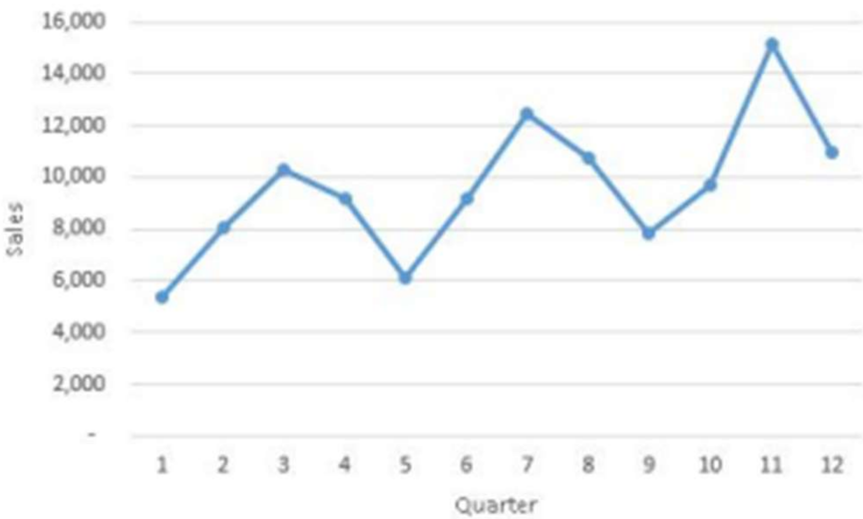


Method by decomposition – method 2

Périodes	N°	Tendances	Coefficients	Prévisions
Janvier	25	25 471,0	97,8 %	24 906
Février	26	25 695,4	97,8 %	25 125
Mars	27	25 919,7	97,8 %	25 344
Avril	28	26 144,1	105,3 %	27 532
Mai	29	26 368,4	105,3 %	27 768
Juin	30	26 592,8	105,3 %	28 004
Juillet	31	26 817,1	94,3 %	25 296
Août	32	27 041,4	76,0 %	20 540
Septembre	33	27 265,8	92,5 %	25 221
Octobre	34	27 490,1	107,7 %	29 604
Novembre	35	27 714,5	107,7 %	29 846
Décembre	36	27 938,8	119,3 %	33 323

Method by decomposition- method 3

Forecasting with Seasonality Dr. Ron Lembke, the seasonality is defined from n-period
See Forecasting with Seasonality from Dr. Ron Lembke at your disposal on Moodle.



Period	Cycle 1	Cycle 2	Cycle 3	Average
1	5,384	6,118	7,825	6,442.3
2	8,081	9,139	9,693	8,971.0
3	10,282	12,460	15,177	12,639.7
4	9,156	10,717	10,990	10,287.7
Overall Average				9,585.17

So we have found what the average demand is for period 1 of a cycle, for period 2, etc. If we divide these averages by the overall average, we get the following seasonal indices:

Period	Period Avg	Overall Avg	Index
1	6,442.3	÷ 9,585.17	=0.672
2	8,971.0	÷ 9,585.17	=0.936
3	12,639.7	÷ 9,585.17	=1.319
4	10,287.7	÷ 9,585.17	=1.073

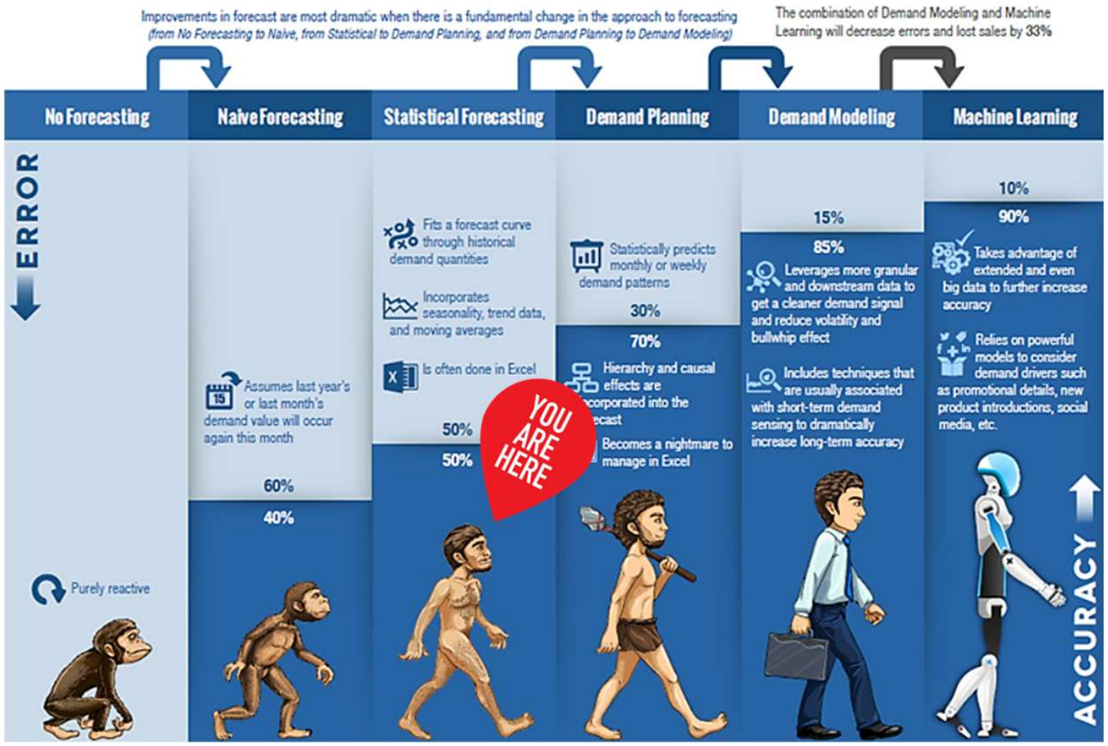
Conclusions

Opinions/Point of view/Brainstorming are efficient

Salesman are constantly in contact with the customer, they have a relevant “feeling”

- Specific training can be proposed to them
- Market study

Conclusions



Conclusions

Advanced software solutions enable organizations to:

- Measure and monitor performance with interactive, self-service dashboards and visualizations
- Examine root causes through high-fidelity analysis of dimensionally rich data
- Assess trends and make predictions automatically from internal or external data
- Quickly prepare what-if scenarios and create timely, reliable plans and forecasts

Conclusions

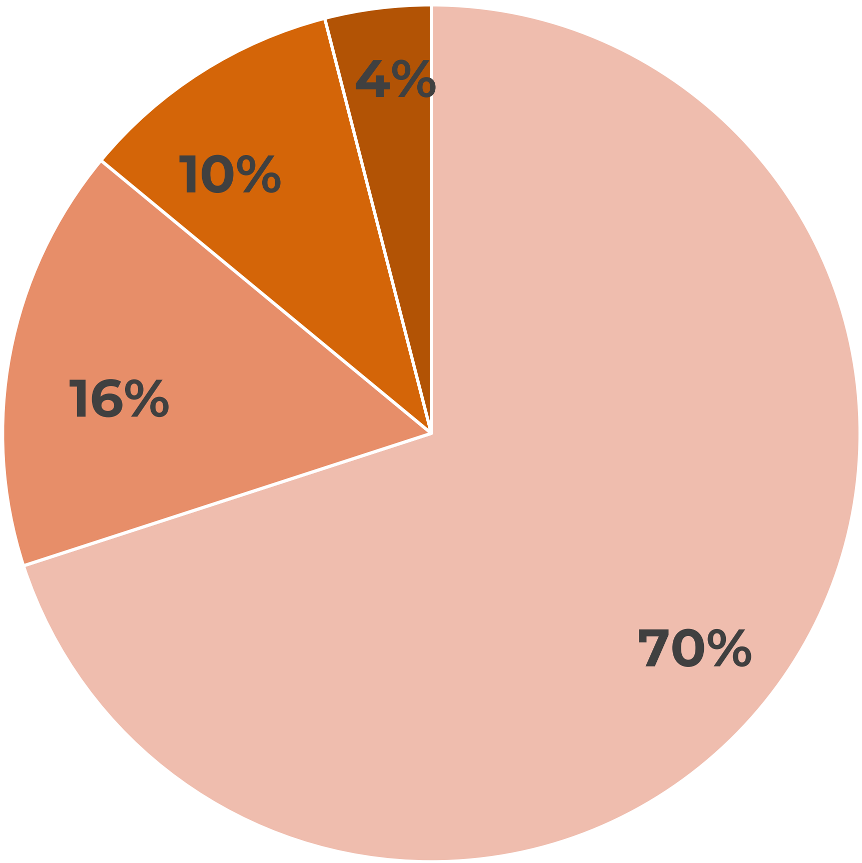
Despite advances in AI and analytics, spreadsheets remain the dominant tool for planning, budgeting, and forecasting:

- 70% of companies say they rely heavily on spreadsheets for reporting, while only 16% use specialized on-premise software and only 10% use cloud-based software for planning.

The Future of Planning, Budgeting and Forecasting Global Survey, Workday and FSN, 2017 (PDF, 2.64 MB)

Even with modern tools available, most organizations still rely heavily on spreadsheets for forecasting.

Nearly half depend exclusively on them, though a growing number are adopting cloud-based and specialized planning solutions to improve accuracy and agility.



PIC: Plan Industriel et commercial

Sales and Operations Planning

News : https://adameo.com/blog/le-sop-pierre-angulaire-de-la-prevision-et-de-la-planification/

Lire: La planification industrielle et ses limites


TECHNIQUES DE L'INGÉNIEUR

Réf. : AG5115 V2

La planification industrielle et ses limites

Date de publication : 10 janvier 2019

Date de dernière validation : 24 mars 2022

Cet article est issu de : Génie industriel | Logistique et Supply chain

par Patrick GENIN, Samir LAMOURI, André THOMAS

Introduction

- Tensions easily appear between financial and operational department, when one is late or inaccurate, the other is deeply impacted, with big effort to solves problem “created” by the other department.
  https://www.youtube.com/watch?v=HVnHyTsGZaY

- Sales forecast department is always the base of the operational plans

Sales forecasts → S&OP → Manufacturing Planning and Scheduling → Requirement/ Load calculations

: Prévisions commerciales

PIC: Plan Industriel et commercial

PDP: Plan Directeur de Production

Based on forecasting, the strategy of the company is represented by a Sales and Operations Planning (S&OP)

To manage resources of manufacturing, the S&OP is declined in a Manufacturing Planning and Scheduling

Sales and Operations Planning (S&OP)

Sales and Operations Planning (S&OP) is the high-level plan for managing a factory's resources.

- It is based on sales forecasts by product families.
- It allows the company to estimate needs in terms of workforce, equipment capacity, and long-term supply.
- It helps align production capacity with the commercial demand.
- It provides a 3-year projection of activity, synchronizing the commercial plan with the manufacturing plan.
- It anticipates potential issues, especially mismatches between demand and capacity, and enables proactive decisions to ensure the desired customer service.



Input → **S&OP process** → Output

Input

- Production quantities by product family
- Target stock levels
- Material and human resources required
- Availability of resources

Output

- Short-term investment decisions
- Workforce costs (hiring, firing, overtime, short-time work)
- Capacity subcontracting requirements
- Machine shutdown planning

Sales & Operations Planning (S&OP) – Key Points

The number of product families is generally limited to **5–20**.

S&OP reviews are typically held monthly, involving the management board and operations managers.

The **planning period** used to define quantities can vary (month, semester, etc.) depending on products, delivery times for raw materials, or equipment. This is a critical characteristic of the process.

The **unit of measure** for quantities should be representative of the product family.

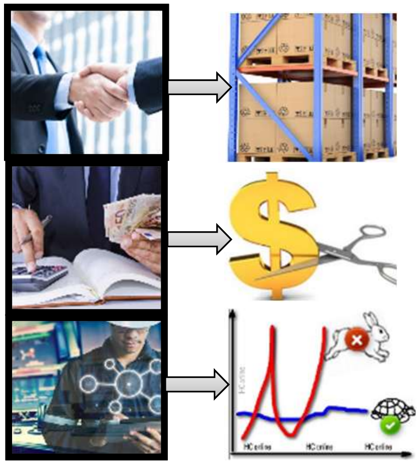
Often, the **sales value in k€** is used.

Serving as a **global agreement** between the commercial and manufacturing departments, the S&OP is based on both **commercial and production forecasts**.

Sales and Operations Planning (S&OP)

The S&OP gives the available stock at the end of each period

- The commercial department wants to be sure to have enough stock to satisfy his customer
- The company wants to minimize the financial impact of the stock into the final result
- The manufacturing department cannot respond to sudden changes and must distribute the production load.



Example of families of products (Lohr industrie)

It's a *contract* between the Commercial, the Supply Chain and the Production services to satisfy the customer needs for the next 6 months.

Sales and Operations Planning (S&OP)

S&OP is not just a meeting or a dashboard, it is a decision-making process that balances demand and supply, integrates financial and operational planning, and connects high-level strategy with day-to-day operations.

Sales and Operations Planning (S&OP)

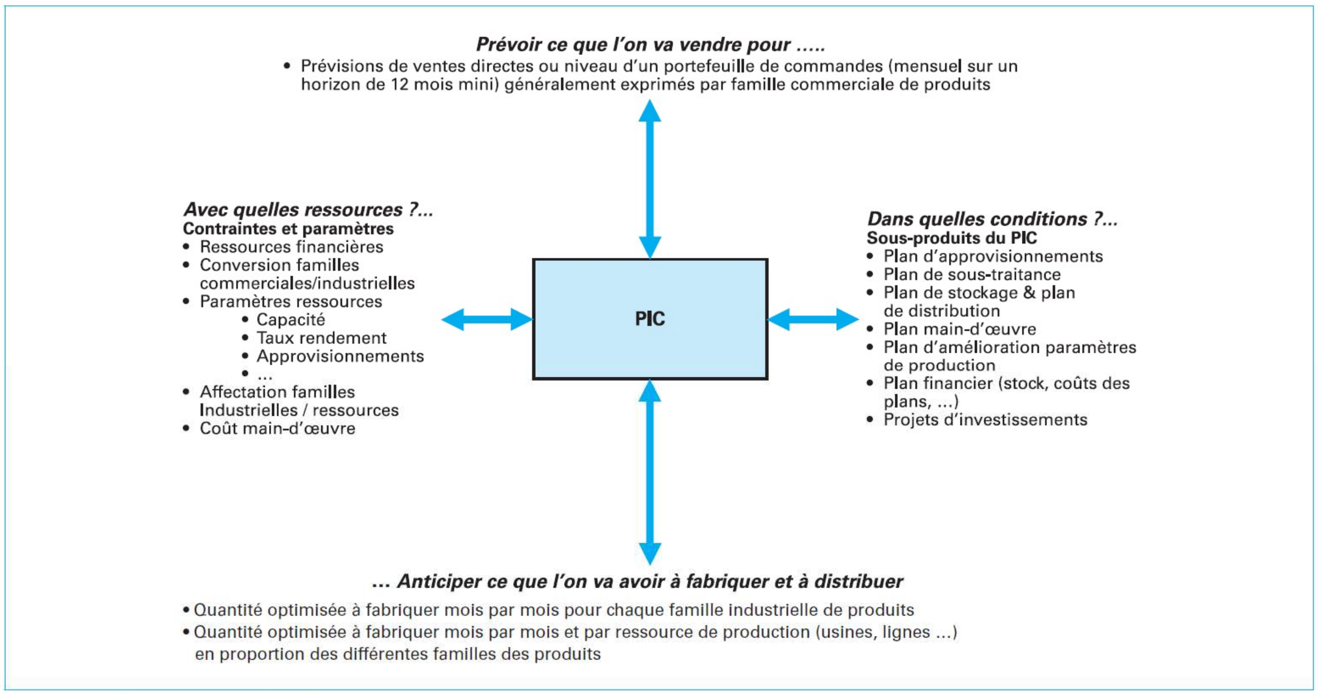


Figure 3 – Cadre décisionnel du PIC

Sales and Operations Planning (S&OP)

Forecast what we are going to sell…

- Sales forecasts at the level of direct sales or an order portfolio (monthly, over at least a 12-month horizon), generally expressed per commercial product family

Under which conditions?…
Outputs of the PIC

- Procurement plan
- Subcontracting plan
- Storage and distribution plan
- Workforce plan
- Plan for improving production parameters
- Financial plan (stock, costs of the plans, …)
- Investment projects

PIC

With which resources?…
Constraints and parameters

- Financial resources
- Conversion between commercial and industrial families
- Resource parameters:
  - Capacity
  - Yield rate
  - Supplies
  - …
- Allocation of industrial families to resources
- Labor cost

… Anticipate what we will have to manufacture and distribute

- Optimized monthly quantities to be produced for each industrial product family
- Optimized monthly quantities to be produced per production resource (plants, lines, …) in proportion to the different product families

Sales and Operations Planning (S&OP)

The S&OP document is built with 3 charts for each family:

- Sales
- Production
- Stocks

Each chart have information about passed periods with real information and future periods with forecasting

