Sustainable Products & Supply Chains (ME-203)

Introduction to Products & Supply Chain Management

Amin Kaboli

Week 3 – March 06th, 2025

The Learning Outcomes

By the end of this class , the student must be able to understand:


How products are made and moved across supply chains


How different supply chain players coordinate and respond to changes


How companies adapt to changes and navigate disruptions


How to rethink supply chains for efficiency, resilience, and sustainability


How supply chains transition from linear to circular models and practical strategies for implementation

Sustainable Products & Supply Chains (ME-203)

From Materials to Markets

Amin Kaboli

Week 3 – Session 1 – March 06th, 2025

How are products made & moved?

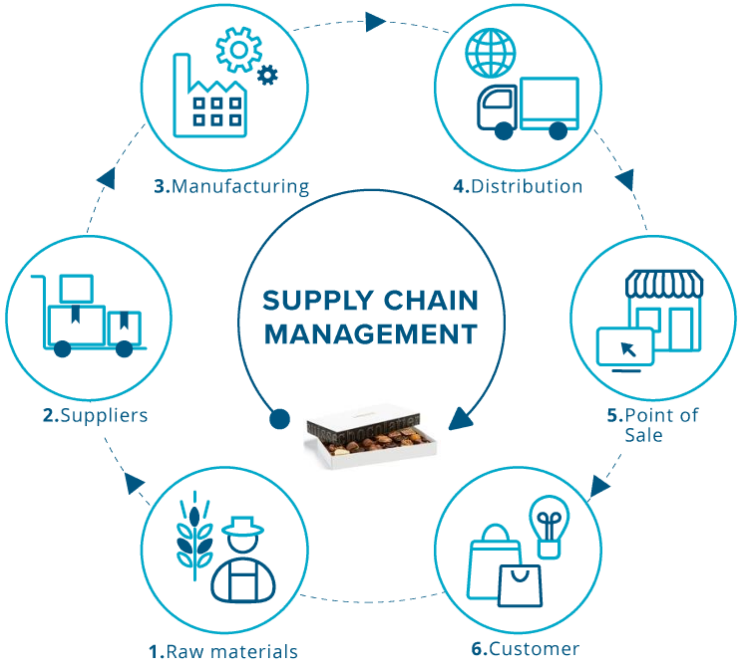
What These Items Have in Common?

From Raw Materials, to Market-Ready Products

Coca beans

Sugar

Milk



Raw Materials

Product

Supply Chain

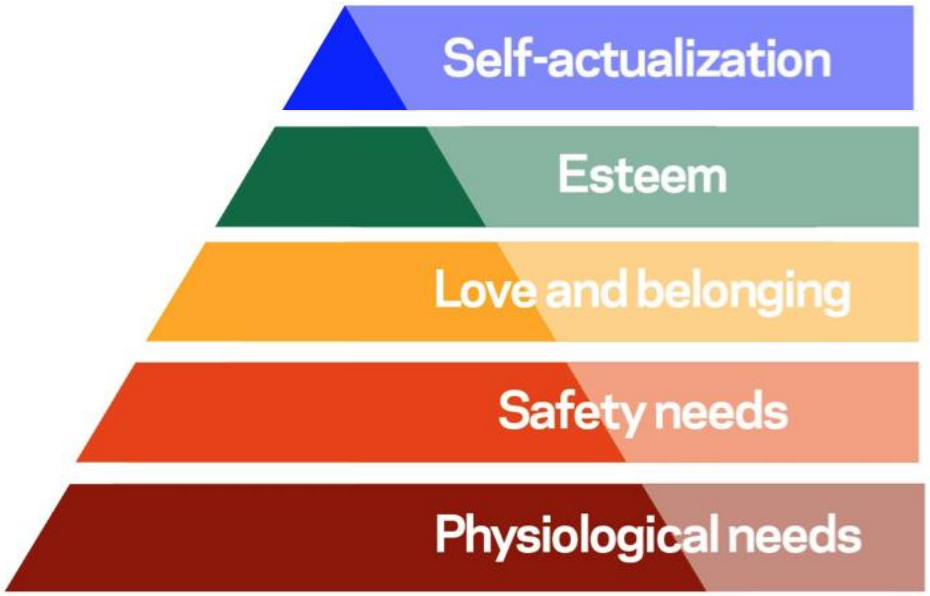
Why Do We Choose & Value These Products?

Heritage, Timekeeping, status symbol, durability, …

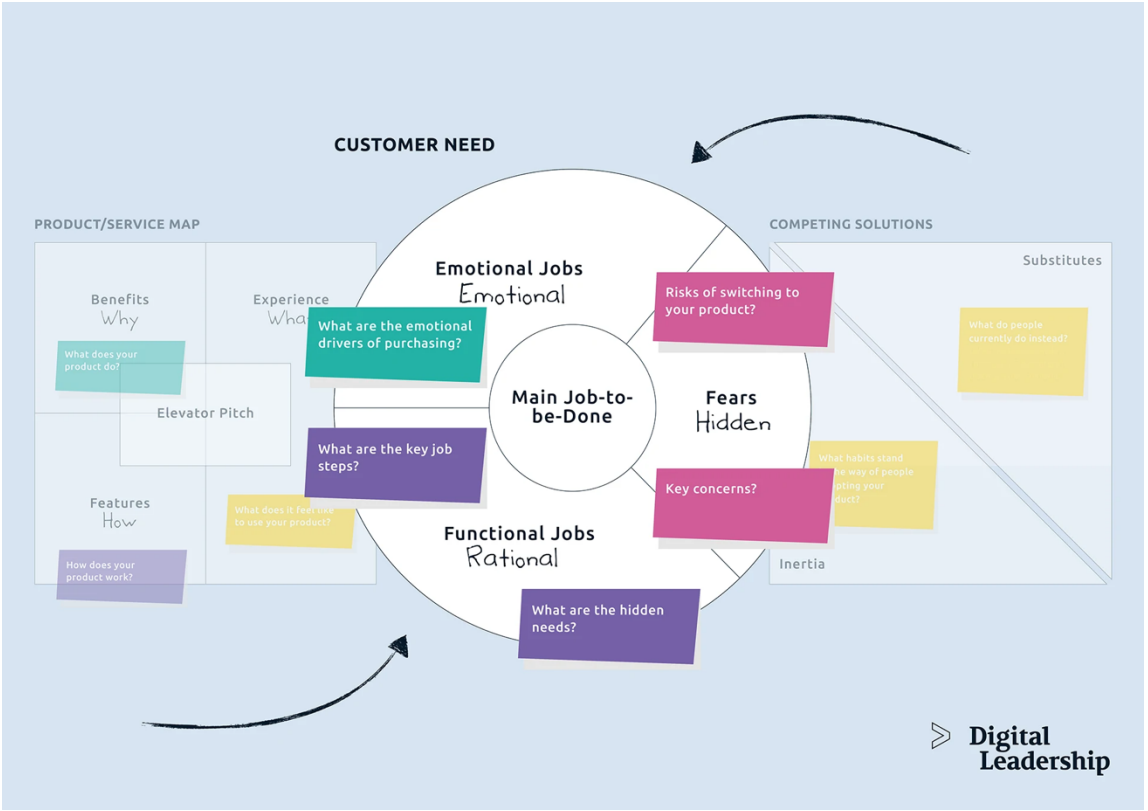
Versatility, utility, all-in-one-toolset, convenience, …

Pleasure, gifting, energy boost, relaxation, …

Human Needs & Value

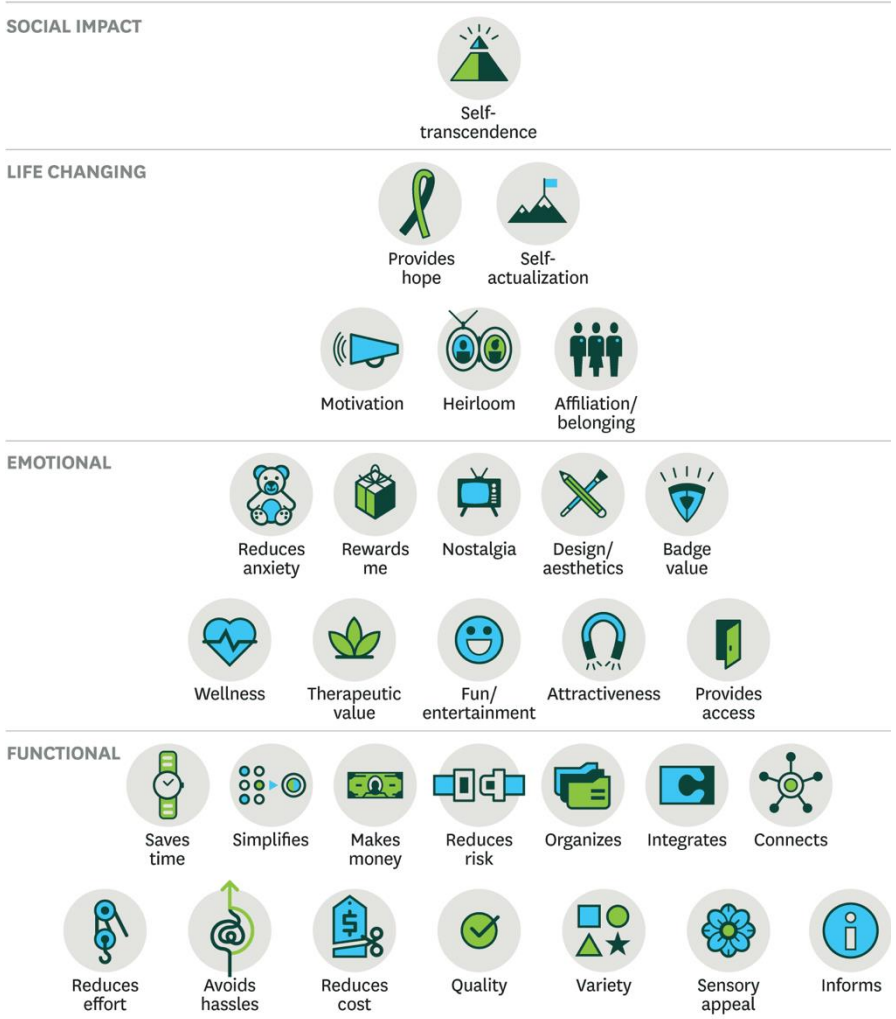


Source: A. Maslow, A Theory of Human Motivation, 1943.