Family: Unit: Date:

Sales	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
Forecast								
Real								
Difference								
Difference in %								

Production	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
Forecast								
Real								
Difference								
Difference in %								

Stocks	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
Forecast								
Real								
Difference								
Difference in %								

Stock target:

Past information with real data

Stock "Financial" target

Sales and Operations Planning (S&OP)

A meeting is organised into the company the 2nd of April to establish the S&OP

The history was filled for January to February during the previous meeting

The real value of sales and production of March are known just before the meeting

Definition of the stock level

Family: **A** Unit: **k€**

Sales	M-3 January	M-2 Febrary	M-1 March	M April
Sales Forecast	500	500	500	
Sales Real	510	510	510	
Difference	10	10	10	
Difference in %	2%	2%	2%	

Production	M-3 January	M-2 Febrary	M-1 March	M April
Prod Forecast	490	500	500	
Prod Real	480	490	490	
Difference	-10	-10	-10	
Difference in %	-2%	-2%	-2%	

Stocks	M-3 January	M-2 Febrary	M-1 March	M April
Stocks Forecast	250	230	210	
Stocks Real	230	210	190	
Difference	-20	-20	-20	
% of the target	92%	84%	76%	

$$St_{mar} = St_{feb} + P_{mar} - Sa_{mar}$$
$$= 210 + 490 - 510 = 190$$

Sales and Operations Planning (S&OP)

Definition of performance

Family: A Unit: k€

Sales	M-3	M-2	M-1	M
	January	Febrary	March	April
Sales Forecast	500	500	500	
Sales Real	510	510	510	
Difference	10	10	10	
Difference in %	2%	2%	2%	

$$Sales\ Performance = \frac{Real - Forecast}{Forecast} = \frac{510 - 500}{500} = 2\%$$

Production	M-3	M-2	M-1	M
	January	Febrary	March	April
Prod Forecast	490	500	500	
Prod Real	480	490	490	
Difference	-10	-10	-10	
Difference in %	-2%	-2%	-2%	

$$Production\ Performance = \frac{Real - Forecast}{Forecast} = \frac{490 - 500}{500} = -2\%$$

Stocks	M-3	M-2	M-1	M
	January	Febrary	March	April
Stocks Forecast	250	230	210	
Stocks Real	230	210	190	
Difference	-20	-20	-20	
% of the target	92%	84%	76%	

$$Stock\ Performance = \frac{Stock\ real}{Stock\ Target} = \frac{190}{250} = 76\%$$

stock max	300
stock target	250
stock min	200

Sales and Operations Planning (S&OP)

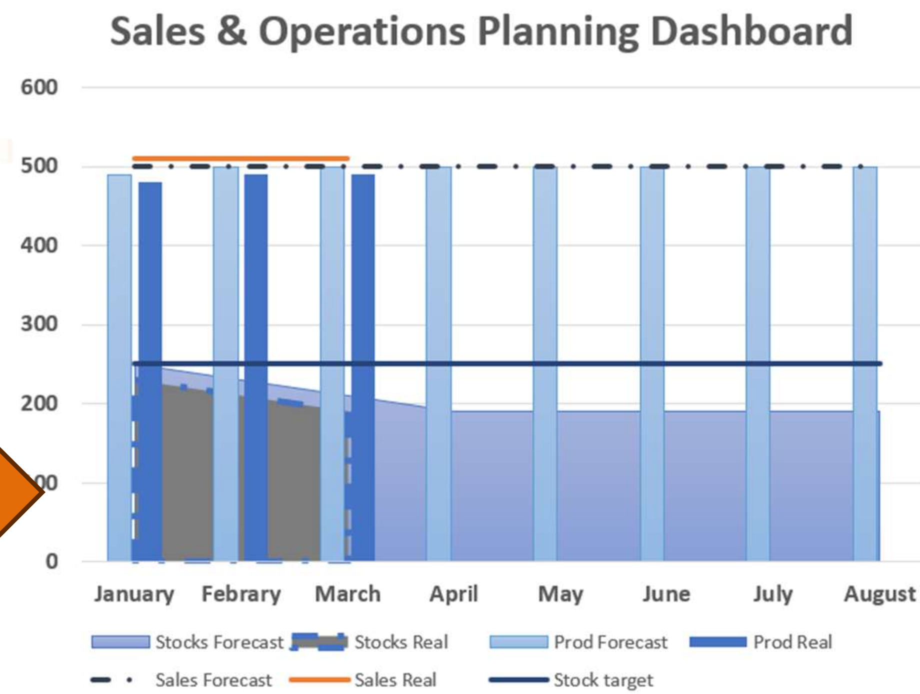
Family: A   Unit: k€   Date: April, 2nd

Sales	M-3 January	M-2 Febrary	M-1 March	M April	M+1 May	M+2 June	M+3 July	M+4 August
Sales Forecast	500	500	500	500	500	500	500	500
Sales Real	510	510	510	480				
Difference	10	10	10					
Difference in %	2%	2%	2%					

Production	M-3 January	M-2 Febrary	M-1 March	M April	M+1 May	M+2 June	M+3 July	M+4 August
Prod Forecast	490	500	500	500	500	500	500	500
Prod Real	480	490	490	495				
Difference	-10	-10	-10					
Difference in %	-2%	-2%	-2%					

Stocks	M-3 January	M-2 Febrary	M-1 March	M April	M+1 May	M+2 June	M+3 July	M+4 August
Stocks Forecast	250	230	210	190	190	190	190	190
Stocks Real	230	210	190					
Difference	-20	-20	-20					
% of the target	92%	84%	76%					

stock max	300
stock target	250
stock min	200



The analysis of the past three month shows :

The manufacturing department didn't reach its forecasts

The commercial department have exceed agreed sales target

- By consequence, the stock is under the target

Sales and Operations Planning (S&OP)

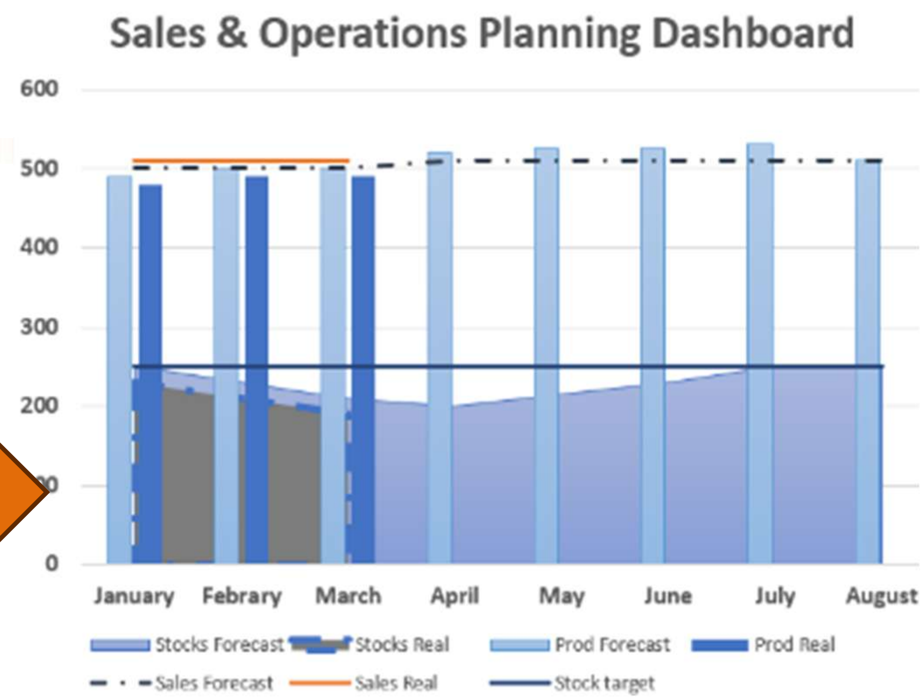
Family: A Unit: k€ Date: April, 2nd

Sales	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
	January	Febrary	March	April	May	June	July	August
Sales Forecast	500	500	500	510	510	510	510	510
Sales Real	510	510	510					
Difference	10	10	10					
Difference in %	2%	2%	2%					

Production	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
	January	Febrary	March	April	May	June	July	August
Prod Forecast	490	500	500	520	525	525	530	510
Prod Real	480	490	490					
Difference	-10	-10	-10					
Difference in %	-2%	-2%	-2%					

Stocks	M-3	M-2	M-1	M	M+1	M+2	M+3	M+4
	January	Febrary	March	April	May	June	July	August
Stocks Forecast	250	230	210	200	215	230	250	250
Stocks Real	230	210	190					
Difference	-20	-20	-20					
% of the target	92%	84%	76%					

stock max	300
stock target	250
stock min	200



The chart is completed with the new sales forecast, and the hypothesis that manufacturing problems are resolved, to be able to obtain 520-530k€ for the next months

- By consequence, the level of stock will grow to the target

Sales and Operations Planning (S&OP)

PIC	Famille : tablettes iTechMedia	Unité : Quantité	Date : 3 janvier

Ventes	Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnelles	10 000	12 200	13 800	14 700	17 100	19 800	23 000	24 000	25 000
Réelles	9 800	12 500	14 000						
Écart	– 200	300	200						
Écart en %	– 2,0	2,5	1,4						

Production	Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnelle	10 000	12 200	16 500	15 000	17 100	19 800	23 000	24 000	25 000
Réelle	10 000	10 000	16 000						
Écart	0	– 2 200	– 500						
Écart en %	0,0	– 18,0	– 3,0						

Stock		Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnel		2 500	2 700	2 900	2 500	2 500	2 500	2 500	2 500	2 500
Réel	2 500	2 700	200	2 200						
Écart/Obj.		200	– 2 300	– 300					800	mini
Écart/Obj. %		8,0	– 92,0	– 12,0		Objectif de stock	2 500			
									5 000	maxi

1st scenario :

- Due to a problem in Novembre only 10 000 tablets were assembled
- Therefore, the stock has decreased significantly
- To resolve this, the production increased on December

PIC	Famille : tablettes iTechMedia	Unité : Quantité	Date : 3 janvier

Ventes	Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
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Prévisionnelle	10 000	12 200	16 500	15 000	18 000	21 000	23 400	20 000	26 500
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Stock		Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
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Réel	2 500	2 700	200	2 200						
Écart/Obj.		200	– 2 300	– 300					800	mini
Écart/Obj. %		8,0	– 92,0	– 12,0		Objectif de stock	2 500			
									5 000	maxi

2nd scenario :

- Anticipation of May, with many public holydays
- This allows respecting a sufficient stock level and a lighter production rate.

Sales and Operations Planning (S&OP)

PIC	Famille : tablettes iTechMedia	Unité : Quantité	Date : 3 janvier

Ventes	Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnelles	10 000	12 200	13 800	14 700	17 100	19 800	23 000	24 000	25 000
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Stock		Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnel		2 500	2 700	2 900	2 500	2 500	2 500	2 500	2 500	2 500
Réel	2 500	2 700	200	2 200						
Écart/Obj.		200	– 2 300	– 300						
Écart/Obj. %		8,0	– 92,0	– 12,0						

	800	mini
Objectif de stock	2 500	
	5 000	maxi

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Stock		Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin
Prévisionnel		2 500	2 700	2 900	2 500	3 400	4 600	5 000	1 000	2 500
Réel	2 500	2 700	200	2 200						
Écart/Obj.		200	– 2 300	– 300						
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	800	mini
Objectif de stock	2 500	
	5 000	maxi

2nd scenario :

- Anticipation of May, with many public holydays
- This allows respecting a sufficient stock level and a lighter production rate.

Sales and Operations Planning (S&OP)

In case of overload, actions taken are:

- Overtime work
- Transfers of salaries from a workshop to another
- Transfers of activities from a workshop to another
- Hiring of salaries
- Outsourcing
- Delay of promotional actions
- Weekend teams
- Purchasing of equipment

In case of underload, actions taken are:

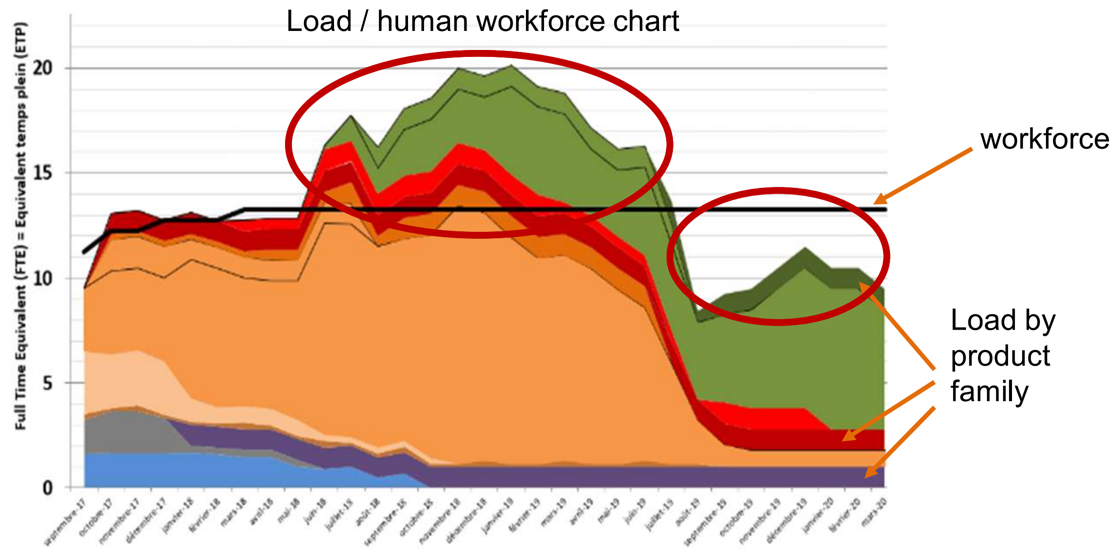
- Overtime work reduction
- Transfers of salaries from a workshop to another
- Stopping temporary work contract
- Outsourcing reduction
- Restart of promotional actions
- Sale or destruction of unused equipment
- Temporary lay-off

Sales and Operations Planning (S&OP)

Balance between production load and workforce of the factory is a key point of industrial management

To be sure to take good decisions about load calculation, the time frame must be large enough

To make the production load calculation based on product families closer to capacity, a ratio of salaries per family needed is define

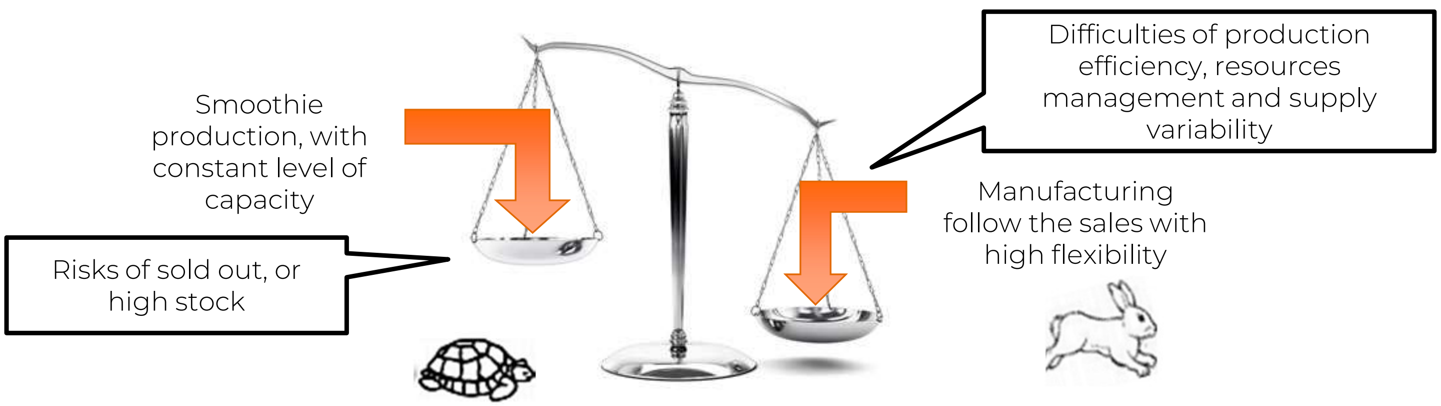


Sales and Operations Planning (S&OP)

The S&OP can be **maintained and managed** with an ERP software or with Microsoft Exel.

All datas and **parameters are defined and entered** by the manager.

S&OP is a process in which **departments collaborate to find a compromise** between these two extremes :



Average Daily Consumption (CMJ)

To make decisions at the shop floor level, we often need **to translate forecasts into daily needs.** This is where the Average Daily Consumption comes in.

The **Average Daily Consumption (CMJ)** is the quantity of a product used or sold **on average per day.**

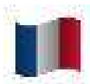
CMJ = Total forecasted demand over the period / Number of working days

Objective :

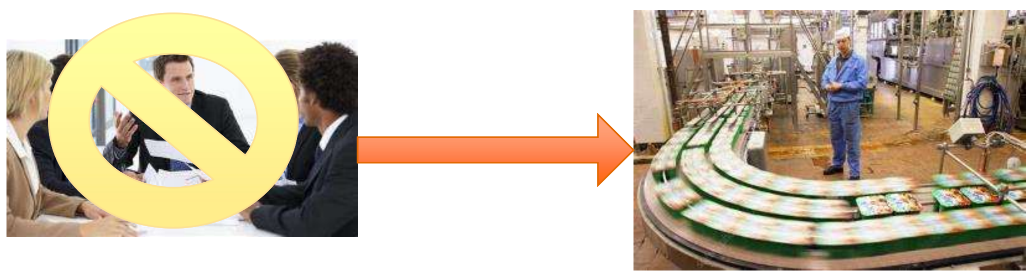
- Helps calculate **reorder points**
- Used to set **stock targets** and **kanban sizes**
- Links strategic planning to **daily operations**

Example:
Forecast for July = 2,000 units
Number of working days = 20

CMJ = 2,000 / 20 = 100 units/day

 : Plan Directeur de Production (PDP)

Detailed planification: Manufacturing Planning and Scheduling tool (or Master Production Schedule)



Detailed planification - MPS tool

Example of software with some functions of an ERP (like Divalto)
Have a focus on the problems mentioned

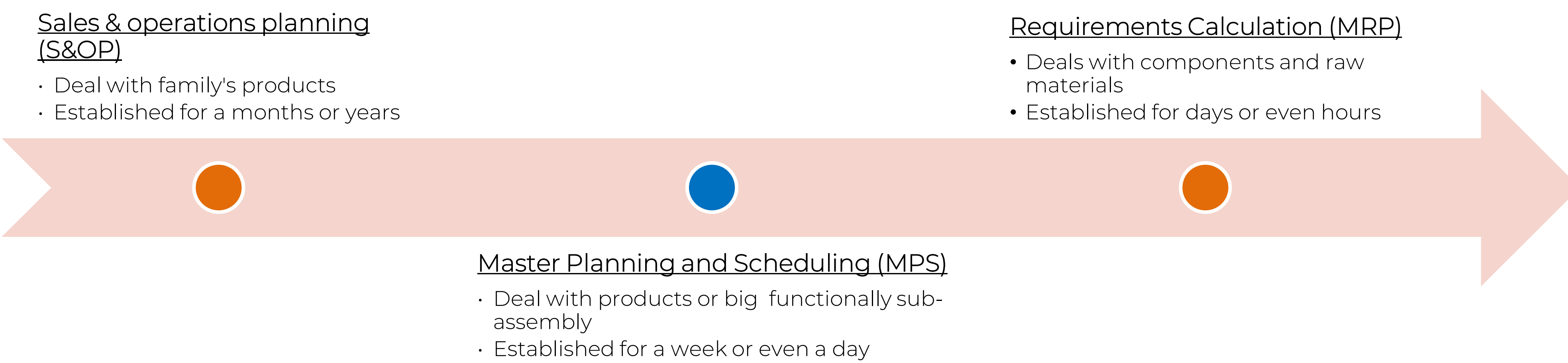
https://youtu.be/HDG6k1n9XSc

Detailed planification - MPS tool

Now the global family finished products production is planned, we will deal with the day-to day

Many parameters will interfere (supplier delivery times ; production delivery times ; carrier delivery times ; production uncertainties)

- Generally, we will then fix a tolerance of +/- 5%

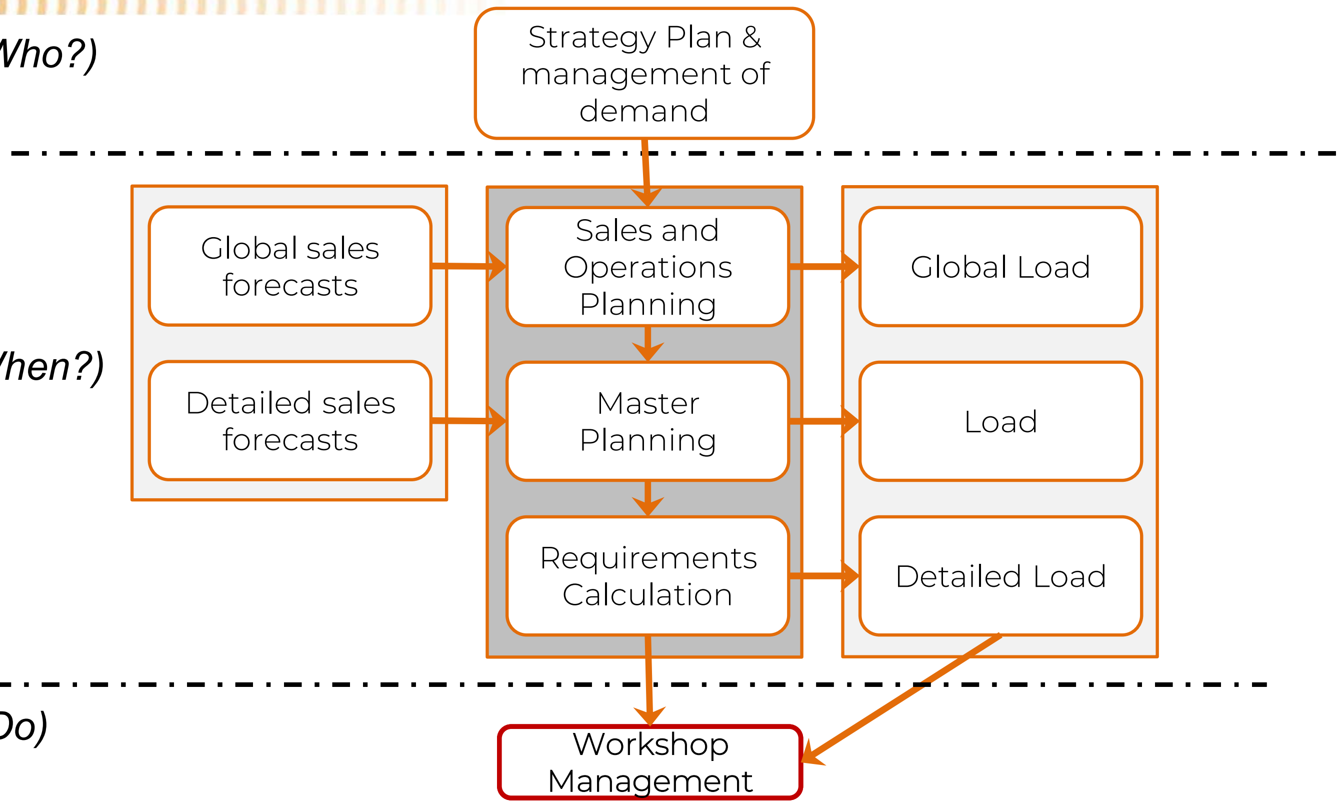


Detailed planification - MPS tool

Strategic level(Why? What? Who?)
Horizon : years

Tactical level (Where? How? When?)
Horizon : months

Operational level (Do)
Horizon : weeks



Detailed planification - MPS tool

A factory produce and buy its parts depending on its needs, Joseph Orlicky have defined, consequently to the definition of MRP, that needs are divided in 2 types:

- Independent needs are those that are coming from outside the company, independent of its will.
  - Ex : Finished products need or spare parts bought by customer of the company
- Dependent needs are those that are generated by independent needs. They come from inside the company.
  - Ex : Subsets, components, raw materials, … assembled to make the sales products

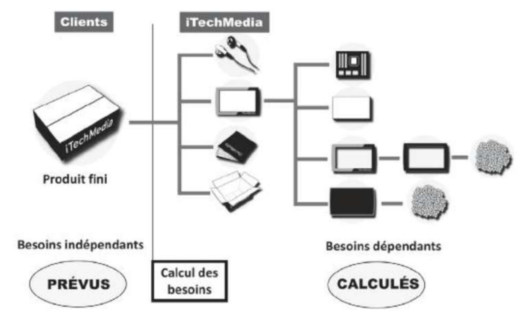


Figure 5.1. – Besoins indépendants et besoins dépendants

The Orlicky principles is:

- Independent needs can be estimate by forecasts → S&OP
- Dependent needs, in opposite, can and must be calculated → Net requirement calculation and MPS

: Nomenclature

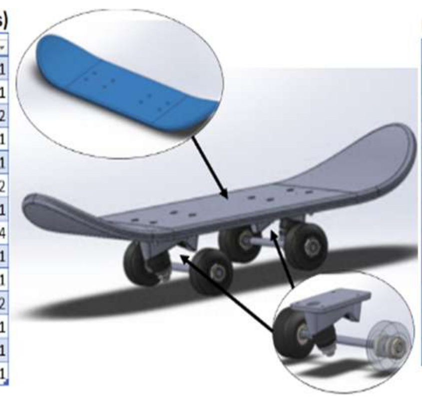
Detailed planification - MPS tool – Bill Of Material

To determine the dependent needs with a net requirement calculation, you need technical data called “Bill Of Materials”

- BOM is like a recipe : it describe the required items/ingredients, with quantities and units, through a tree of hierarchical links

eBOM (Engineering Bill Of Materials)

Level	Name	Quantity
0	SKATEBOARD	1
1	BOARD	1
1	COMPLETE AXLE	2
2	BASE	1
2	AXLE	1
2	RUBBER BEARING	2
2	NUT M12	1
2	BOARD FIXATION	4
3	SCREW M4x25	1
3	NUT M4	1
2	COMPLETE WHEEL	2
3	WHEEL AXLE	1
3	WHEEL	1
2	NUT M10	1



mBOM (Manufacturing Bill Of Materials)

Level	Name	Quantity
0	SKATEBOARD	1
1	BOARD	1
2	BOARD WITHOUT PAINT	1
3	BOARD WITHOUT FINITION	1
4	BOARD WITHOUT HOLES	1
5	COATED WOOD	8
6	LAMINATED SHEETS	1
7	MAPLE WOOD BOARD	0,002
1	PURCHASED AXLE	2
1	RUBBER BEARING	4
1	PURCHASED SCREWS KIT	1

Detailed planification - MPS tool

The main functionalities are:

- To manage the requirement calculation by giving information for product orders through the Bill Of Materials (BOM)
- To translate the S&OP built with families in real finished goods
- To follow the real sales by comparing orders received and forecasts
- To give to the commercial department the available quantity for sales without reviewing the Manufacturing Planning and Scheduling engaged
- To evaluate the level of stock

Detailed planification - MPS tool

Before planning the production of a finished product, it is necessary to determine

- The planning horizon is the period from the current date for which the software will plan requirements, and therefore production and procurement. This horizon depends on the lead times, your supplier delivery time, the complexity of the bill of material, the production quality of the items to be managed....
- The quantities that will be sold (the commercial need), it is calculated from the following information
  - Firm orders: these are customer orders already recorded
  - Forecast orders: some customers sometimes provide information on future orders
  - Forecasts of sales: carried out by the sales department to estimate future sales to customers who do not send forecast orders.

PF500Go	1	2	3	4	5	6	7	8	9	10
Prévisions de ventes	220	300	330	400	600	750	950	1 200	1 400	1 500
Commandes fermes	150	120	80	20						
Prévisions restantes	70	180	250	380	600	750	950	1 200	1 400	1 500
Besoin commercial	220	300	330	400	600	750	950	1 200	1 400	1 500

When a new customer pass an order, we remove it from « Prévisions restantes » line and add it to « Commandes fermes » line.

Detailed planification - MPS tool

The Initial stock is the real value of the stock at the beginning of the calculation

Orders launched are manufacturing orders in progress or purchase orders in the process of delivery

The Lot value represents the quantity of products made in one production order

The required time to obtain the production order (OF ordre de fabrication).

Stock target

Security stock

Commercial need

"Orders proposed" are orders suggested from the system to satisfy the Net Requirements at the end date. The line named Start give the proposed order by considering the delay to obtain the product

PF500Go

Taille de lot = x 400 — Délai = 1s — Stock = 400 — SS = 300

Niveau = 0 — Unité = Pièce

		1	2	3	4	5	6	7	8	9	10
Prévisions restantes		70	180	250	380	600	750	950	1 200	1 400	1 500
Commandes fermes		180	120	80	20						
Stock disponible	100										
Ordres lancés (fin)											
Ordres proposés (fin)											
Ordres proposés (déb)											

Detailed planification - MPS tool

The schedule is generally done each week, giving details for every day

- Net Requirements must be satisfied at the beginning of the period
- Orders launched (Waiting to be produced or to be delivered from the supplier) are at the beginning of the period
- Orders proposed have a start and end date at the beginning of the period
- Forecast stock is available at the end of the period

The time frame depends of the process scheduled

- If the delay to make the product for the all BOP (lead time) takes 3 weeks, the time frame must be at least this period
- Global time to obtain a product must include all the delays, like manufacturing, supplying, etc.

Detailed planification - MPS tool

PF500Go

Taille de lot = x 400 Délai = 1s Stock = 400 SS = 300
Niveau = 0 Unité = Pièce

		1	2	3	4	5	6	7	8	9	10
Prévisions restantes		70	180	250	380	600	750	950	1 200	1 400	1 500
Commandes fermes		180	120	80	20						
Stock disponible	100	– 150	350	20	20	220	270	120	120	320	20
Ordres lancés (fin)											
Ordres proposés (fin)			800		400	800	800	800	1 200	1 600	1 200
Ordres proposés (déb)		800		400	800	800	800	1 200	1 600	1 200	

Messages : utilisation du stock de sécurité en S1 ; lancer un OF de 800 PF500Go pour la semaine 2.

All the values are available for the beginning of the period except for the forecast stock

"-" means that the security stock is used

: Calcul des Besoins Nets (CBN)

Detailed planification - The Net Requirements calculation

The **Net Requirements** calculation uses the Master Planning and the Bill Of Process as **inputs** to be able to calculate

The Net Requirements calculation is used to **define the dependent needs based on the independent needs**

It give as a result the **supplies and production orders of all parts and all finished products**

It checks **the consistency between the delivery date and the date of needs**

Detailed planification - The Net Requirements calculation

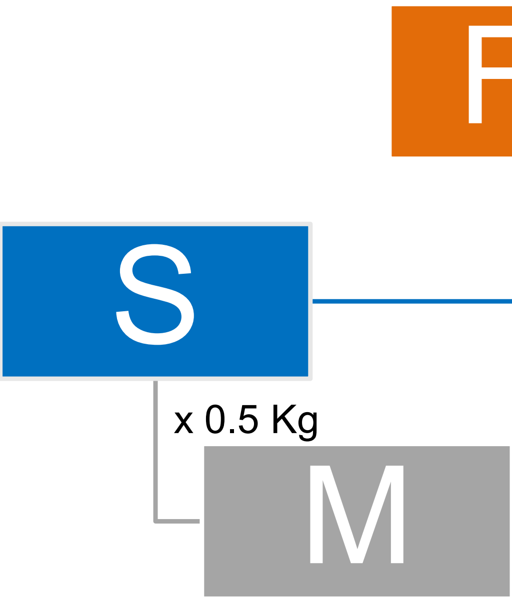
Information needed for the calculation are:

- Master Planning of all materials
- Bill Of Process of all independent needs
- Delays to obtain parts (Production, Assembly, Procurement of bought components)
- Resources build with components in stock or products that will be available in plan
- Rules of management like the lot size, the value of safety stock or reject rates

Results of the calculation are:

- Production orders for manufacturing or for supply
- Messages for the manager to take decision based on proposition of the calculation

Detailed planification - MPS tool - 2nd Example



A finished product *FP* is composed of 2 materials *S*, each *S* is made from 0.5 Kg of the material *M*

Material FP		1	2	3	4	5
Gross Requirements		100	150	150	200	250
Orders launched						
Forecast stock	300	200	50	150	200	200
Orders proposed	Finish			250	250	250
	Start		250	250	250	
Message						

Manufacturing information	
St	300
L	250
D	1

Week 1

- $NR_1 = GR_1 - FS_0 = 100 - 300 < 0 \rightarrow NR_1 = 0$
- $FS_1 = FS_0 - GR_1 = 300 - 100 = 200$

Week 2

- $NR_2 = GR_2 - FS_1 = 150 - 200 < 0 \rightarrow NR_2 = 0$
- $FS_2 = FS_1 - GR_2 = 200 - 150 = 50$

Week 3

- $NR_3 = GR_3 - FS_2 = 150 - 50 = 100 \rightarrow OP_3 = Lot = 250$ with a start in $3 - D = 3 - 1 = 2$
- $FS_3 = FS_2 + OP_3 - GR_3 = 50 + 250 - 150 = 150$

Week 4

- $NR_4 = GR_4 - FS_3 = 200 - 150 = 50 \rightarrow OP_4 = 250$ with a start in $4 - D = 4 - 1 = 3$
- $FS_4 = FS_3 + OP_4 - GR_4 = 150 + 250 - 200 = 200$

Week 5

- $NR_5 = GR_5 - FS_4 = 250 - 200 = 50 \rightarrow OP_5 = 250$
- $FS_5 = FS_4 + OP_5 - GR_5 = 200 + 250 - 250 = 200$