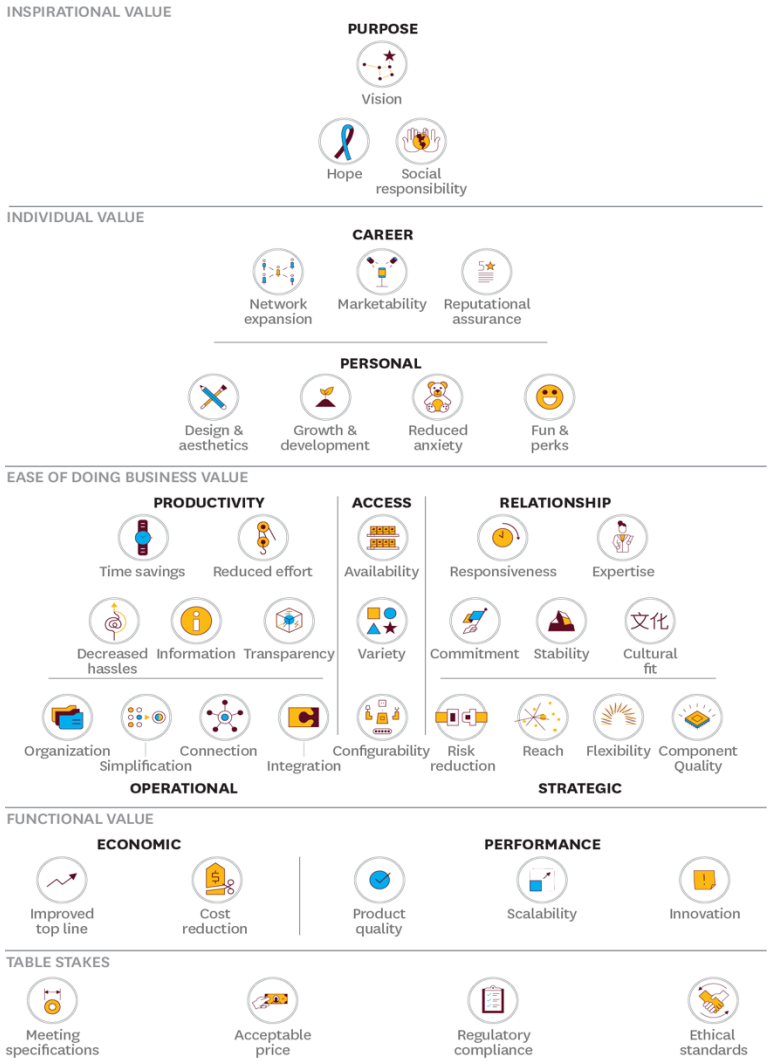


A **value** is a conscious choice to act in a certain manner to meet your own **needs**.

The Elements of Value

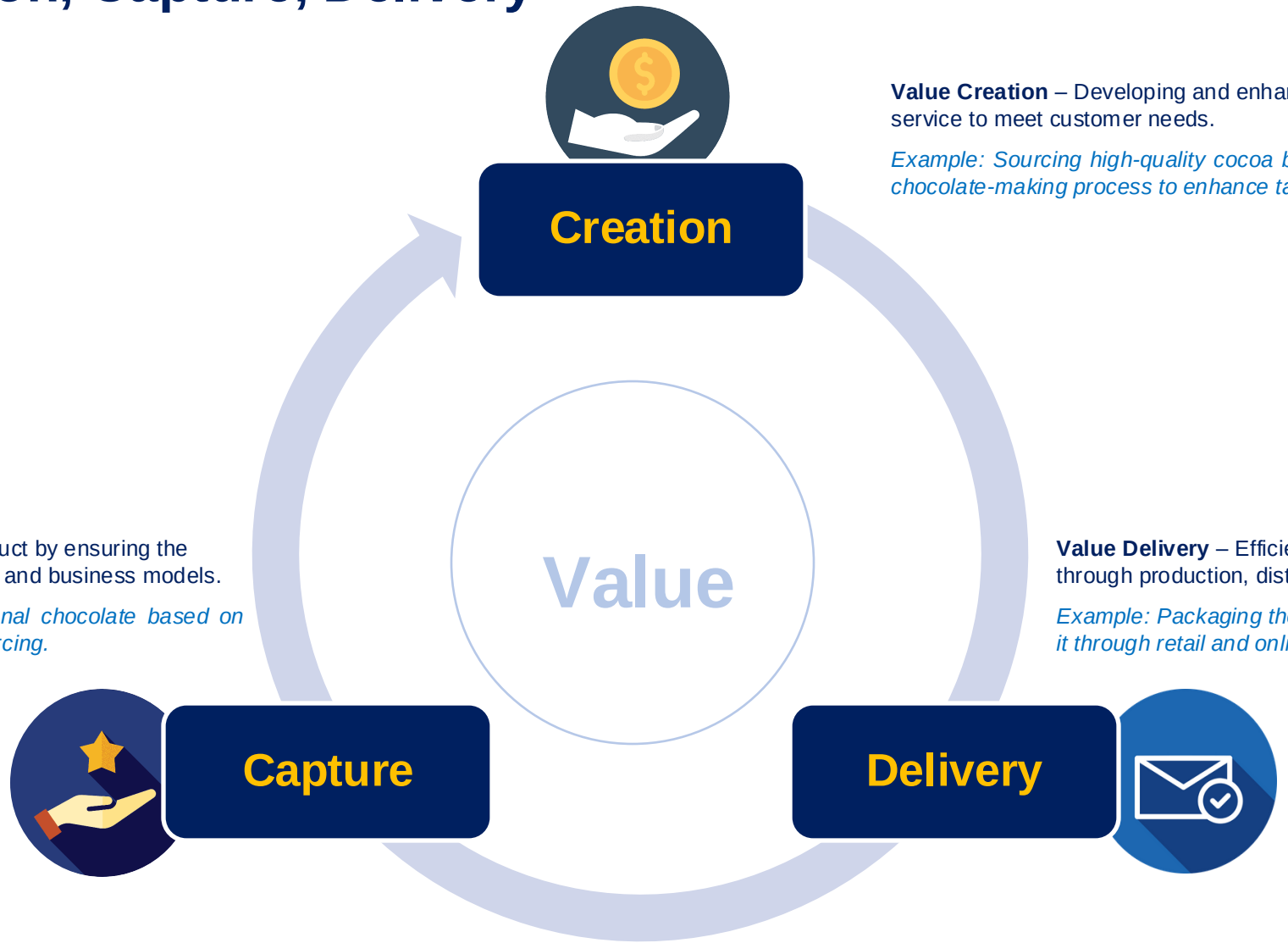


Source: 2015 Bain & Company - The Elements of Value, Harvard Business Review, 2015



Source: 2018 Bain & Company - The B2B Elements of Value, Harvard Business Review, 2018

Value Creation, Capture, Delivery



Value Creation – Developing and enhancing a product or service to meet customer needs.

Example: Sourcing high-quality cocoa beans and refining the chocolate-making process to enhance taste and texture.

Value Capture – Monetizing the product by ensuring the business earns profits through pricing and business models.

Example: Premium pricing for artisanal chocolate based on brand reputation and sustainable sourcing.

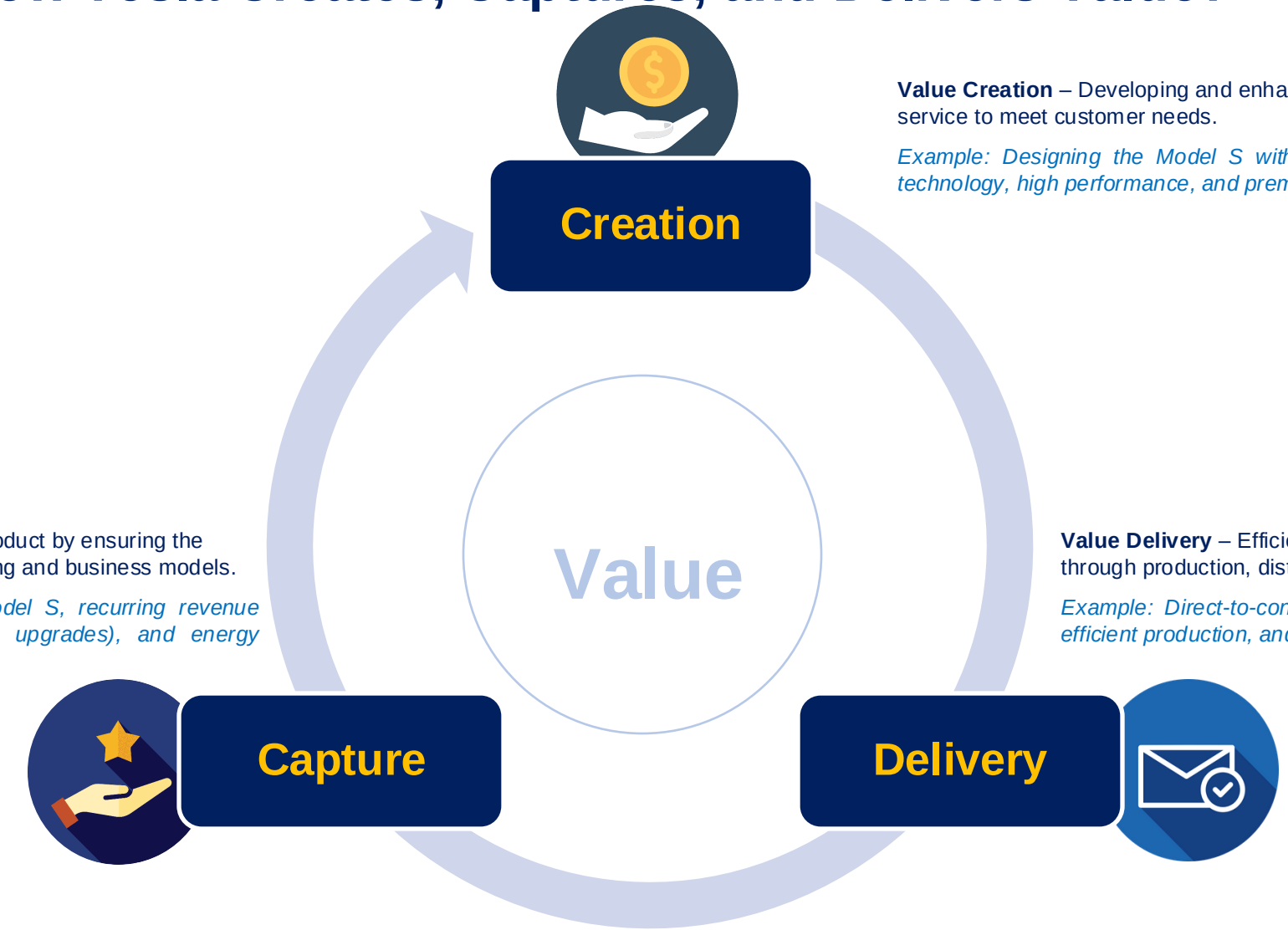
Value Delivery – Efficiently getting the product to customers through production, distribution, and marketing.