Detailed planification - MPS tool - 2nd Example

If we take care of the BOM of FP, to be able to produce this product, we need 2 materials S

- By consequence, it create the Gross Requirements for the material S: $GR_2 = GR_3 = GR_4 = 2 \times 250 = 500$

Material FP		1	2	3	4	5
Orders proposed	Finish			250	250	250
	Start		250	250	250	

Material S	1	2	3	4	5
Gross Requirements		500	500	500	

Material S		1	2	3	4	5
Gross Requirements			500	500	500	
Orders launched			500			
Forecast stock	150	150	150	150	150	150
Orders proposed	Finish			500	500	
	Start	500	500			
Message		Launch 500 S in period 1				

Manufacturing information	
St	150
L	500
D	2

Week 1

- $NR_1 = GR_1 - FS_0 = 0 - 500 < 0 \rightarrow NR_1 = 0$
- $FS_1 = FS_0 - GR_1 = 150 - 0 = 150$

Week 2

- $NR_2 = GR_2 - FS_1 - OL_2 = 500 - 150 - 500 < 0 \rightarrow NR_2 = 0$
- $FS_2 = FS_1 + OL_2 - GR_2 = 150 + 500 - 500 = 150$

Week 3

- $NR_3 = GR_3 - FS_2 = 500 - 150 = 350 \rightarrow$ $OP_3 = 500$ with a start in $3 - D = 3 - 1 = 2$
- $FS_3 = FS_2 + OP_3 - GR_3 = 150 + 500 - 500 = 150$

Week 4

- $NR_4 = GR_4 - FS_3 = 500 - 150 = 350 \rightarrow$ $OP_4 = 250$ with a start in $4 - D = 4 - 1 = 3$
- $FS_4 = FS_3 + OP_4 - GR_4 = 150 + 500 - 500 = 150$

Week 5

- $NR_5 = GR_5 - FS_4 = 0 - 150 < 0 \rightarrow NR_5 = 0$
- $FS_5 = FS_4 + OP_5 - GR_5 = 150 + 0 - 0 = 0$

Detailed planification - MPS tool - 2nd Example

If we take care of the BOM of FP, to be able to produce material S, we need 0.5 Kg of material M

- By consequence, it create the Gross Requirements for the material M: $GR_1 = GR_2 = 0.5 \times 500 = 250$

Material S		1	2	3	4	5
Orders proposed	Finish			500	500	
	Start	500	500			

Material M	1	2	3	4	5
Gross Requirements	250	250			

Material M		1	2	3	4	5
Gross Requirements		250	250			
Orders launched			200			
Forecast stock	300	50	0	0	0	0
Orders proposed	Finish					
	Start					
Message						

Manufacturing information	
St	300
L	200
D	3

Week 1

- $NR_1 = GR_1 - FS_0 = 250 - 300 < 0$ ➔ $NR_1 = 0$
- $FS_1 = FS_0 - GR_1 = 300 - 250 = 50$

Week 2

- $NR_2 = GR_2 - FS_1 - OL_2 = 250 - 50 - 200 = 0$ ➔ $OP_2 = 0$
- $FS_2 = FS_1 + OL_2 - GR_2 = 50 + 200 - 250 = 0$

Week 3

- $NR_3 = GR_3 - FS_2 = 0$
- $FS_3 = FS_2 - GR_3 = 0$

Detailed planification - MPS tool - 3nd Example

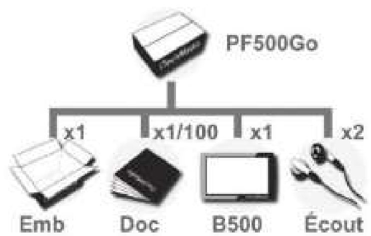


Figure 5.15. – Nomenclature mononiveau de PF500Go

PF500Go — Taille de lot = x 400 · Délai = 1s · Stock = 400 · SS = 300 · Niveau = 1 · Unité = Pièce

	1	2	3	4	5	6	7	8	9	10
Ordres proposés (fin)		800		400	800	800	800	1 200	1 600	1 200
Ordres proposés (déb)	800		400	800	800	800	1 200	1 600	1 200	

B500 — Taille de lot = x 600 · Délai = 1s · Stock = 300 · SS = 750 · Niveau = 1 · Unité = Pièce

		1	2	3	4	5	6	7	8	9	10
Besoins bruts		800		400	800	800	800	1 200	1 600	1 200	
Stock disponible	– 450										
Ordres lancés (fin)		1 200									
Ordres proposés (fin)											
Ordres proposés (déb)											

Messages :

Figure 5.17. – Le calcul des besoins bruts de B500

Lorsque les besoins bruts d'un article sont obtenus, il suffit ensuite de faire le calcul des besoins nets.

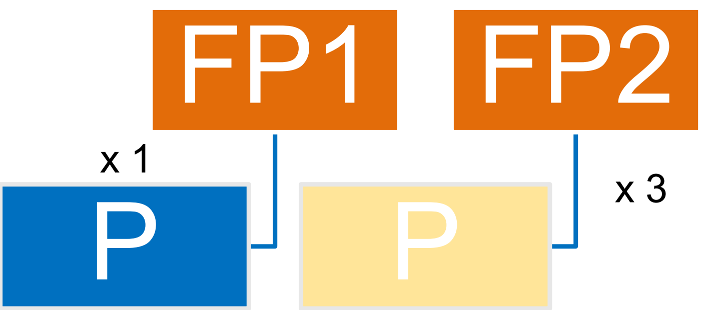
B500 — Taille de lot = x 600 · Délai = 1s · Stock = 300 · SS = 750 · Niveau = 1 · Unité = Pièce

		1	2	3	4	5	6	7	8	9	10
Besoins bruts		800		400	800	800	800	1 200	1 600	1 200	
Stock disponible	– 450	– 50	550	150	550	350	150	150	350	350	350
Ordres lancés (fin)		1 200									
Ordres proposés (fin)			600		1 200	600	600	1 200	1 800	1 200	
Ordres proposés (déb)		600		1 200	600	600	1 200	1 800	1 200		

Messages : lancer un OF de 600 B500 pour la semaine 2.

Figure 5.18. – Le calcul des besoins nets de B500

Detailed planification - MPS tool – 4th Example



A material *P* is used into the finished products *FP1* and *FP2* with respectively a link of 1 and 3

Detailed planification - MPS tool – 4th Example

Material FP1		1	2	3	4	5
Gross Requirements		100	150	150	200	250
Orders launched						
Forecast stock	300	200	50	150	200	200
Orders proposed	Finish			250	250	250
	Start		250	250	250	
Message						

Manufacturing information	
St	300
L	250
D	1

Material FP2		1	2	3	4	5
Gross Requirements			100		100	
Orders launched						
Forecast stock	150	150	50	50	150	150
Orders proposed	Finish				200	
	Start		200			
Message						

Manufacturing information	
St	150
L	200
D	2

Material P		1	2	3	4	5
Gross Requirements			850	250	250	
Orders launched						
Forecast stock	300	300	50	400	150	150
Orders proposed	Finish		600	600		
	Start	600	600			
Message		Launch 600 *P* in period 1				

Manufacturing information	
St	300
L	600
D	1

Detailed planification - MPS tool – 4th Example

We can see that the Gross Requirement of *P* is the sum of the requirements generated by *FP1* and *FP2*

- By consequence, it create the Gross Requirements for the material P: $GR_2 = 1 \times 250 + 3 \times 200 = 850$

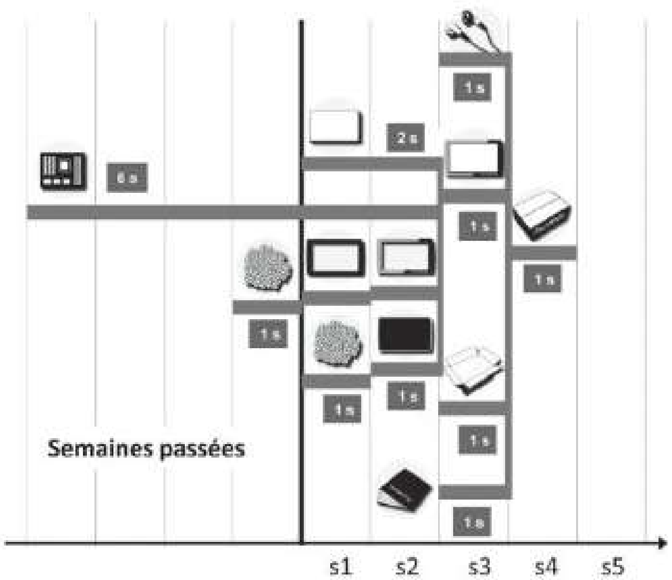
Material FP1		1	2	3	4	5
Orders proposed	Finish			250	250	250
	Start		250	250	250	

Material FP2		1	2	3	4	5
Orders proposed	Finish				200	
	Start		200			

Material P	1	2	3	4	5
Gross Requirements		850	250	250	

Detailed planification - MPS tool – Closed area & Available to sell notions

PF120Go	1	2	3	4	5	6	7	8	9	10
Ordres proposés (fin)					800					
Ordres proposés (déb)				800						



General schedule for a batch of PF120Go tablet

This production order still seems distant, as it will only begin in 3 weeks. However, if we look at the schedule below, we can see that for this future production of finished products PF120Go, the electronic cards and the plastic material have already been ordered, and we are about to place orders for the touch screens very soon.

PF500Go — Taille de lot = x 400; Délai = 1s; Stock = 400; SS = 300; Niveau = 0; Unité = Pièce; Zone ferme = 5s

		1	2	3	4	5	6	7	8	9	10
Prévisions restantes		70	180	250	380	600	750	950	1 200	1 400	1 500
Commandes fermes		180	120	80	20						
Stock disponible	100	– 150	350	20	20	220	270	120	120	320	20
PDP (fin)			800F		400F	800F	800	800	1 200	1 600	1 200
PDP (déb)		800F		400F	800F	800	800	1 200	1 600	1 200	

Messages : utilisation du stock de sécurité en S1 ; lancer un OF de 800 PF500Go pour la semaine 2 ; affermir l'ordre proposé de la semaine 6.

Detailed planification - MPS tool – Closed area & Available to sell notions

Managers might need to adjust planned quantities if sales exceed expectations. The challenge is to align production with market flexibility.

- A limit should be set on the quantities that can be sold.
- This doesn't mean restricting sales absolutely but rather recognizing that factory production is planned based on sales forecasts, which in turn constrains how much can be sold.

Available to Sell(ATS):

It represents the quantities that can be sold without disrupting the established manufacturing program (MPS).

- It includes finished products in stock and products that will be manufactured (under the 'PDP Fin' line).
- Customer orders already recorded (under the 'Firm Orders' line) must also be taken into account to calculate ATS.

Detailed planification - MPS tool – Closed area & Available to sell notions

Closed Area
A period or zone in the production plan where orders cannot be changed or moved. It is designed to stabilize production and ensure the schedule is reliable.

Available to Sell
The quantity of finished products that can be sold to customers, taking into account current inventory, reserved stock, and confirmed orders.

Detailed planification - MPS tool – Closed area & Available to sell notions

In terms of calculations:

- **Closed area:** The software only calculates the end-of-week inventory; placing or moving orders is not allowed.
- Only the manager can make changes in the closed area, but **interventions should be rare to maintain production stability**.
- **Rules should be defined** to guide any necessary modifications, providing some flexibility while preserving stability.
- **Open area:** The software performs a classic net requirements calculation and automatically suggests orders.

Detailed planification - MPS tool – Closed area & Available to sell notions

PF500Go		Taille de lot = x 400 Niveau = 0			Délai = 1s Unité = Pièce			Stock = 400 Zone ferme = 5s		SS = 300	
		1	2	3	4	5	6	7	8	9	10
Prévisions restantes		70	180	250	380	600	750	950	1 200	1 400	1 500
Commandes fermes		180	120	80	20						
Stock disponible	100	– 150	350	20	20	220	270	120	120	320	20
PDP (fin)			800F		400F	800F	800	800	1 200	1 600	1 200
PDP (déb)		800F		400F	800F	800	800	1 200	1 600	1 200	
Disponible à vendre		220	600		380	800					

The safety stock is still not taken into account !

Disponible à vendre

Disponible à vendre (1) = Stock + PDP (1) – sommes des commandes fermes jusqu'à la prochaine réception prévue (PDP fin)

Disponible à vendre (n) = PDP (n) – Somme des commandes fermes jusqu'à la prochaine réception prévue (PDP fin)

Available to sell W1 = 400 (in stock) – 180 already ordered = 220

Available to sell W2 = 800 (produced) – 120 already produced – 80 (already produced with no other order until W4).

Available to sell W4 = 400 (produced) – 20 already produced = 380

Available to sell W4 = 400 (produced) – 20 already produced = 380

Available to sell W5 = 800

Detailed planification - MPS tool – Closed area & Available to sell notions

St = 125 Lot = 100 Delay = 1 SS = 5 Closed Area = 4

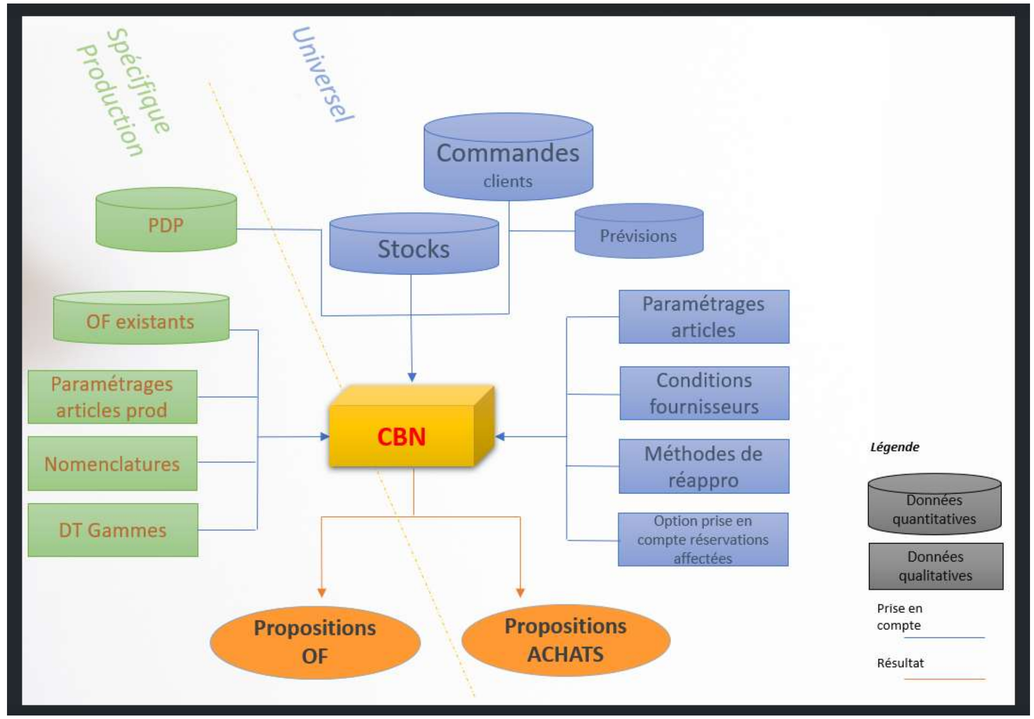
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Sales forecasts		5	20	30	40	45	50	50
Firm orders		35	20	15	5	2		
Available planned products	120	80	40	95	50	3	53	3
Master Planning (Final date)				100			100	
Available to sale		70		78			100	
Master Planning (Start date)			100			100		

Available To Sale calculation

- $ATS_1 = St - FO_1 - FO_2 = 125 - 35 - 20 = 70$
- For periods others than the first, we only take care on MPS resources, because all the available planned products have been sale into the previous ATS
- $ATS_3 = FMP_3 - FO_3 - FO_4 - FO_5 = 100 - 15 - 5 - 2 = 78$
- $ATS_6 = FMP_6 = 100$ because there is no more orders

Manufacturing Resource Planning – Calcul Besoin Net

- MRP is a program capable of (re)supply components and raw materials for production.
- MRP is a tool whose purpose is to issue (re)procurement proposals based on a range of quantitative data (stock levels, customer and purchase order portfolios) and qualitative data (specific procurement parameters and third-party characteristics), <u>with the aim of covering needs</u> (requirements to meet customer orders and component requirements for production).
- <u>Push system scenario</u>



Manufacturing Resource Planning – Calcul Besoin Net

- To sum up, he applies this universal formula:

Besoin brut – encours (stock + approvisionnements prévus) = Besoin net

- The gross requirement is made up of customer orders and possibly sales targets or forecasts.
- The CBN translates net requirements into :
  - Manufacturing proposal(s) for manufactured products ;
  - Purchase proposal(s) for purchased items.

Conclusions

All the calculations are obviously done by computer and ERP software, now with computers, **net requirement calculation are done every day**, not so long ago it took a week to obtain such results

The Net Requirement Calculation, from sales forecasts and technical data, allows to plan and coordinate **supplies, then manufacturing, then assembly, and finally packaging**, in a way to be able to distribute the finished products which will be ordered by the customers.