Example: Packaging the chocolate attractively and distributing it through retail and online channels.

How you ever toured a production line?

Exercise: How Tesla Creates, Captures, and Delivers Value?

3 Min



Value Creation – Developing and enhancing a product or service to meet customer needs.

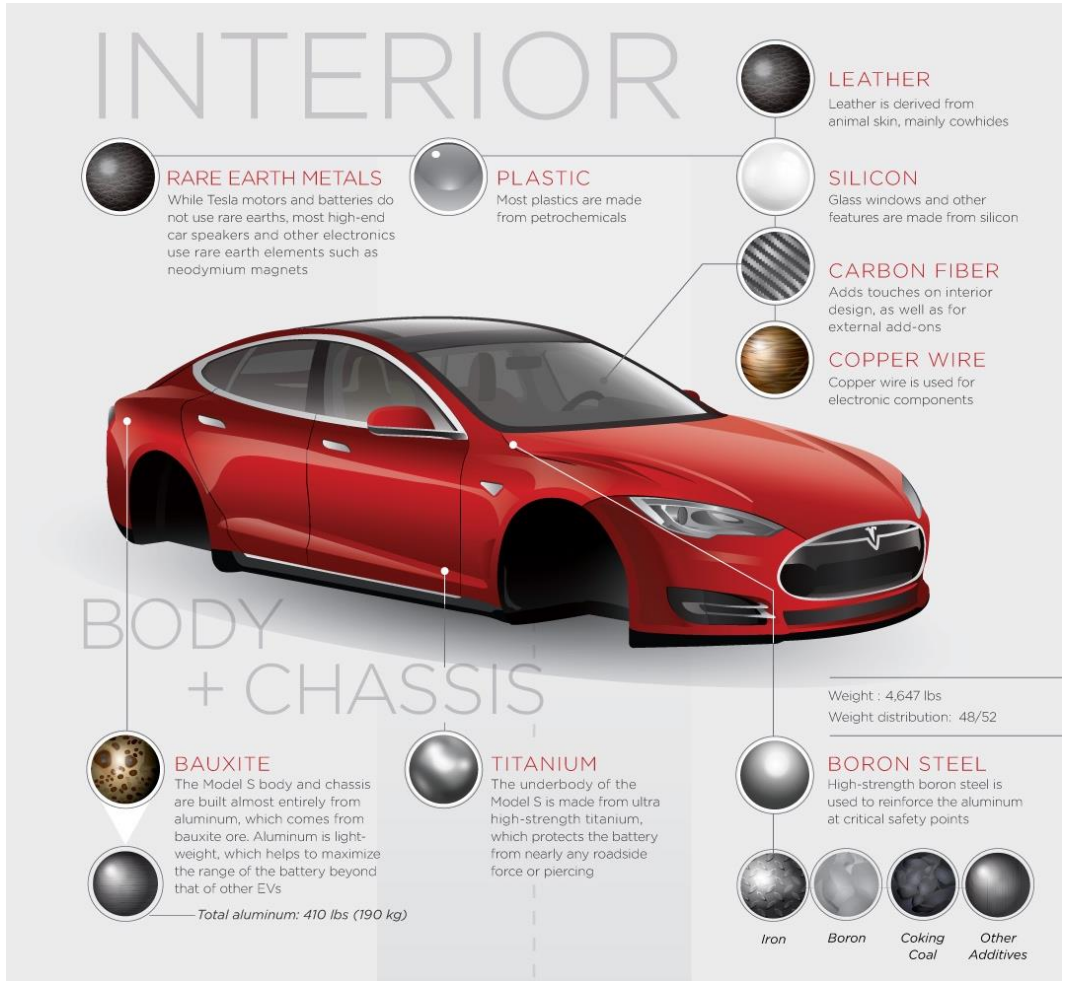
Example: Designing the Model S with cutting-edge battery technology, high performance, and premium features.

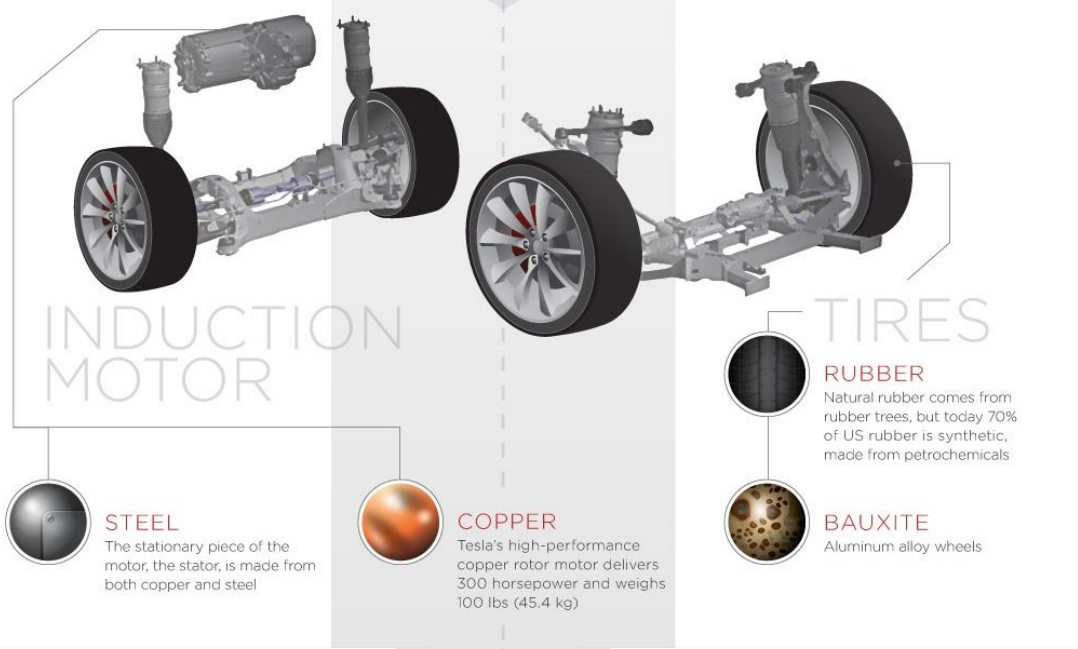
Value Capture – Monetizing the product by ensuring the business earns profits through pricing and business models.

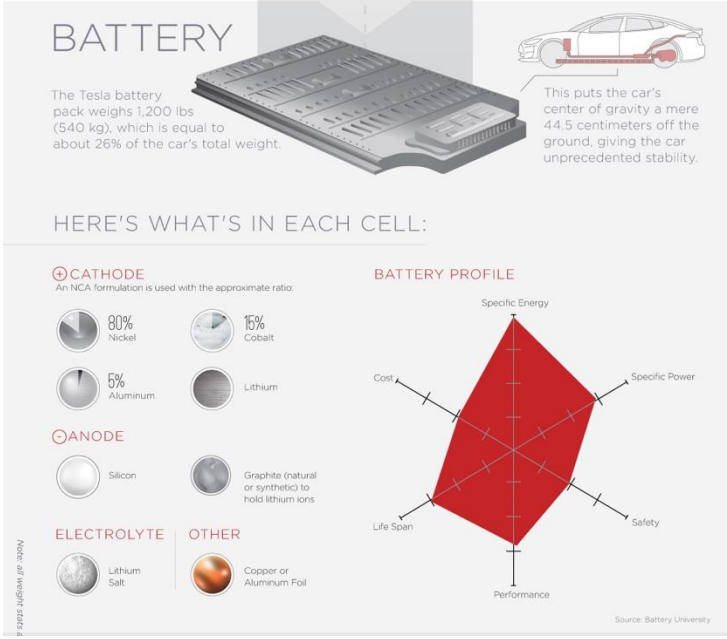
Example: Premium pricing for Model S, recurring revenue from software features (Autopilot upgrades), and energy solutions.

Value Delivery – Efficiently getting the product to customers through production, distribution, and marketing.

Example: Direct-to-consumer sales model, Gigafactories for efficient production, and over-the-air software updates.