Conclusions

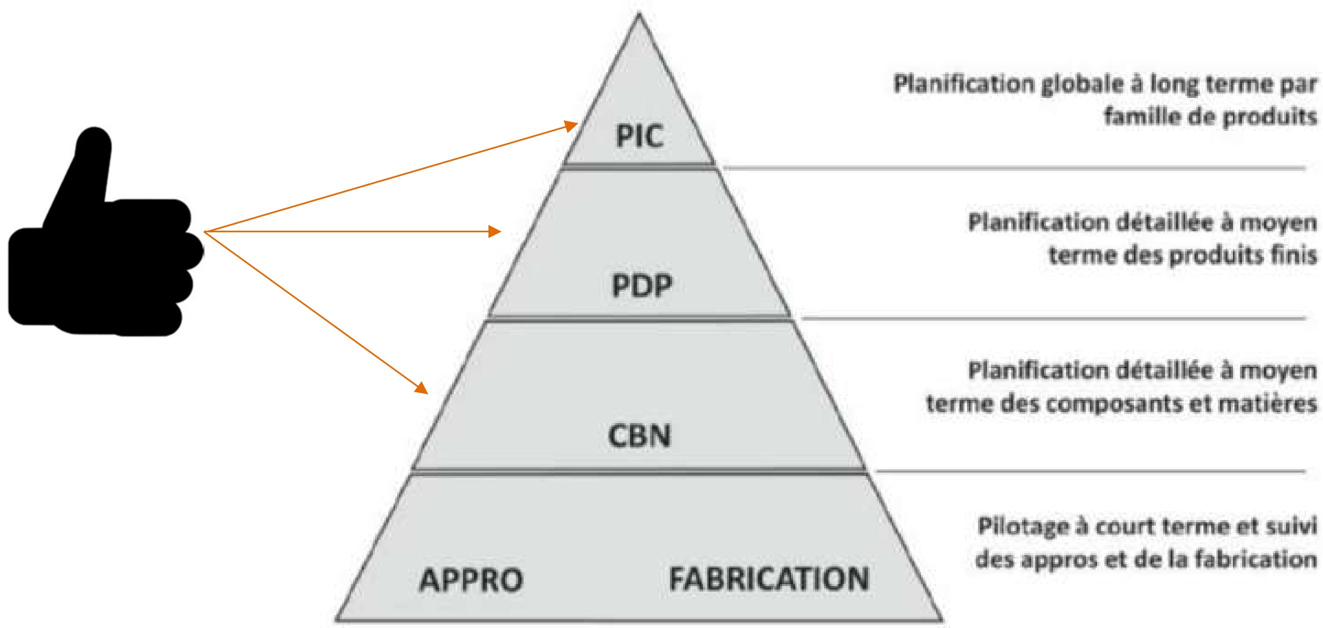
The information necessary for the Net requirement Calculations are:

- The Bill of Material giving the constituents of each article
- The times for obtaining the articles (times of manufacture, assembly or supply of purchased products)
- Resources made up of items in stock or items that will be available (launched production orders, purchase orders in progress and firm planned orders, i.e. fixed by the manager)
- Detailed planning business rules such as batch size, lead time, safety stock or scrap rate.

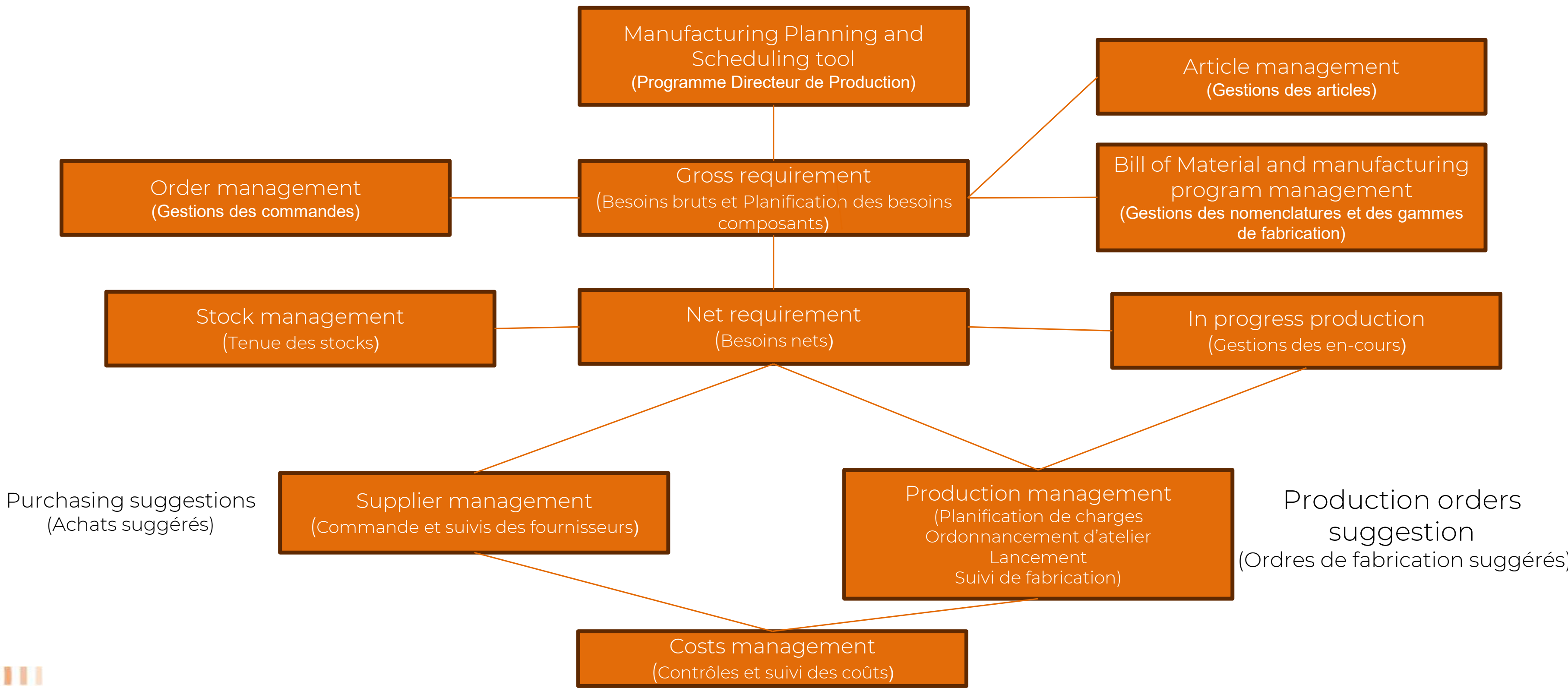
The results of the net requirements calculation are:

- Proposed orders, i.e. releases forecasts in manufacturing or forecast supplies
- Messages proposing to the manager the specific actions to be carried out (launch, advance, delay a manufacturing order).

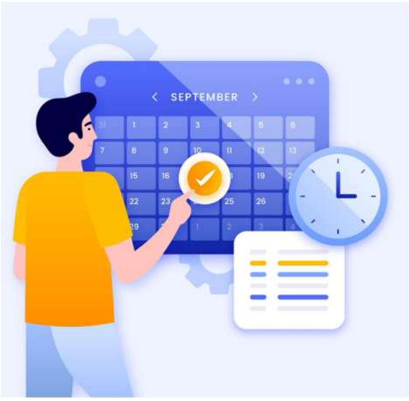
Conclusions



Presentation GPAO and ERP tool.



Production Scheduling: Managing Capacity and Resources



Production Scheduling and Capacity Constraints

Now that we've planned what to produce and when, let's focus on how we organize production on the shop floor.

We'll talk about capacity, queues, and how to optimize production sequences.

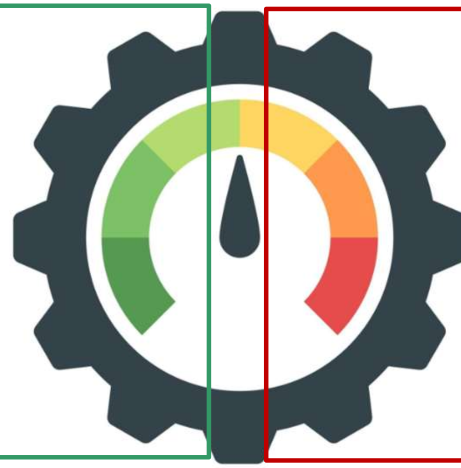
In this part, we will focus on how to schedule production orders based on available capacity, waiting times, and optimization methods like Johnson's algorithm.

Capacity-based Scheduling

Every factory has limited machines, tools, and people. So, how do we assign production orders without overloading the system?

Each production resource (machine, worker, tool) has a limited availability.That is why, orders must be assigned to resources according to their capacity.

Underload =
loss of productivity,
wasted resources

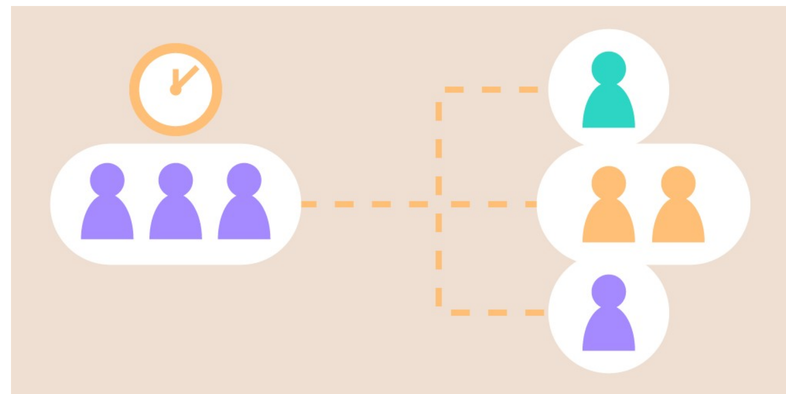


Overload =
delays, stock-outs, loss
of efficiency.

Scheduling aims to match production needs with available capacity.

Queuing Theory Basics

In production, jobs don't always flow smoothly. When machines or operators are busy, tasks must wait. Queuing theory helps us understand and reduce these waiting times.



Queuing theory is used when:

- **Demand exceeds machine capacity** (temporarily or regularly)
- Jobs **accumulate in front of a machine**
- We want to **measure and reduce waiting times**

What can we calculate with queuing models?

- **Average queue length** (How many jobs are waiting?)
- **Average waiting time** (How long do they wait?)
- **Machine utilization rate** (How busy is the machine?)

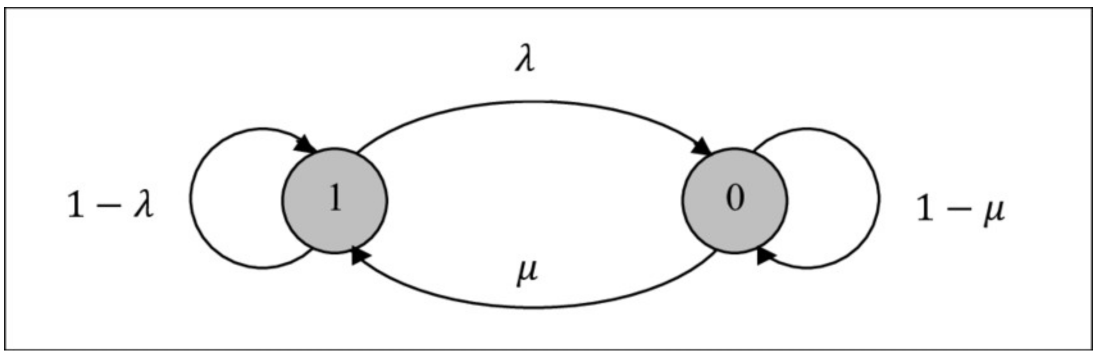
A simple example:
A machine can process **10 parts/hour**
But the demand is **12 parts/hour**
Result: The machine cannot follow — a **queue builds up**, and **waiting time increases**.

Markov chains:

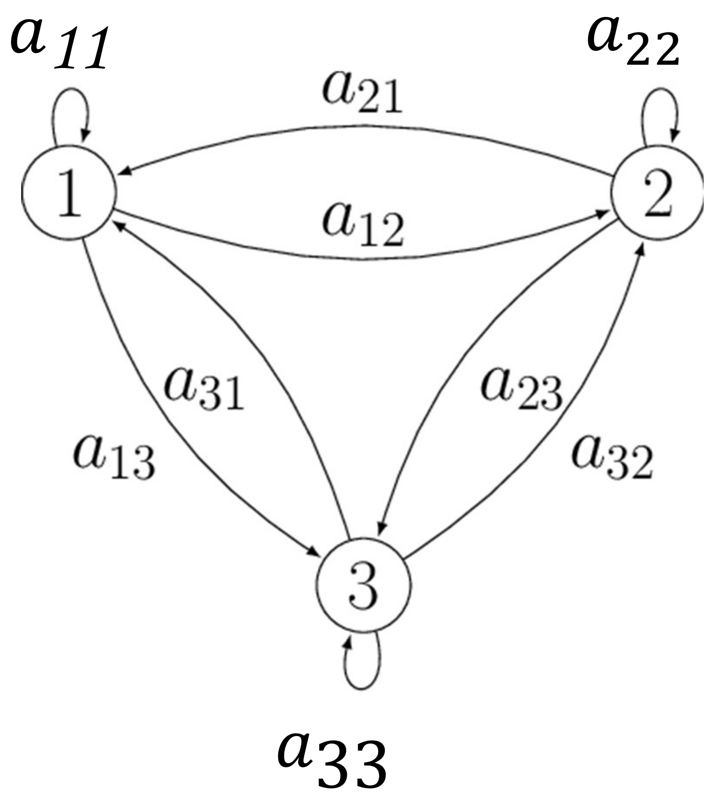
We use stochastic models based on Markov chains:

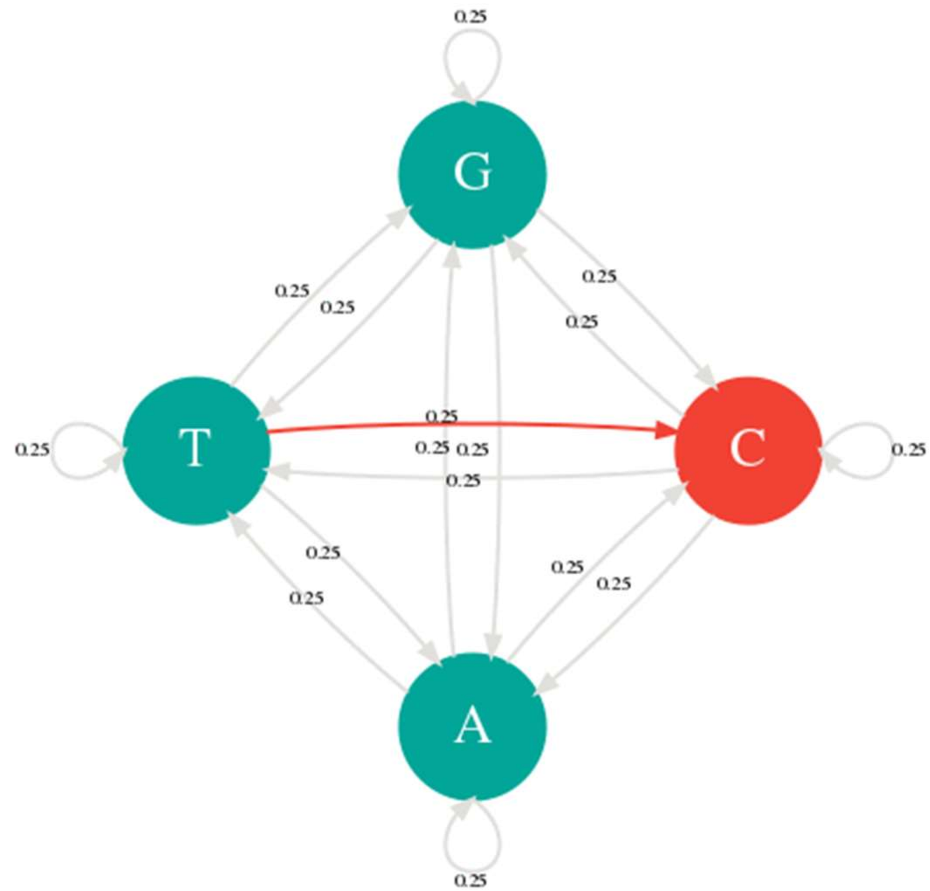
- The system evolves over time from one state (0, 1 job in queue) to another.
- Markovian means the future state depends only on the current state, not the past.