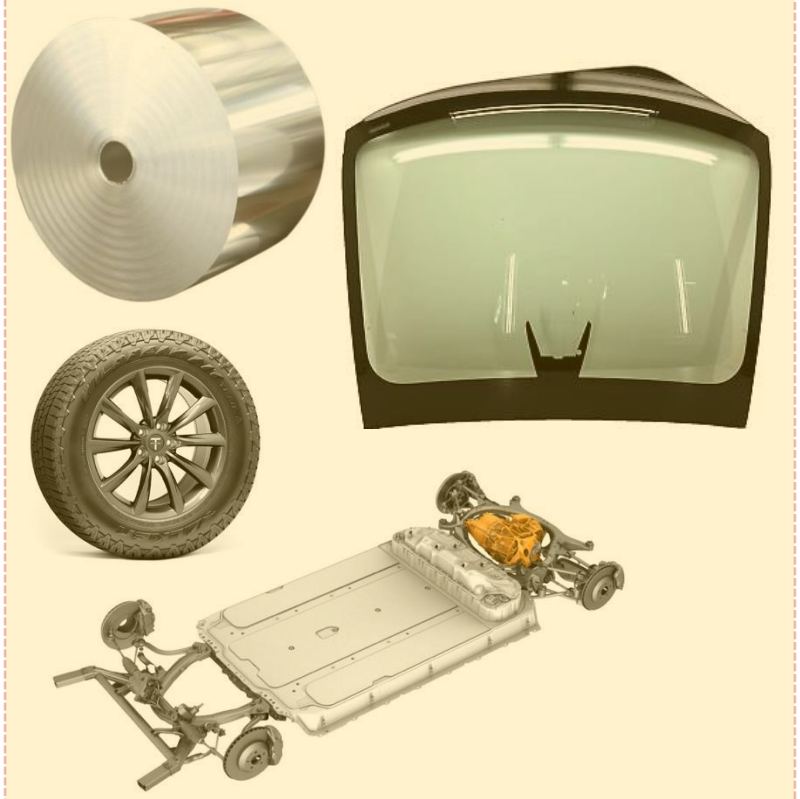


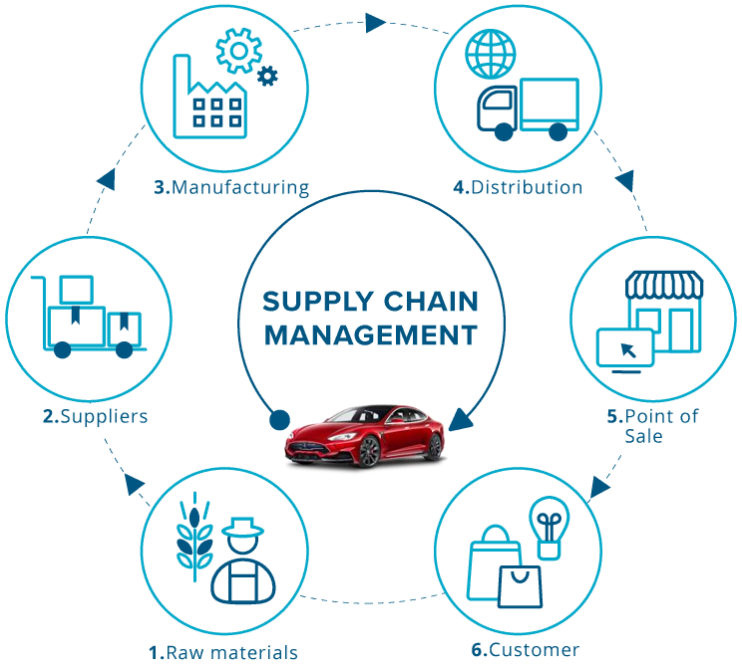




Source: https://www.visualcapitalist.com/extraordinary-raw-materials-in-a-tesla-model-s/

From Materials to Market – Tesla





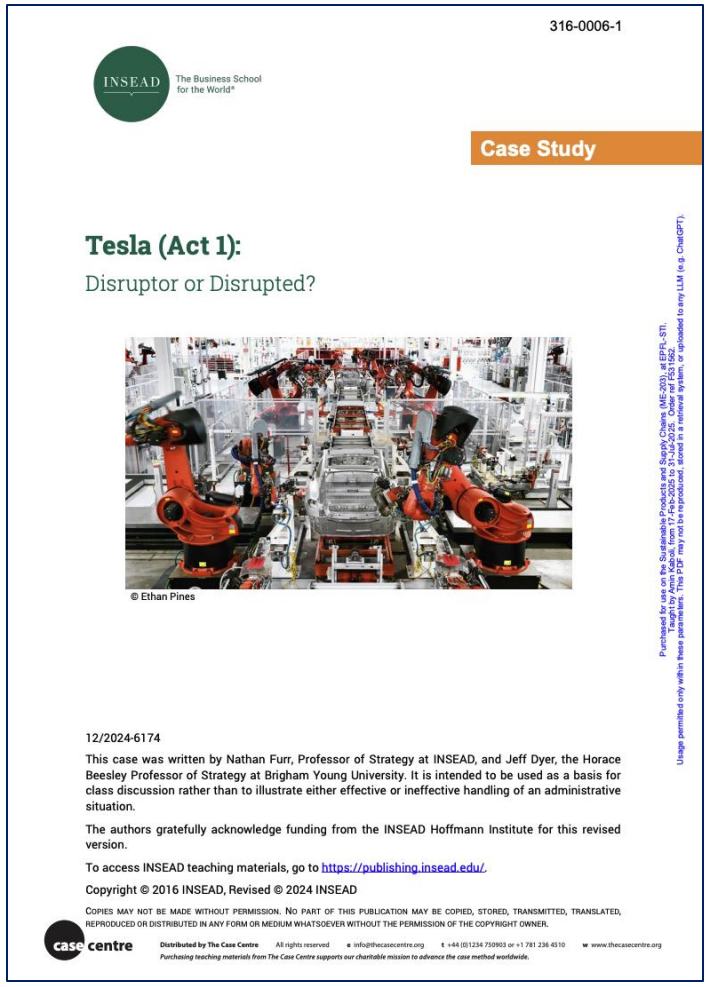
Materials

Product

Supply Chain

Case Study Tesla – Next Week

Reminder: Read the case fully during the week and before the class



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INSEAD The Business School for the World®

Case Study

Tesla (Act 1):

Disruptor or Disrupted?

© Ethan Pines

12/2024-6174

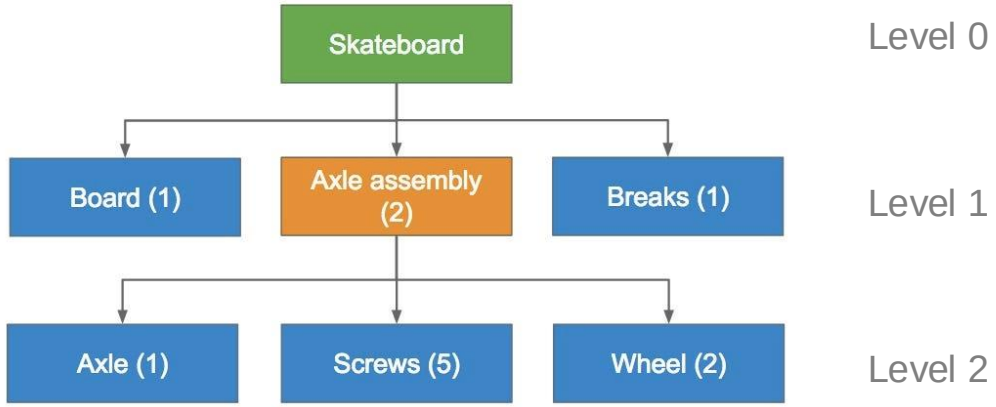
This case was written by Nathan Furr, Professor of Strategy at INSEAD, and Jeff Dyer, the Horace Beesley Professor of Strategy at Brigham Young University. It is intended to be used as a basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

The authors gratefully acknowledge funding from the INSEAD Hoffmann Institute for this revised version.

To access INSEAD teaching materials, go to https://publishing.insead.edu/.

How does a company like Tesla systematically organize and manage all the materials and components needed to manufacture a product?

Bill of Materials (BoM) – Definition



An extensive list of raw materials, components, and instructions required to construct, manufacture, or repair a product or service. It lists the **finished product at the top, followed by individual components and materials**. Engineering BOMs are used in the design process while manufacturing BOMs are used in the assembly process.

Source: https://www.investopedia.com/terms/b/bill-of-materials.asp

Bill of Materials (BoM) – Handout

Week number								
Item: X	1	2	3	4	5	6	7	8
Quantity				100				150

FIGURE 12.3
A master schedule for end item X

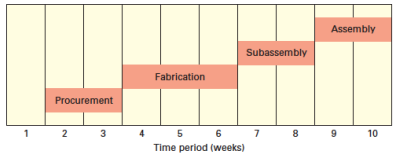


FIGURE 12.4
The planning horizon must cover the cumulative lead time

The quantities in a master schedule come from a number of different sources, including customer orders, forecasts, and orders from warehouses to build up seasonal inventories.

The master schedule separates the planning horizon into a series of time periods or time *buckets*, which are often expressed in weeks. However, the time buckets need not be of equal length. In fact, the near-term portion of a master schedule may be in weeks, but later portions may be in months or quarters. Usually, plans for those more distant time periods are more tentative than near-term requirements.

Although a master production schedule has no set time period that it must cover, most managers like to plan far enough into the future so they have some general idea of probable upcoming demands for the near term. It is important, though, that the master schedule cover the *stacked* or **cumulative lead time** necessary to produce the end items. This amounts to the sum of the lead times that sequential phases of the production or assembly process require, as illustrated in Figure 12.4, where a total of nine weeks of lead time is needed from ordering parts and raw materials until final assembly is completed. Note that lead times include move and wait times in addition to setup and run times.

Cumulative lead time
The sum of the lead times that sequential phases of a process require, from ordering of parts or raw materials to completion of final assembly.

The Bill of Materials

A **bill of materials (BOM)** contains a listing of all of the assemblies, subassemblies, parts, and raw materials that are needed to produce *one* unit of a finished product. Thus, each finished product has its own bill of materials.