State 0 = No jobs in the system (machine is idle)
State 1 = 1 job in the system (being processed or waiting)



- μ = Probability that a new job arrives in the system → Transition from state 0 → 1.
- $1-\mu$ = Probability that no job arrives in that time interval
- λ = Probability that a job finishes and leaves the system → Transition from state, 1 → 0.
- $1-\lambda$ = Probability that no job finishes during that time





TC

Markov chains:

To help predict average waiting times, queue lengths, and system utilization, which are essential for production planning and performance analysis, a production system can be modelled as:

- M/M/1 → random arrivals, random processing times
- M/D/1 → random arrivals, fixed processing times

M/M/1	M/D/1
M = Exponential (random) arrival times M = Exponential (random) service times 1 = One machine (one server) Used when arrivals and service times are random → most general case. Useful when you cannot control how long each task takes (high variability).	M = Exponential (random) arrival times D (Deterministic) = Constant service time 1 = One machine Used when arrival is random, but service time is always the same. Useful when your machine time is fixed, like automated tasks.

These models help simulate how a production system behaves under stress and guide decisions on machine capacity, staffing, or batch size.

Johnson's Rule for Two-Machine Scheduling

When we want to reduce the total time to finish all jobs, especially with two machines in sequence, Johnson's algorithm is a powerful and easy-to-use method.

Goal: Minimize total completion time (makespan) for a set of jobs going through 2 machines (M1 then M2).

Steps:

Step 1 :
List all jobs with their times on M1 and M2.

Step 2:
If M1 time < M2 time → Schedule the job **first**.

Step 3 :
If M1 time > M2 time → Schedule the job **last**.

Step 4 :
Repeat until all jobs are scheduled.

It gives an optimal sequence for minimizing the overall production time.

Johnson’s Algorithm: Detailed Example

Let’s take a concrete example to see how Johnson’s rule works in practice.

Step 1 – Input Data

Job	M1 Time	M2 Time
A	3	6
B	8	4
C	5	2
D	7	9

We want to minimize the **total time** to complete all jobs (makespan), using **1 sequence** of execution for **2 machines in series**.

Johnson's Algorithm: Detailed Example

Step 2 – Apply Johnson's Rule

List all processing times.

At each step, pick the **smallest time** remaining.

- If it's on **M1**, place the job at the **beginning** of the sequence.
- If it's on **M2**, place the job at the **end** of the sequence.

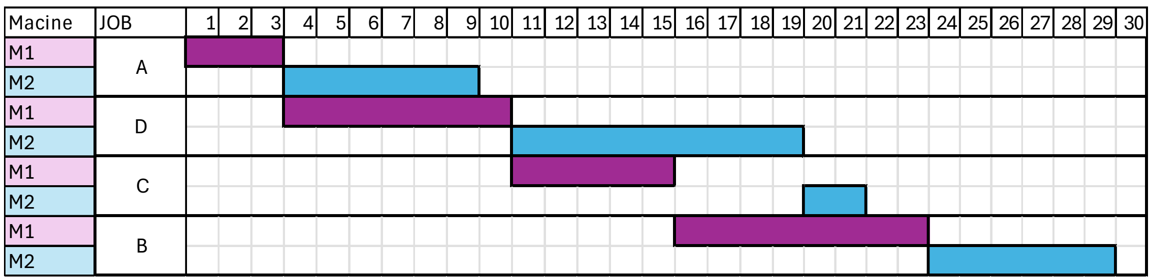
Remaining Jobs	Smallest Time	On Which Machine?	Action	New Sequence
A, B, C, D	2 (C)	M2	Put C at the **end**	— — — C
A, B, D	3 (A)	M1	Put A at the **start**	A — — C
B, D	4 (B)	M2	Put B at the **end**	A — — C B
D	7 (D)	M1	Put D at the **start**	A D — C B

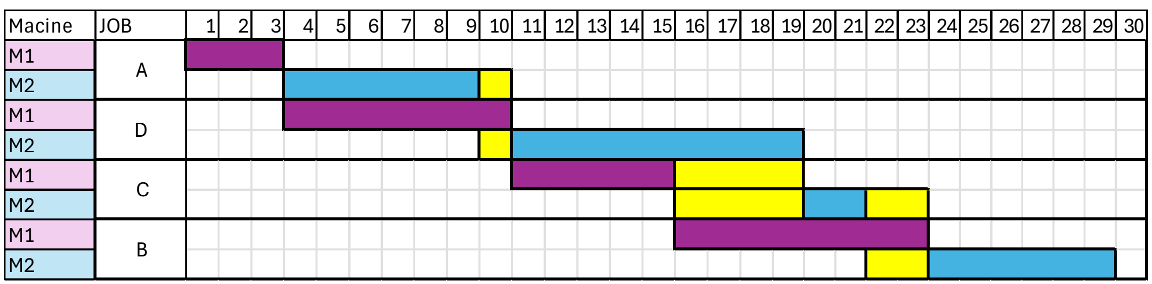
Final optimal sequence: A → D → C → B

Johnson's Algorithm: Detailed Example

Now, let's visualize this sequence using a Gantt chart to understand how it minimizes idle time on the second machine.

This optimal order reduces machine 2 idle time and ensures the entire process is completed in 25 time units. Trying another order would give a longer makespan.





Waiting time is caused when machine 2 finishes earlier than machine 1. This is where idle time appears — it's important to reduce it to increase productivity.

From Forecast to Production Scheduling

Let's take a step back and look at the full planning process — from forecasting sales to optimizing job execution on the machines.

INTEGRATED VIEW OF PLANNING STEPS:

Sales Forecast	S&OP (Sales & Operations Planning) PIC (Plan Industriel et Commercial)	MPS (Master Production Schedule) PDP (Plan Directeur de Production)	Net Requirements (CBN – Calcul des Besoins Nets)	Scheduling with Constraints Ordonnancement
Predicts future **customer demand**	Balances **forecasted demand** with **available resources** (capacity, labor, materials)	Breaks down the S&OP/PIC into **detailed items** and **dates**	Net Requirements= Needs from MPS−Existing Stock−Open Orders	**By Capacity** Assigns jobs to machines based on their availability. → Takes into account time, resources, and workload.
Based on **historical sales**, trends, seasonality, market inputs	Defines **production volume** per family over **mid-term horizon** (3–18 months)	Converts family-level plans into **SKU-level, weekly or daily planning**		**Using Queuing Analysis** Models waiting lines before machines. →Helps predict delays and adjust capacity.
Usually monthly or weekly	Collaborative process: sales + operations + finance	Drives the **launch of production and purchase orders**		**Optimized via Johnson's Algorithm** • Finds the best sequence for jobs on 2 machines. →Minimizes total production time (makespan).
Drives all downstream planning	Sets the **global production target** per period	Takes into account **lead times and inventory**		

Kanban Method

Kanban was developed by Taiichi Ohno, a production engineer at Toyota, in the 1950s.

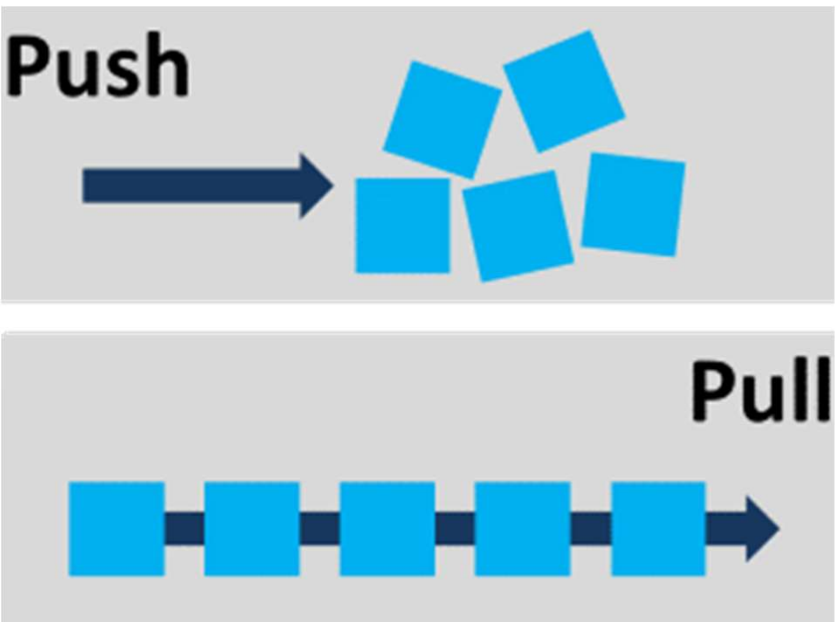
Kanban means “card” or “sign” in Japanese.
It is an information system and a visual tool to control material flow.

Ohno observed that workers tend to overproduce, so he introduced a system to produce:

- the needed product,
- when it is requested,
- in the right quantity.

Principle: **upstream workstations produce only what downstream workstations request**, and the furthest downstream workstation produces only to meet customer demand.

Kanban Method



Instead of producing with a push system, which means manufacturing a product before receiving an order, the idea is to favour a pull system by adjusting the production level to actual demand.

Kanban is part of the Lean philosophy.

Push flow: Producing goods in advance based on forecasts and pushing them to the next stage or to stock, without waiting for actual customer orders.

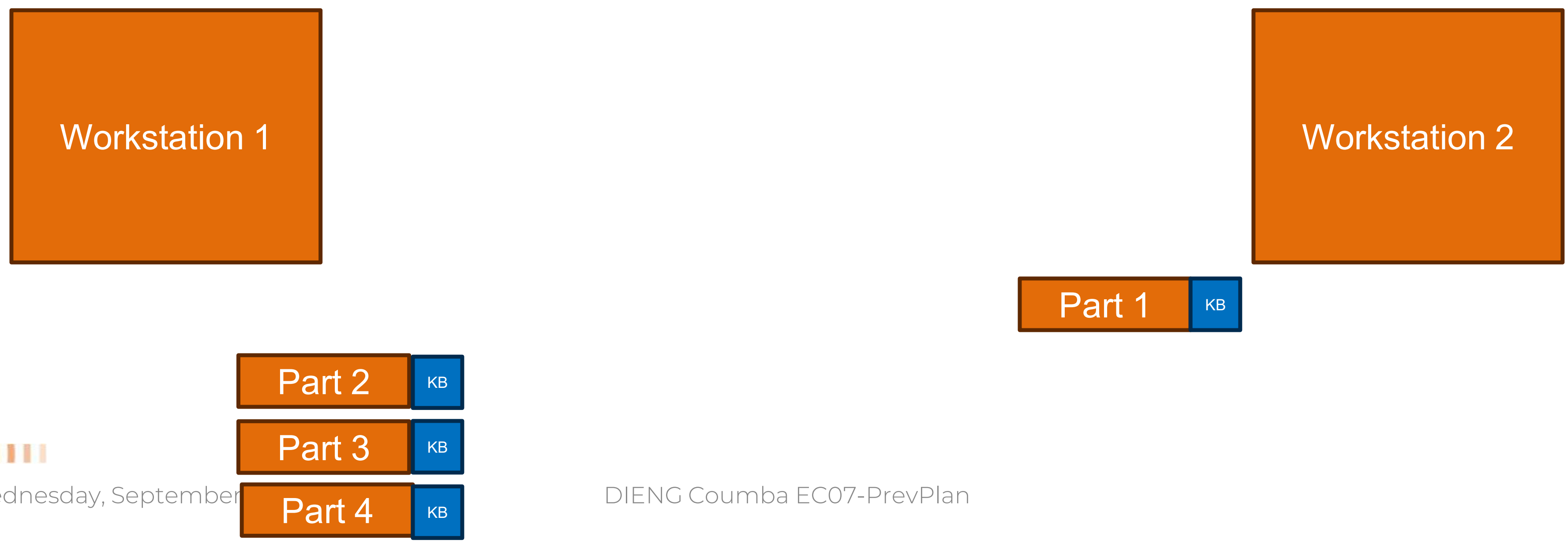
Pull flow: Producing only what is needed, when it is needed, based on real customer demand — production is triggered by actual orders.

Kanban Method

- The flow of production is from left to the right

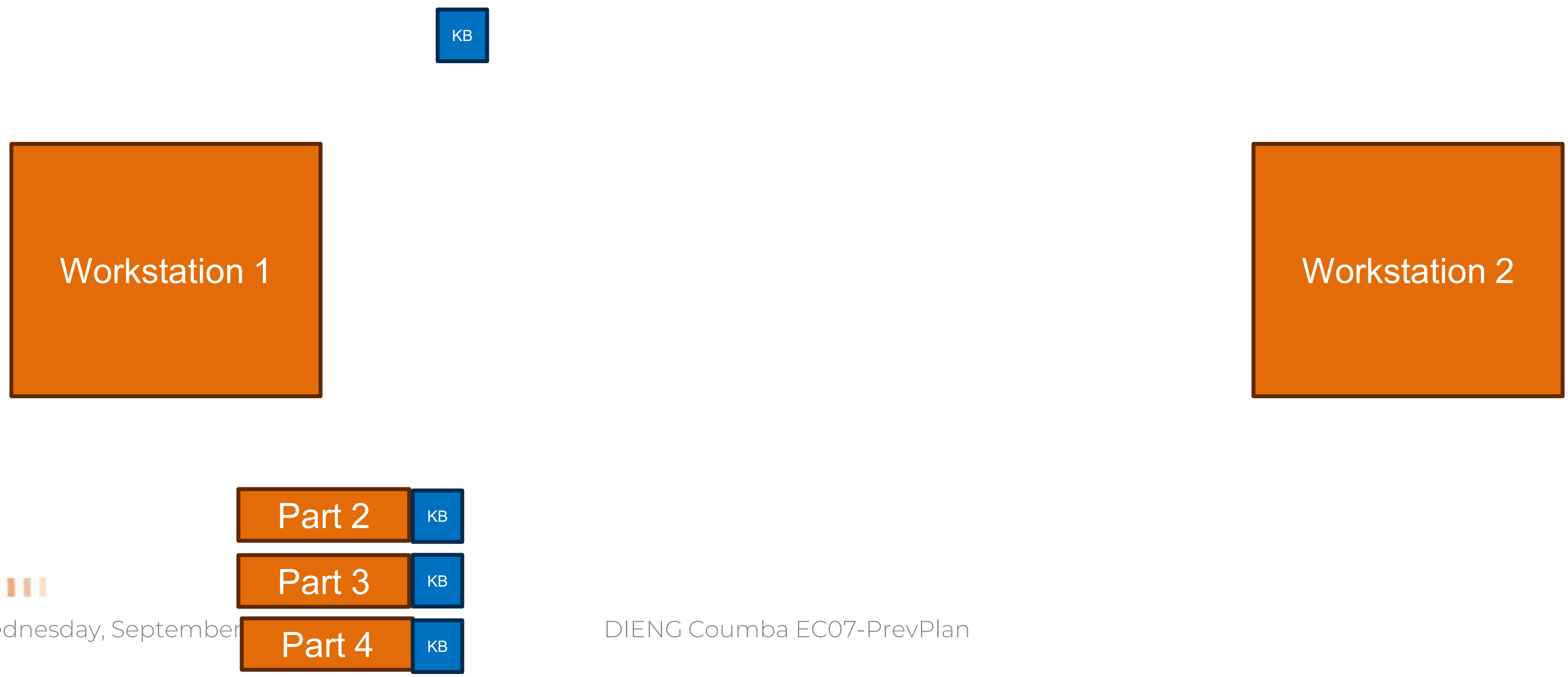
Kanban Method

Workstation n° 2 consumes part produced by station n° 1.



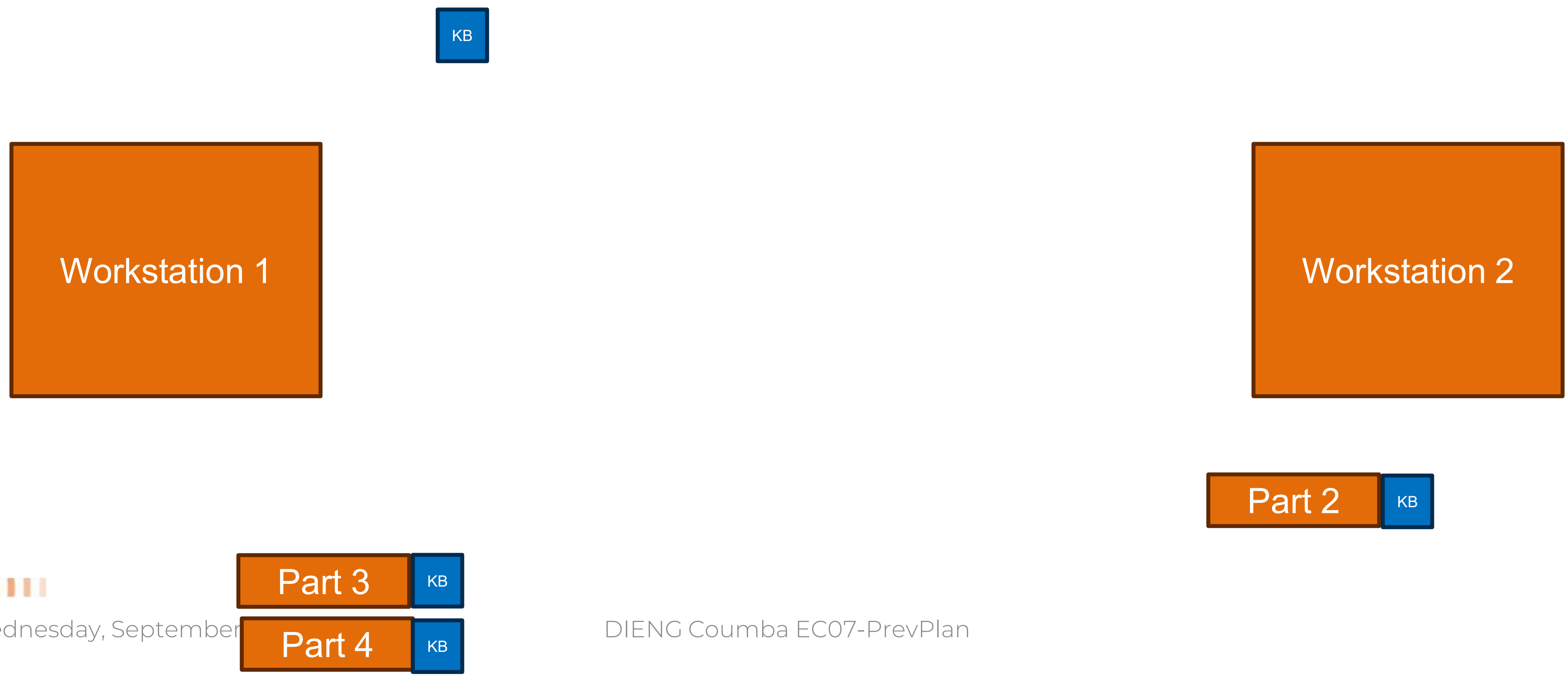
Kanban Method

- Each time workstation n°2 uses a parts, it detaches from it a label called "Kanban" which it returns to station n° 1.