The listing in the bill of materials is hierarchical; it shows the quantity of each item needed to complete one unit of its parent item. The nature of this aspect of a bill of materials is clear when you consider a **product structure tree**, which provides a visual depiction of the subassemblies and components needed to assemble a product. Figure 12.5 shows an *assembly diagram* for a chair and a simple product structure tree for the chair. The end item (in this case, the chair, the finished product) is shown at the top of the tree. Just beneath it are the subassemblies, or major components, that must be put together to make up the end item. Beneath each major component are the necessary lesser components. At each stage moving down the tree are the components (parts, materials) needed to make one unit of the next higher item in the tree.

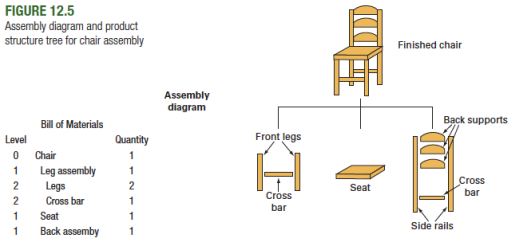
Bill of materials (BOM)
One of the three primary inputs of MRP; a listing of all of the raw materials, parts, subassemblies, and assemblies needed to produce one unit of a product.

A product structure tree is useful in illustrating how the bill of materials is used to determine the quantities of each of the ingredients (requirements) needed to obtain a desired number of end items. Items at the lowest levels of a tree often are raw materials or purchased parts, while items at higher levels are typically assemblies or subassemblies. Product-structure trees for items at the lowest levels are the concerns of suppliers.

Let's consider the product structure tree shown in Figure 12.6. End item X is composed of two Bs and one C. Moreover, each B requires three Ds and one E, and each D requires four Es. Similarly, each C is made up of two Es and two Fs. These *requirements* are listed by *level*,

Product structure tree
A visual depiction of the requirements in a bill of materials, where all components are listed by levels.

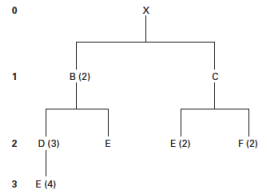
FIGURE 12.5
Assembly diagram and product structure tree for chair assembly



Bill of Materials

Level		Quantity
0	Chair	1
1	Leg assembly	1
2	Legs	2
2	Cross bar	1
1	Seat	1
1	Back assembly	1
2	Side rails	2
2	Cross bar	1
2	Back supports	3

FIGURE 12.6
A product structure tree for end item X



beginning with 0 for the end item, then 1 for the next level, and so on. The items at each are *components* of the next level up and, as in a family tree, are *parents* of their respe components. Note that the quantities of each item in the product structure tree refer only t amounts needed to complete the assembly at the next higher level.

EXAMPLE 1
eXcel
mhhe.com/stevenson12e

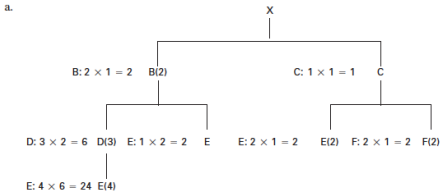
Use the information presented in Figure 12.6 to do the following:

a. Determine the quantities of B, C, D, E, and F needed to assemble one X.
b. Determine the quantities of these components that will be required to assemble 10 X taking into account the quantities on hand (i.e., in inventory) of various components

Component	On Hand
B	4
C	10
D	8
E	60

SOLUTION

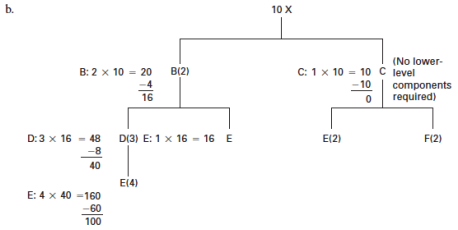
a.



Thus, one X will require

B:	2
C:	1
D:	6
E:	28 (Note that E occurs in three places, with requirements of 24 + 2 + 2 = 28)
F:	2

b.

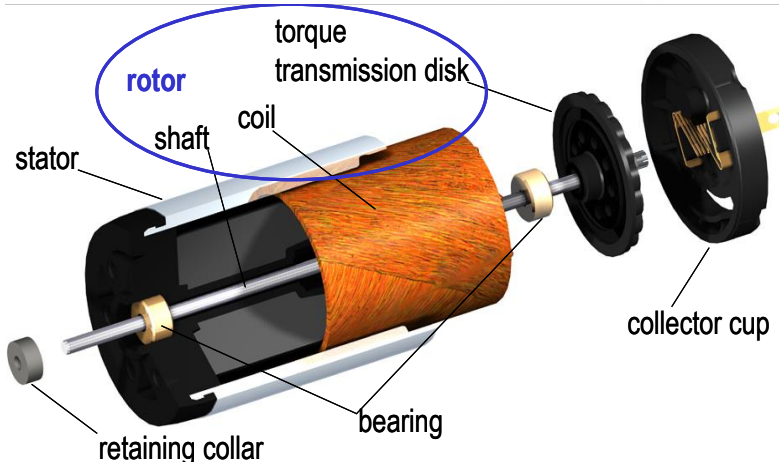


Thus, given the amounts of on-hand inventory, 10 Xs will require

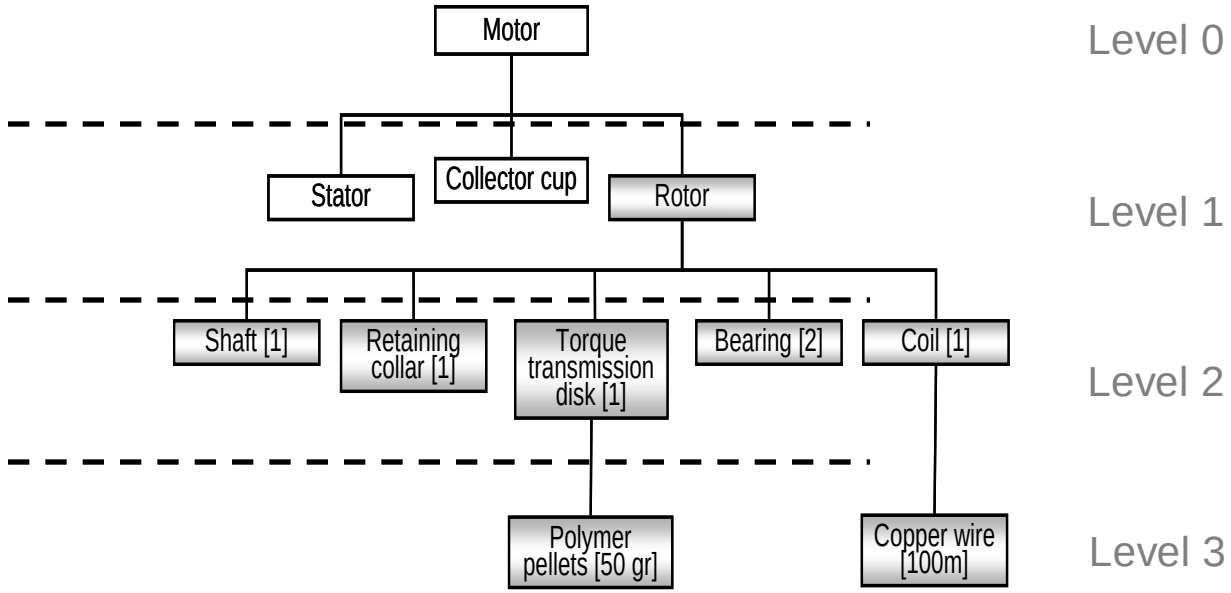
B:	16
C:	0
D:	40
E:	116
F:	0

Determining total requirements is usually more complicated than Example 1 might suggest. For one thing, many products have considerably more components. For another, the issue of *timing* is essential (i.e., when must the components be ordered or made) and must be included in the analysis. Finally, for a variety of reasons, some of the components/subassemblies may be on hand (i.e., currently in inventory). Consequently, in determining total requirements, the amounts on hand must be *netted out* (i.e., subtracted from the apparent requirements) to determine the true requirements as illustrated in Example 1.