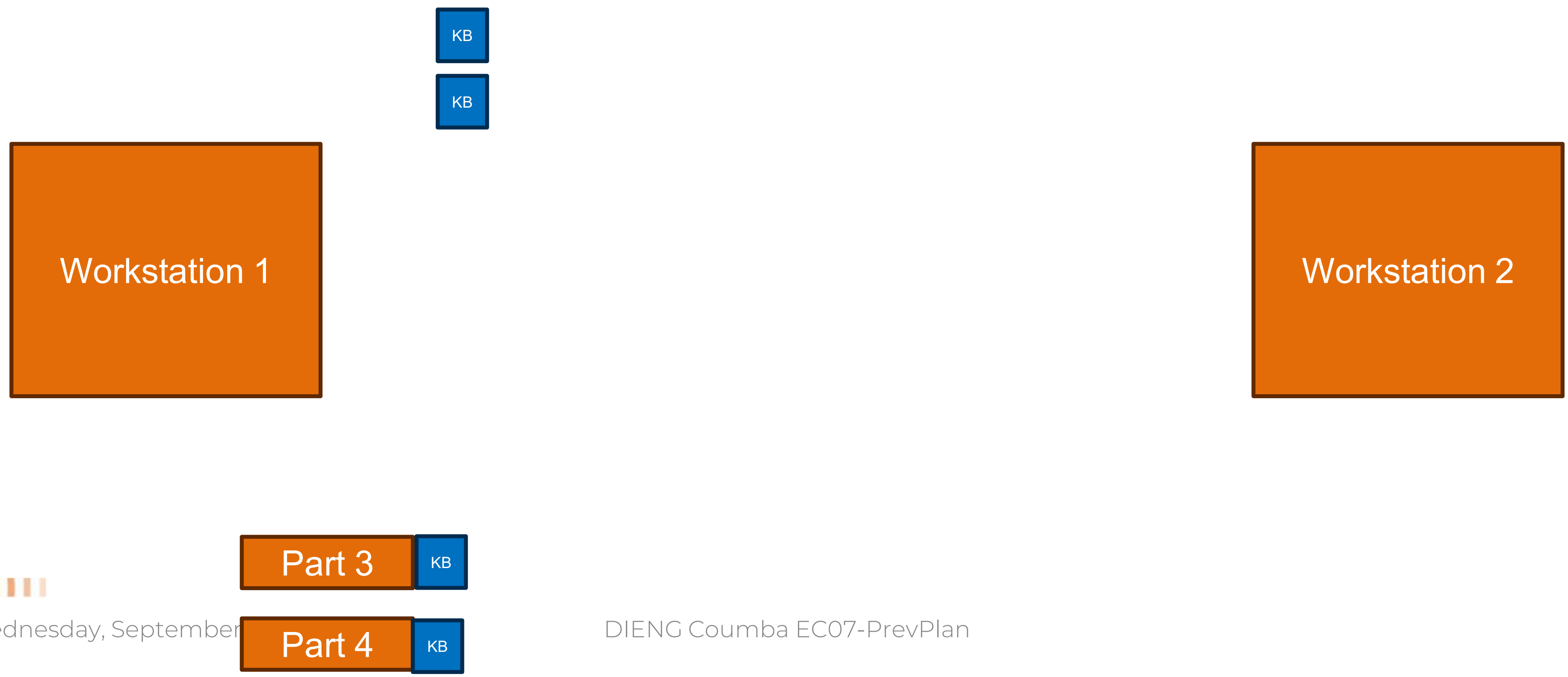


Kanban Method

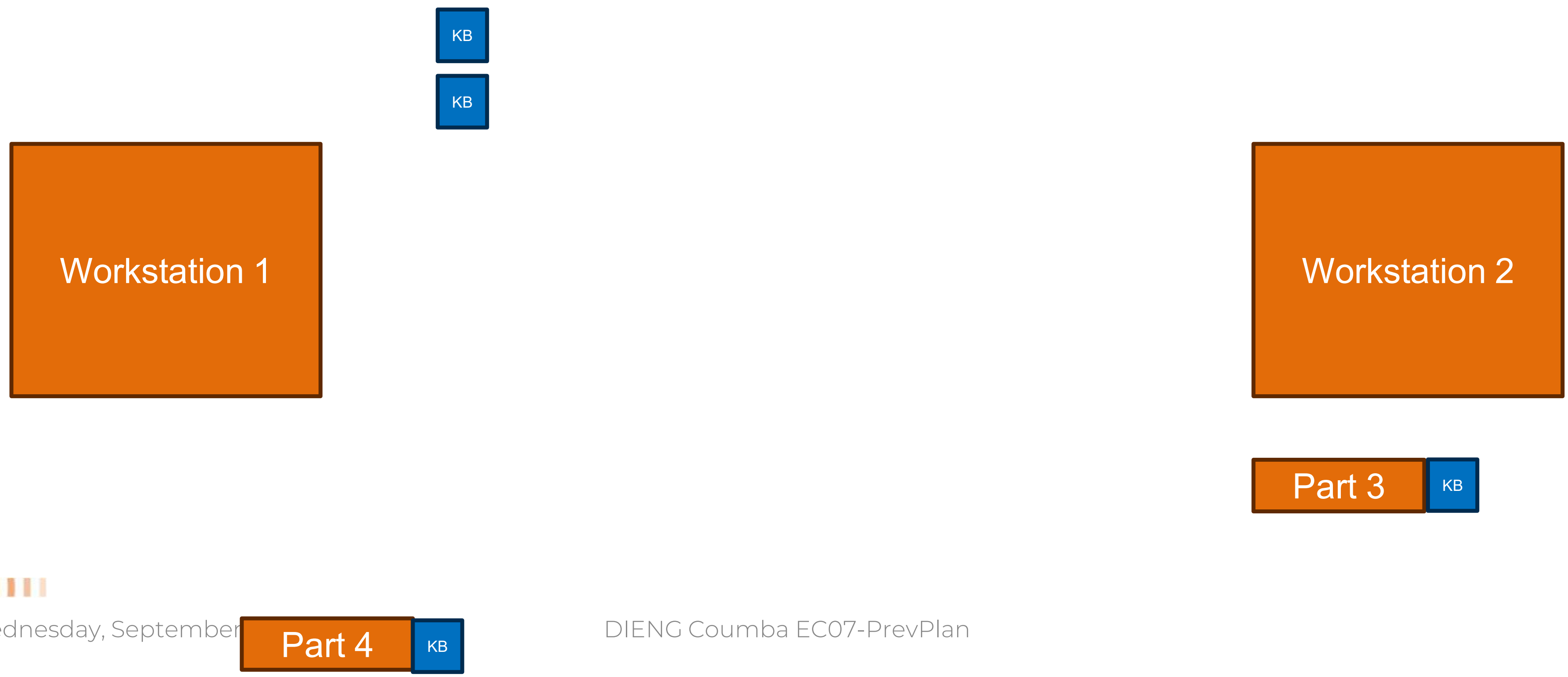
- This label constitutes for station n° 1 a production order for a part.



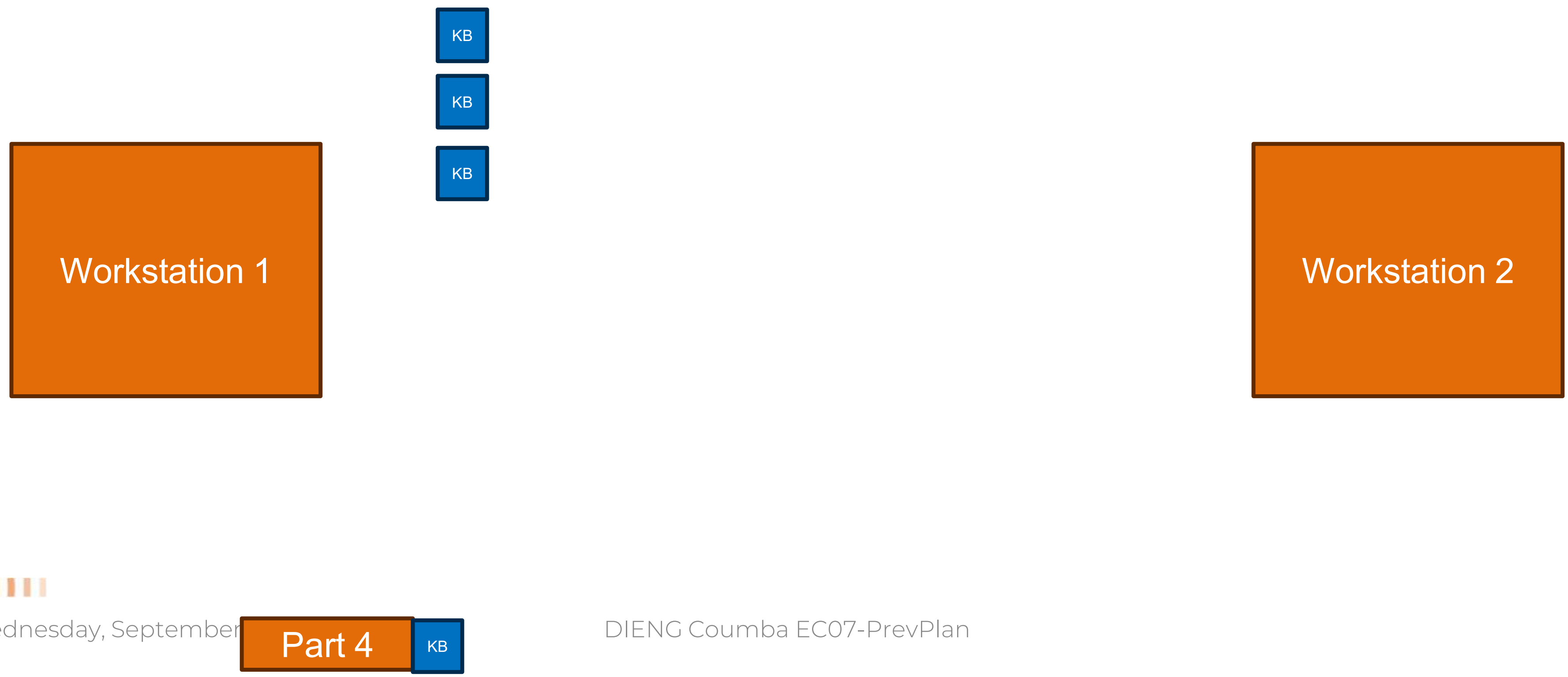
Kanban Method



Kanban Method



Kanban Method

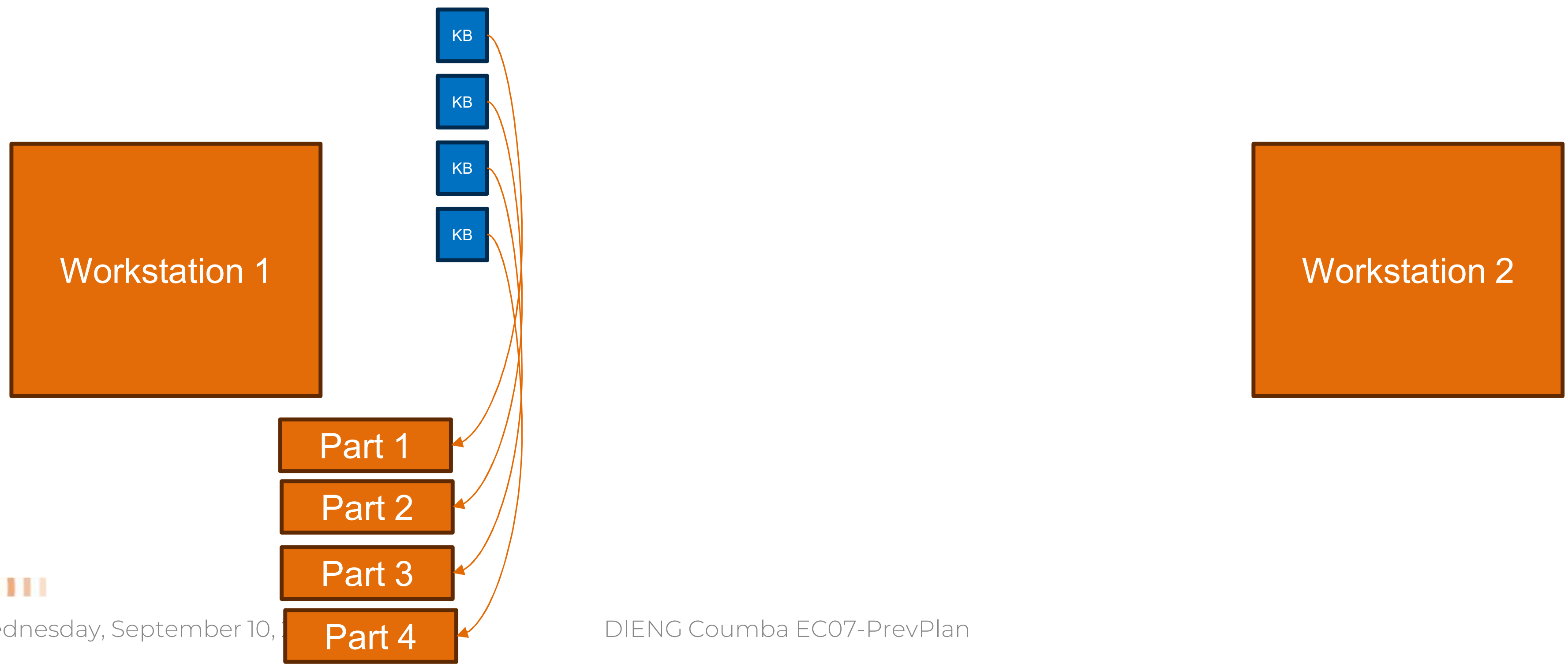


Kanban Method

Kanban Method

Kanban Method

- When station n° 1 has finished manufacturing parts, it attaches the Kanban to it. The parts are then routed to station n° 2.



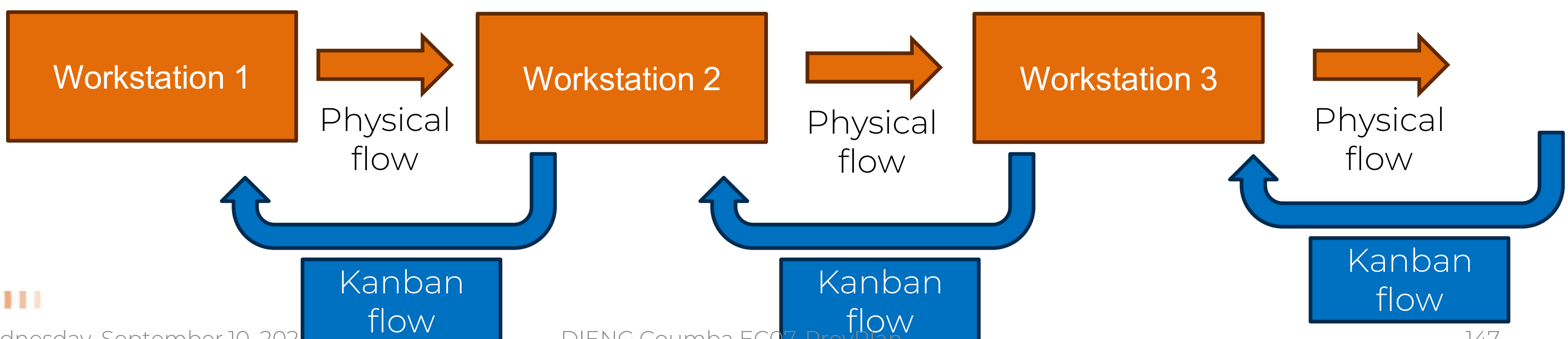
Kanban Method

Most of the time, Kanban cards are attached to containers holding parts.