Bill of Materials (BoM) – Micro Motor

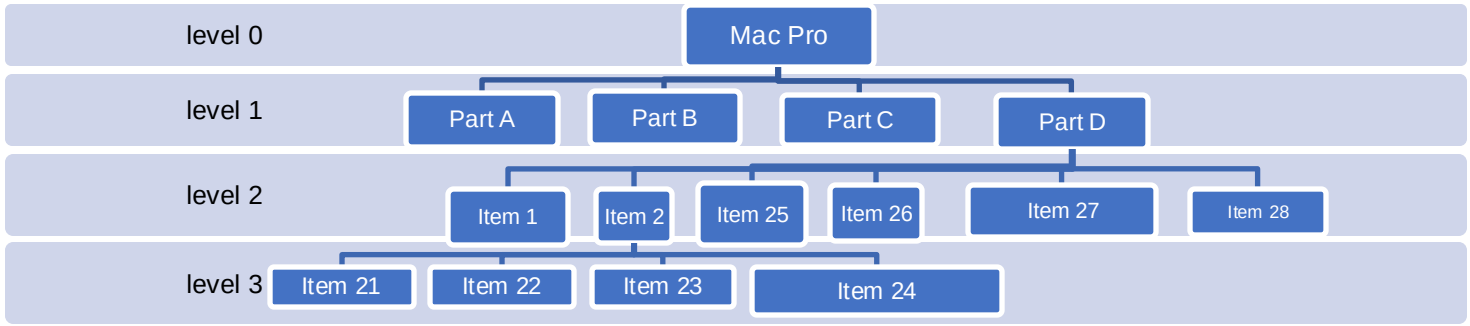


Electrical ironless micro-motor



Exercise: Bill of Materials of Mac Pro

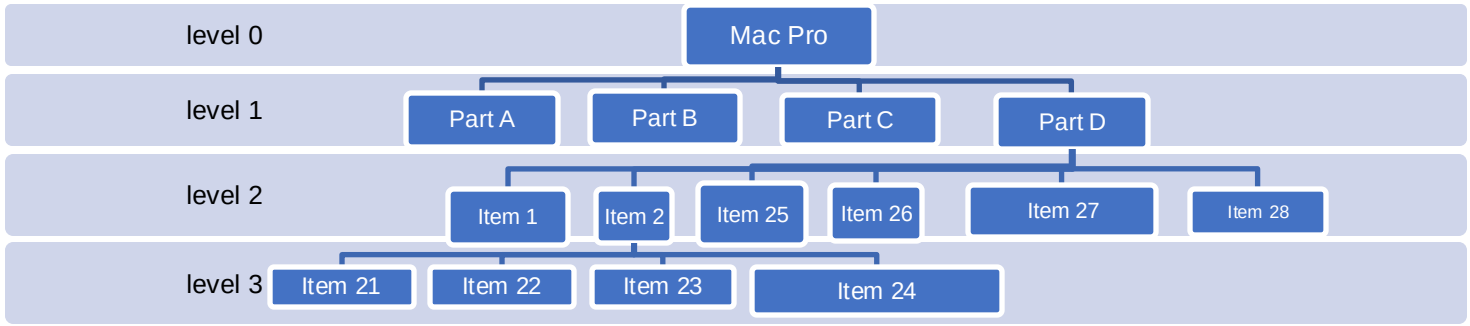
- What is the Bill of materials (BOM) of Mac Pro in your view?
  - Develop your hypothetical BOM, it could be like the blow chart;



Exercise: Bill of Materials of iMac

3 Min

- What is the Bill of materials (BOM) of Mac Pro in your view?
  - Develop your hypothetical BOM, it could be like the blow chart;



Assignment 2 – Evaluation of Current State of Your Products & Supply Chain

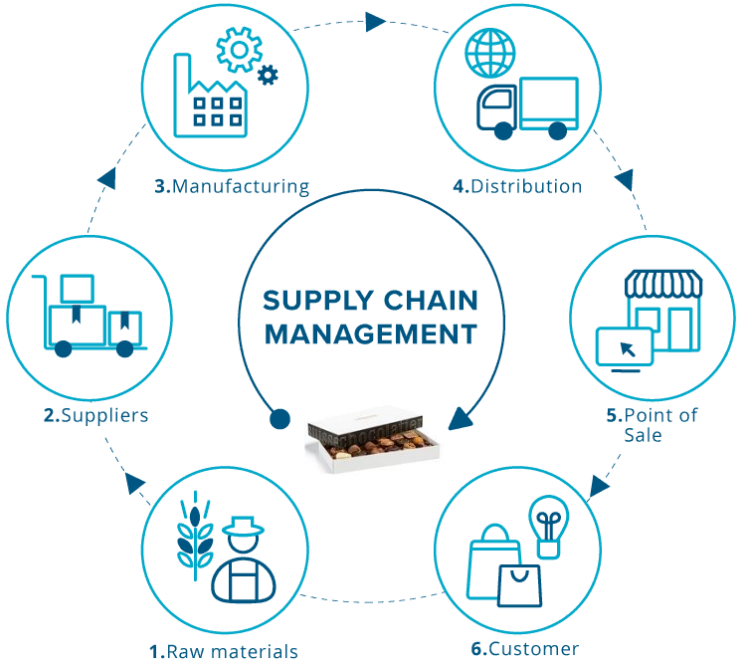
5 Min

No.	Question
1	Describe and visualize the **Bill of Materials (BoM)** of your product group (from level 0 to level 4)
2	Describe and visualize the Value Adding Network (VAN) of your company including material flow and information flow (use schematic provided in slides)
3	How would you define your supply chain—linear, circular, or in transition? Provide evidence to support your evaluation.

Note: If you can't find a real BoM for your product, explore **similar products**. Look for teardown reports, patents, or manufacturer specs to understand BoM structure from **Level 0 to Level 4**. The goal is to grasp how products are built—be resourceful and analytical!

How are products made & moved?

Supply Chain – Definition



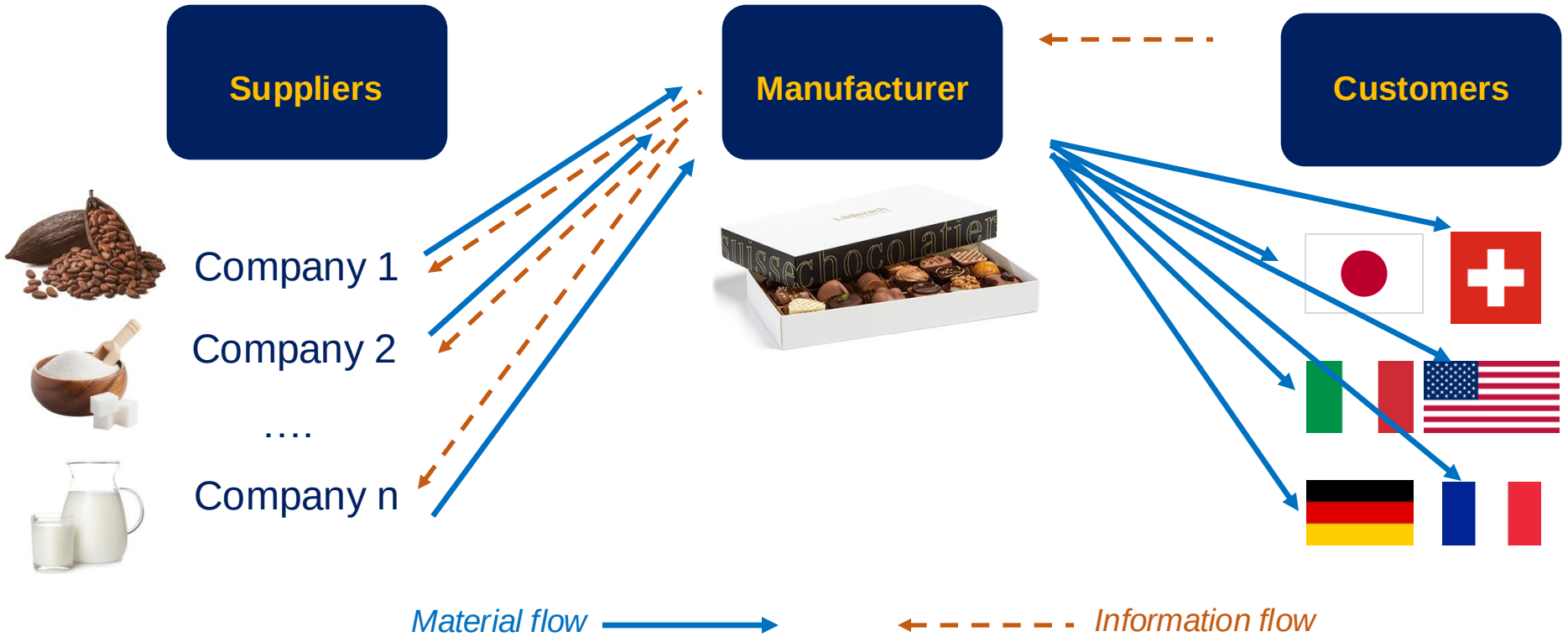
A network of individuals and companies that are involved in creating a product and delivering it to the consumer. Links on the chain begin with the producers of the raw materials and they end when the van delivers the finished product to the user.

Source: https://www.investopedia.com/terms/s/supplychain.asp

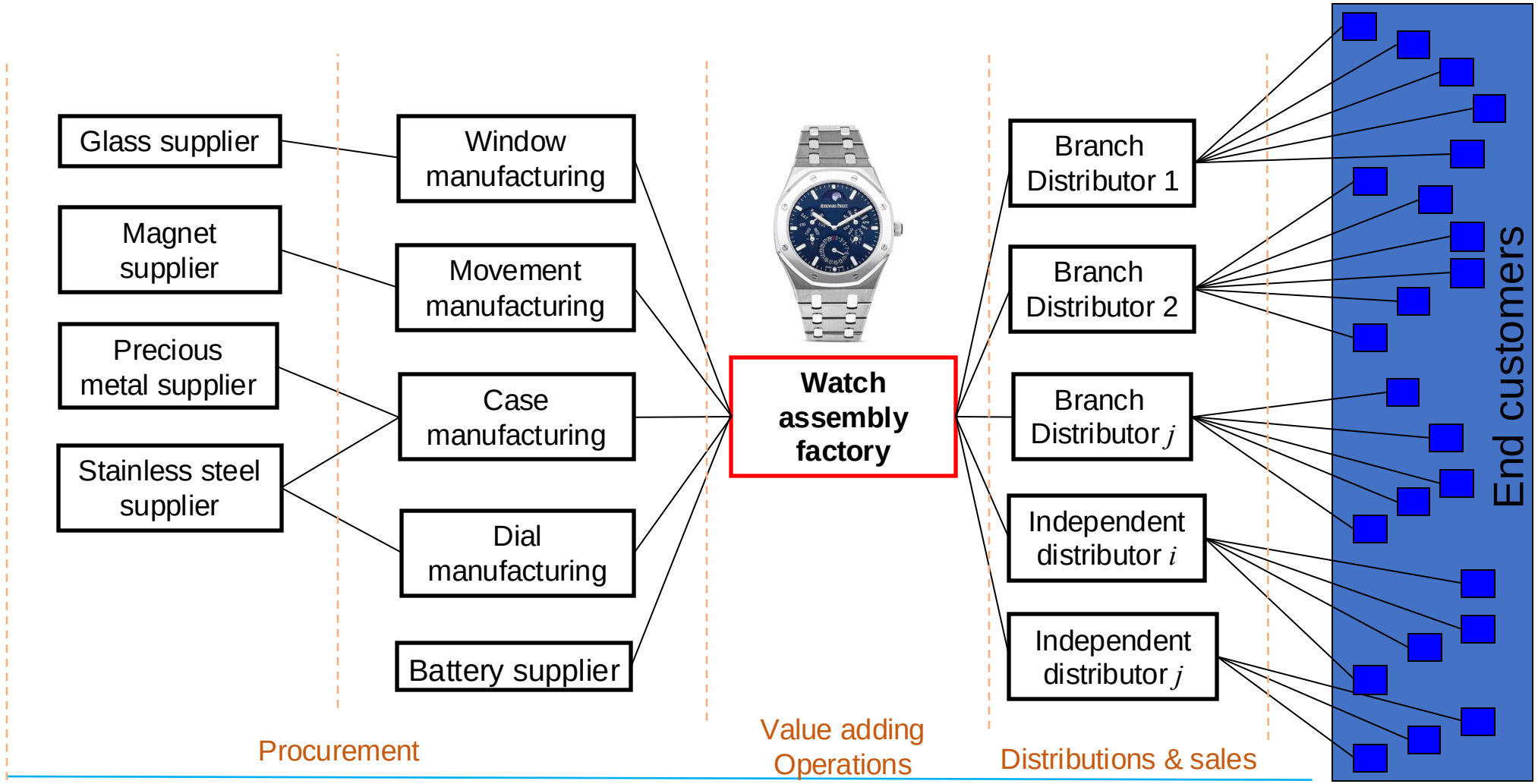
Simplified Supply Chain – Material & Information Flow

Material flow ——→ ←- - - - - Information flow

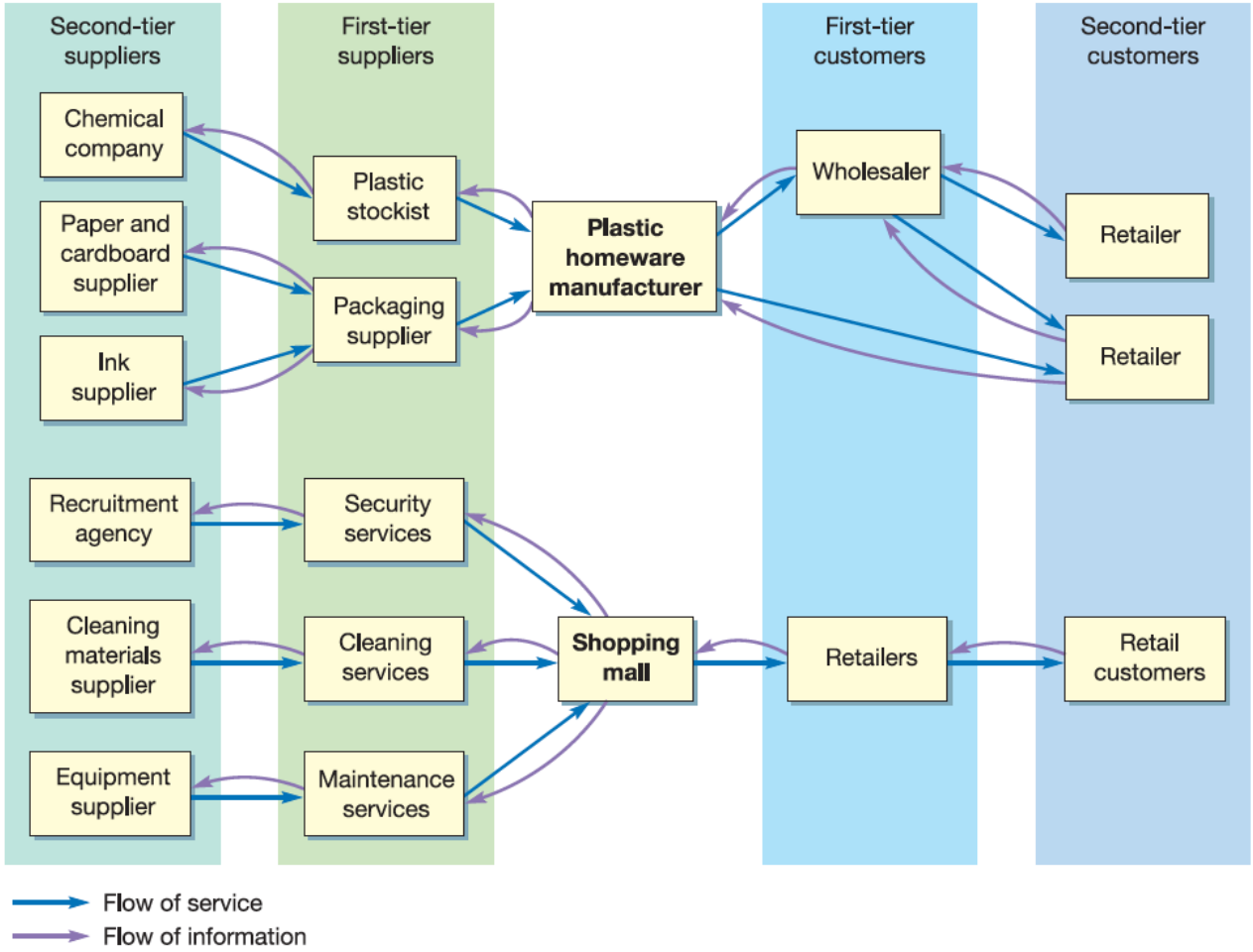
Example: Material & Information Flow – Schematic Representation



Supply Chain Network (Value Adding Network) – Watch

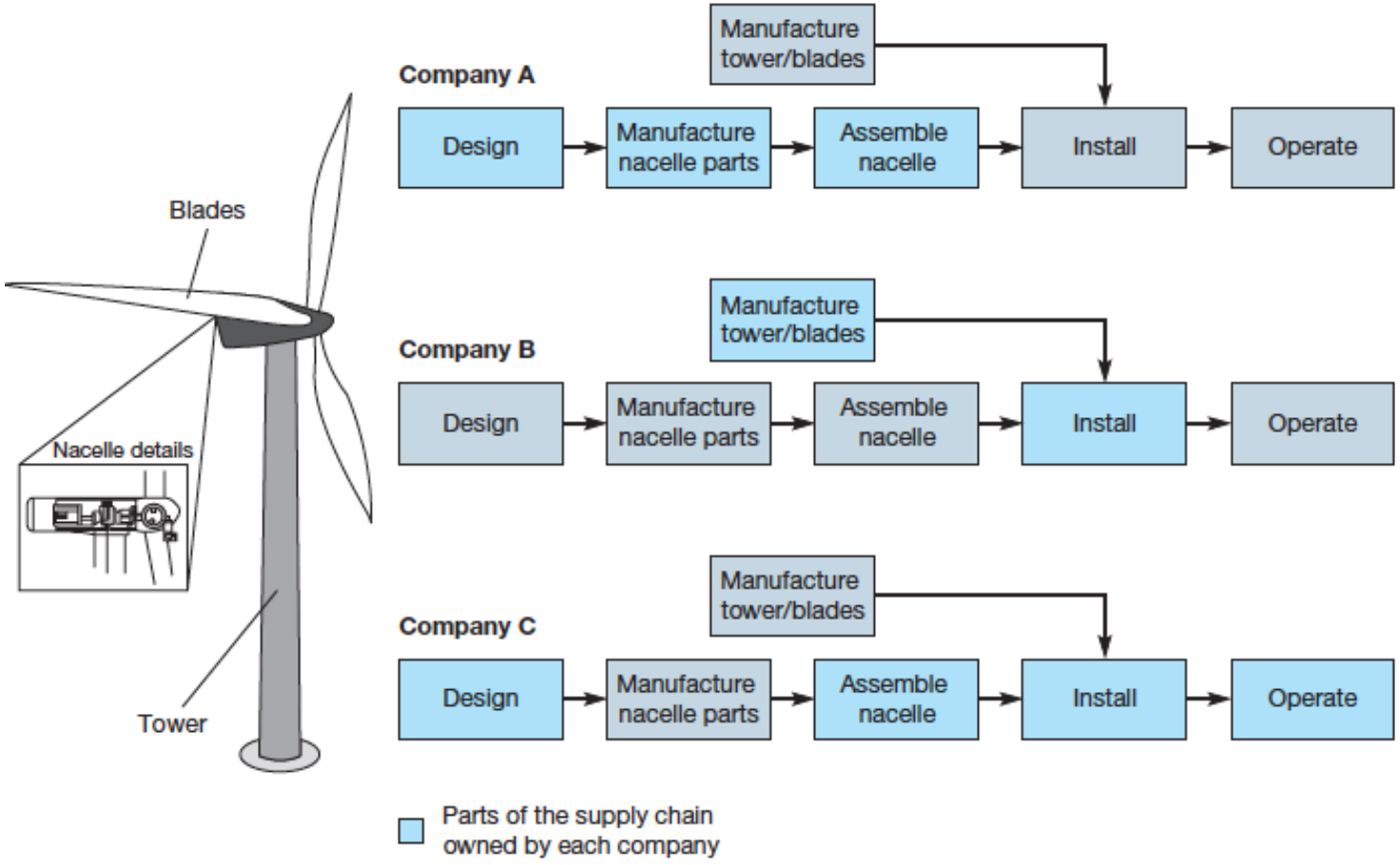


Supply Chain Network (Value Adding Network) – More Examples



Supply chain network for a plastic homeware company and a shopping mall.

Supply Chain Network (Value Adding Network) – Vertical Integration



Three companies operating in the wind power generation industry **with different vertical integration positions**.

Supply Chain Management – Book Chapter

CHAPTER 4

Supply Chain Management

Before studying this chapter you should know or, if necessary, review

1. The implications of competitive priorities, Chapter 2, pp. 36–39.
2. Product design considerations, Chapter 3, pp. 57–65.
3. Process selection considerations, Chapter 3, pp. 65–69.