Between two workstations, a fixed number of Kanbans (and therefore containers) circulate in a closed loop.

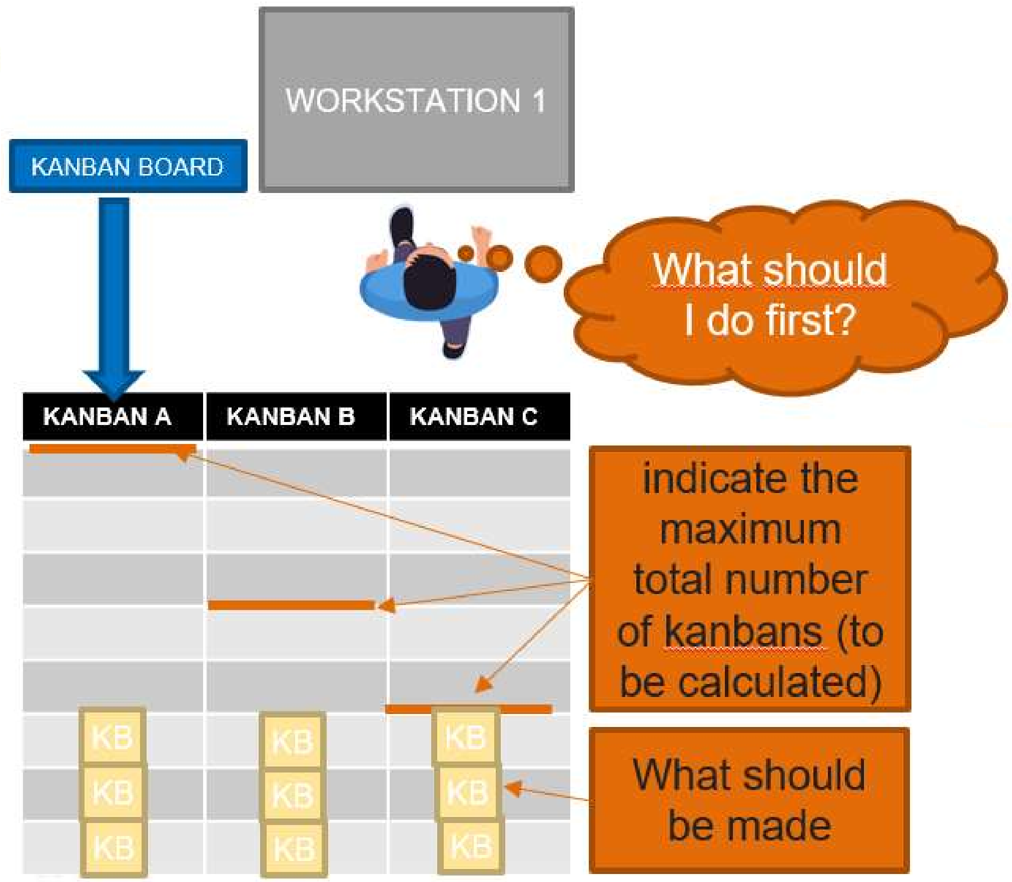
The Kanbans are:·

- Either attached to containers waiting to be used in front of workstation No. 2;
- Or placed on a Kanban board at workstation No. 1, waiting for parts to be produced.



Kanban Method

- If there is no Kanban on the schedule for workstation No. 1, it means that all the Kanbans are attached to containers waiting to be used in front of workstation No. 2.
- Workstation No. 2 is therefore fully supplied, and workstation No. 1 must stop producing.
- The management rule for each workstation is simple: if there are Kanban cards on my production schedule, I produce; if there are none, I do not produce!



Kanban Method

A Kanban is a card or label attached to a container. It carries specific information, which can vary greatly from one company to another. However, all Kanbans include some essential minimum information, such as:

- The **reference of the part** manufactured;
- The **capacity** of the container , therefore the **quantity to be produced**;
- The address or reference of the upstream **supplier station**;
- The address or reference of the **downstream customer station**.

About the Number of Kanbans

Companies generally proceed empirically, step by step, by starting with a large number of Kanbans and then gradually reducing the number until the flow breaks.

There is no magic formula for determining the number of Kanbans!

However, the number of Kanbans must be **sufficient to cover the uncertainties** that exist in the system when the method is implemented (adjustments, breakdowns, quality defects, etc.). **Otherwise, the flow will constantly break down**, and only a few parts will be produced.

The number of Kanbans can be estimated using the following formula:

$$N = \frac{DL + G}{C}$$

Where:

D represents the average customer demand per unit of time,

L is the lead time to make products available,

G is the management factor: a coverage factor for uncertainties and changeovers,

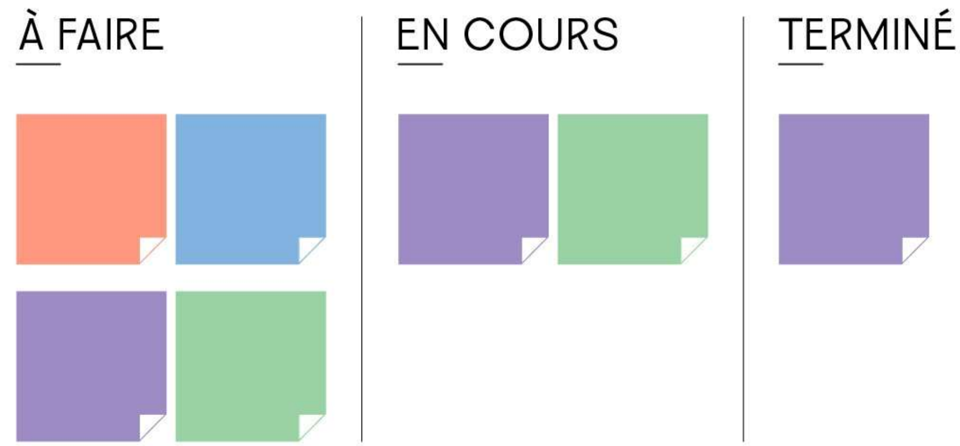
C is the number of pieces contained in one container.

Kanban Method

When applied to project management, a Kanban-based pull system brings key benefits while also presenting certain constraints:

Advantages:
- ✓ Stimulates collective intelligence
- ✓ Enables a pull system approach
- ✓ Makes each project step visible and tangible

Limits:
- No iteration ;
- No priorization.



Forecasting and planning in other engineering branches

Introduction and application case

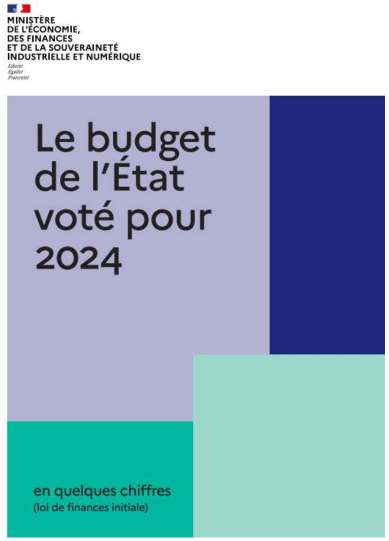
A similar process

1. Define specific indicators ;
2. Define a common way to measure it ;
3. List the parameters impacting it ;
4. Defines threats, limits and drawbacks ;
5. Define planification

Economics

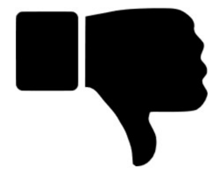
- L'Institut national de la statistique et des études économiques collects, produces, analyzes, and disseminates information on the French economy and society.

https://www.dailymotion.com/video/x175b2r_le-pib-et-la-croissance-en-questions_news



https://www.budget.gouv.fr/reperes/loi_de_finances/articles/le-budget-de-letat-vote-pour-2024

Economics



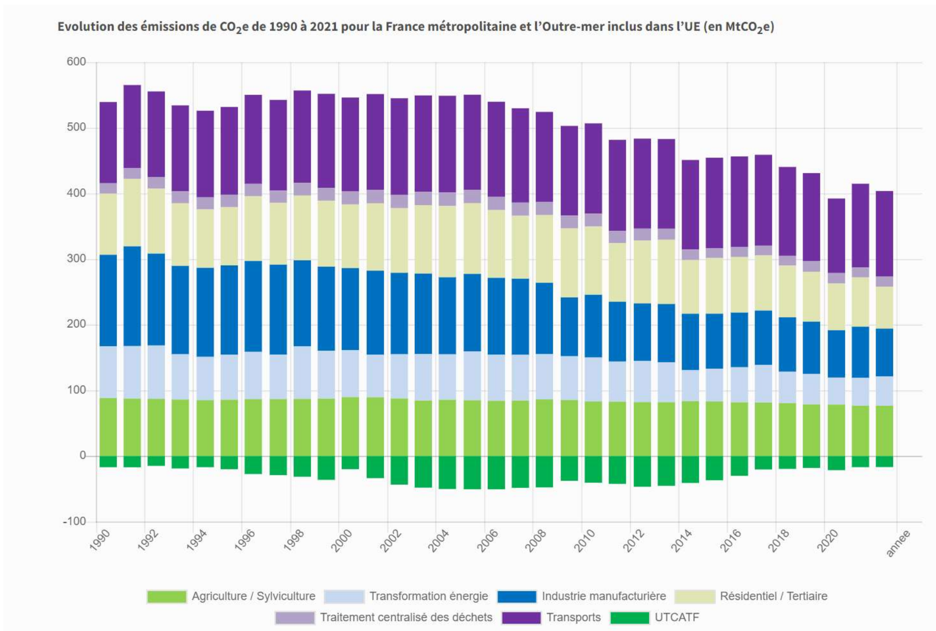
https://www.youtube.com/watch?v=8f8EGOB9X-s

National CO_2 emission

CITEPA

icam

- Citepa (Centre interprofessionnel technique d'études de la pollution atmosphérique) contributes to the fight against air pollution and climate change by calculating, interpreting, and communicating reliable emissions data to policymakers and specialists in France and abroad.



Conjunctural, non reproductible:
- Weather
- Nuclear maintenance
- Population wealth
- International context
- ...

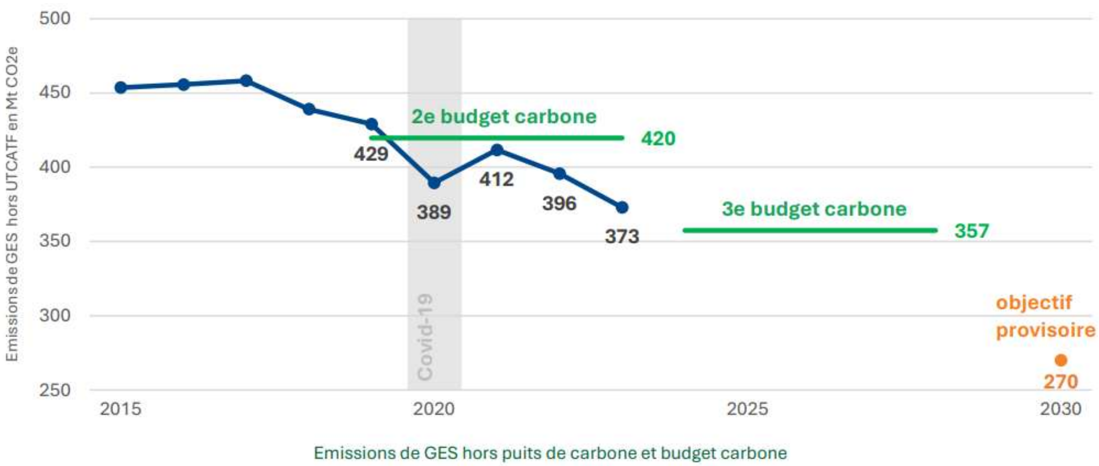
Strutural :
- Weather
- Nuclear maintenance
- Population wealth
- International context
- ...

Footprint ?
National emission ?

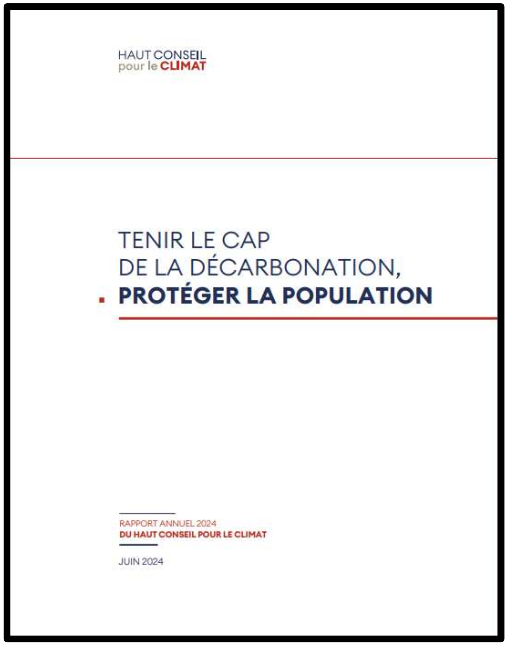
National CO_2 emission

- SNBC 1 (2025-2028), SNBC 2 (2019-2023) et NSBC 3 (2024-2028) et SNBC 4 (2029-2033).

https://www.ecologie.gouv.fr/politiques-publiques/strategie-nationale-bas-carbone-snbc

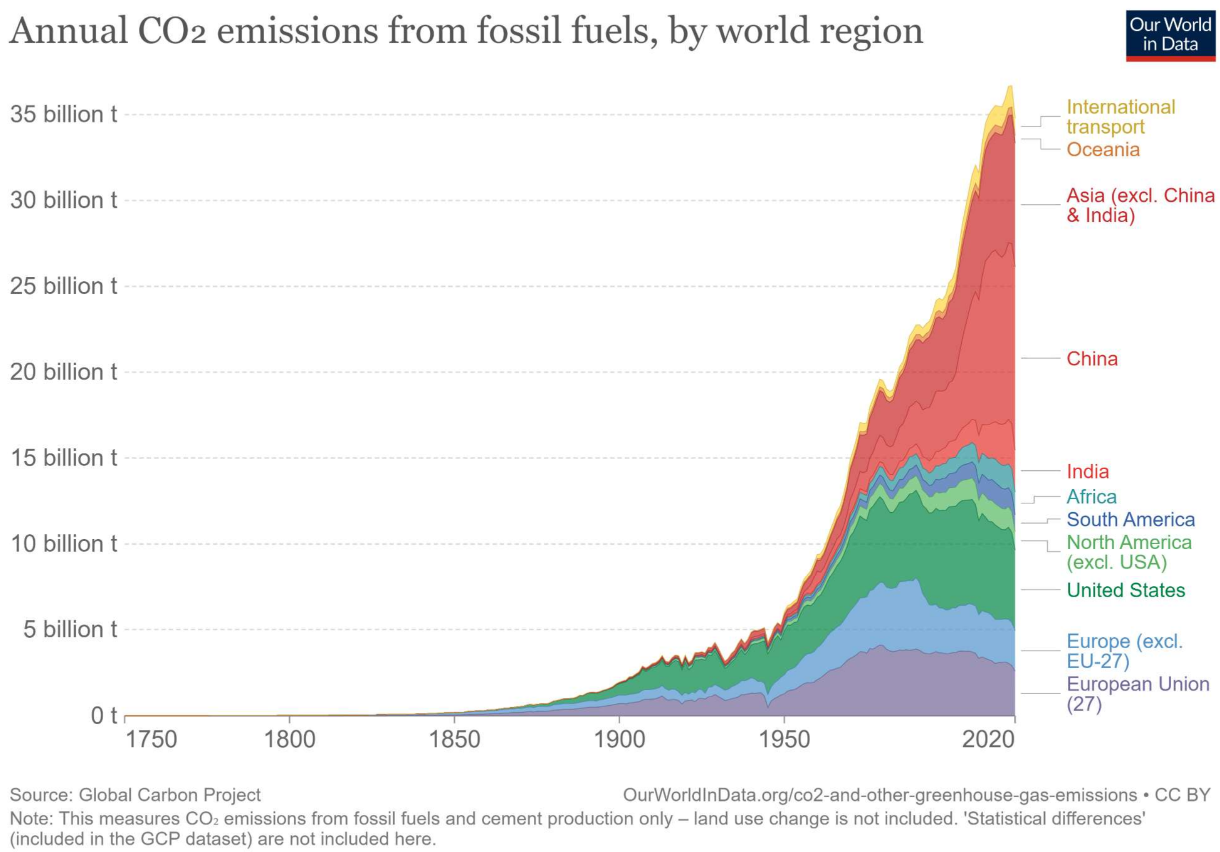


Citepa-Rapport SECTEN 2024



https://www.hautconseilclimat.fr/publications/rapport-annuel-2024-tenir-le-cap-de-la-decarbonation-proteger-la-population/

National CO_2 emission



Other forecasting organism