LEARNING OBJECTIVES

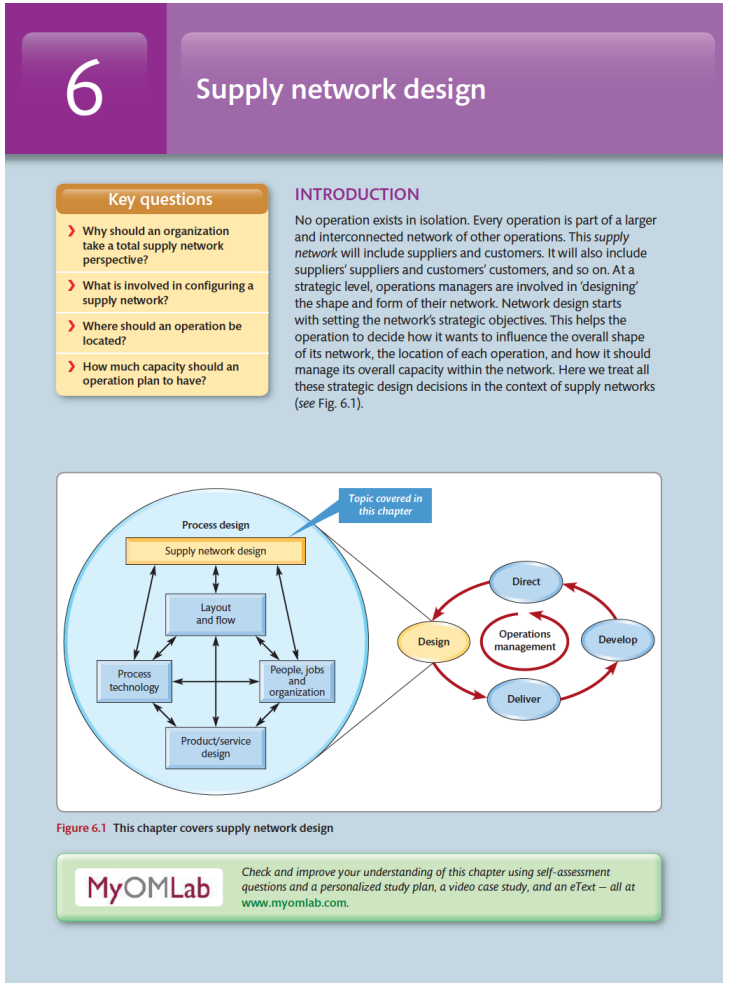
After studying this chapter you should be able to

1. Describe the structure of supply chains.
2. Describe the bullwhip effect.
3. Describe supply chains for service organizations.
4. Describe major issues affecting supply chains.
5. Describe electronic commerce.
6. Describe global issues affecting supply chains.
7. Describe government regulation issues affecting supply chains.
8. Describe green supply chain management.
9. Describe the role of purchasing in supply chain management.
10. Describe sourcing issues.
11. Describe strategic purchasing partnerships.
12. Describe ethics in supplier management.
13. Describe supply chain distribution.
14. Describe how to implement supply chain management.
15. Describe supply chain management metrics.
16. Describe trends in supply chain management.

CHAPTER OUTLINE

WHAT'S IN OM FOR ME?

ACC FIN MKT OM HRM MIS



6 Supply network design

Key questions

- Why should an organization take a total supply network perspective?
- What is involved in configuring a supply network?
- Where should an operation be located?
- How much capacity should an operation plan to have?

INTRODUCTION

No operation exists in isolation. Every operation is part of a larger and interconnected network of other operations. This *supply network* will include suppliers and customers. It will also include suppliers' suppliers and customers' customers, and so on. At a strategic level, operations managers are involved in 'designing' the shape and form of their network. Network design starts with setting the network's strategic objectives. This helps the operation to decide how it wants to influence the overall shape of its network, the location of each operation, and how it should manage its overall capacity within the network. Here we treat all these strategic design decisions in the context of supply networks (*see* Fig. 6.1).

Figure 6.1 This chapter covers supply network design

MyOMLab *Check and improve your understanding of this chapter using self-assessment questions and a personalized study plan, a video case study, and an eText – all at* www.myomlab.com.

Assignment 2 – Evaluation of Current State of Your Products & Supply Chain

5 Min

No.	Question
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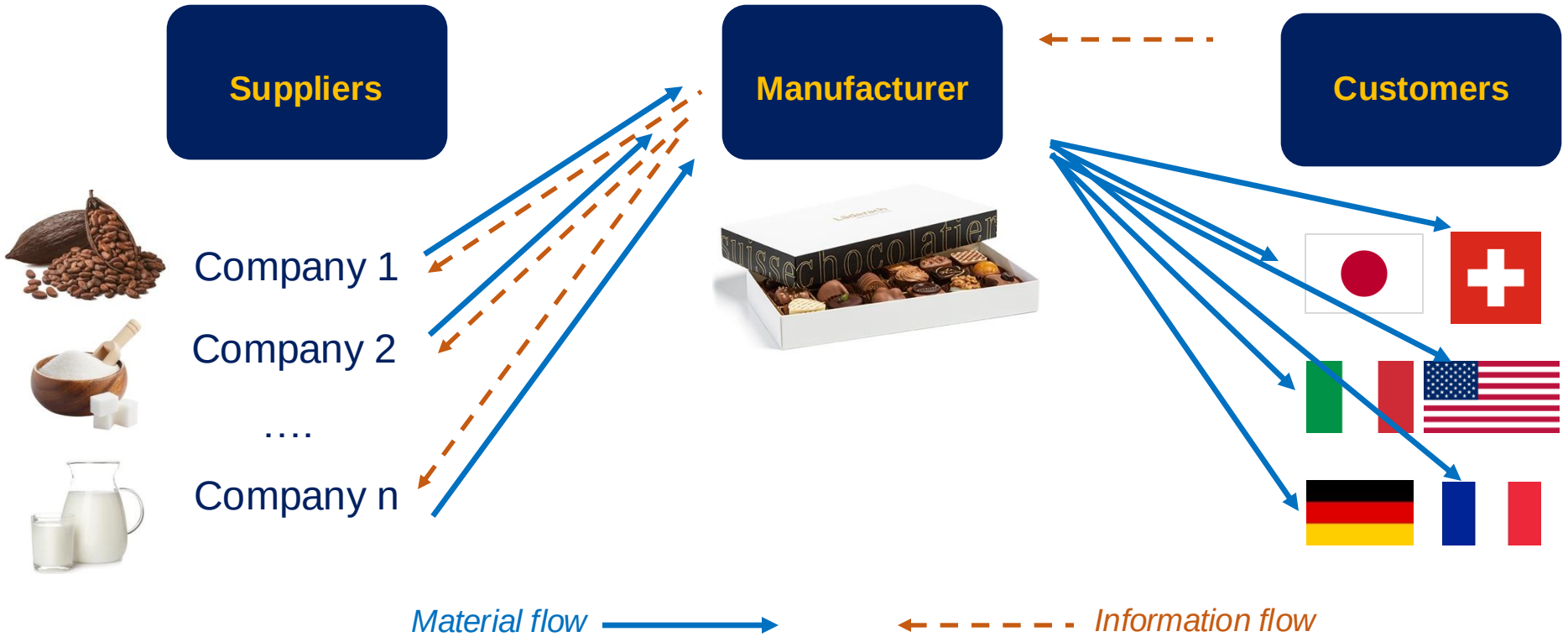
Material & Information Flow – Schematic Representation



Sustainable Products & Supply Chains (ME-203)

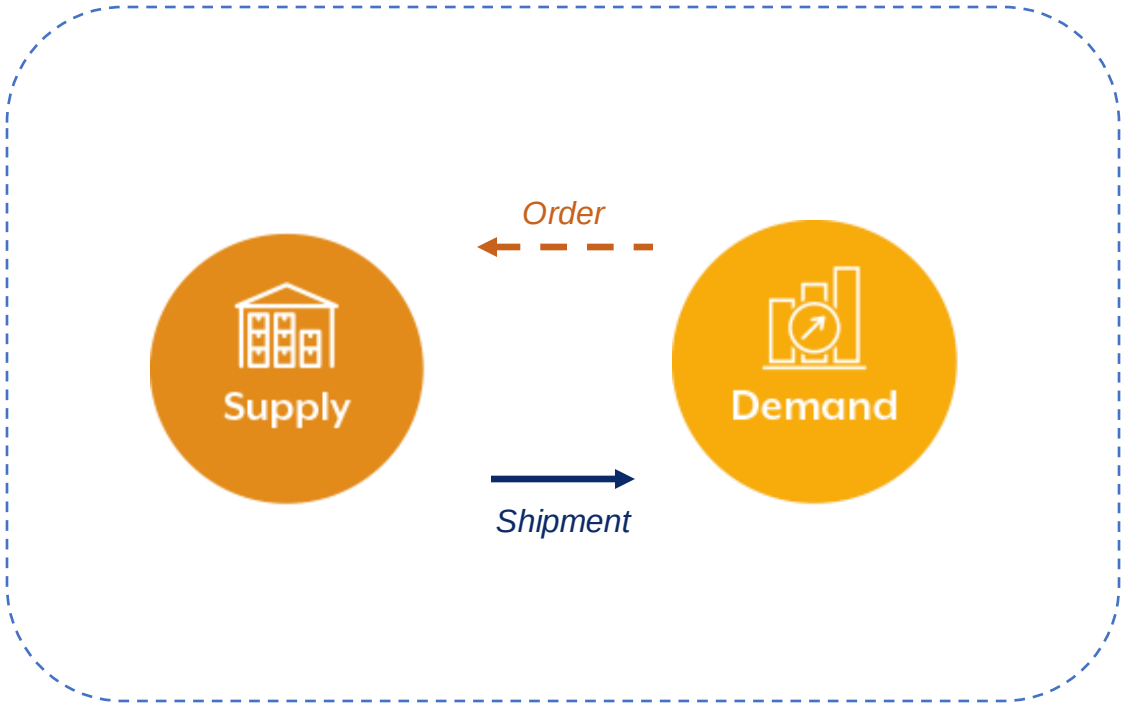
Managing Uncertainties, Disruptions & Demand Shifts

Amin Kaboli

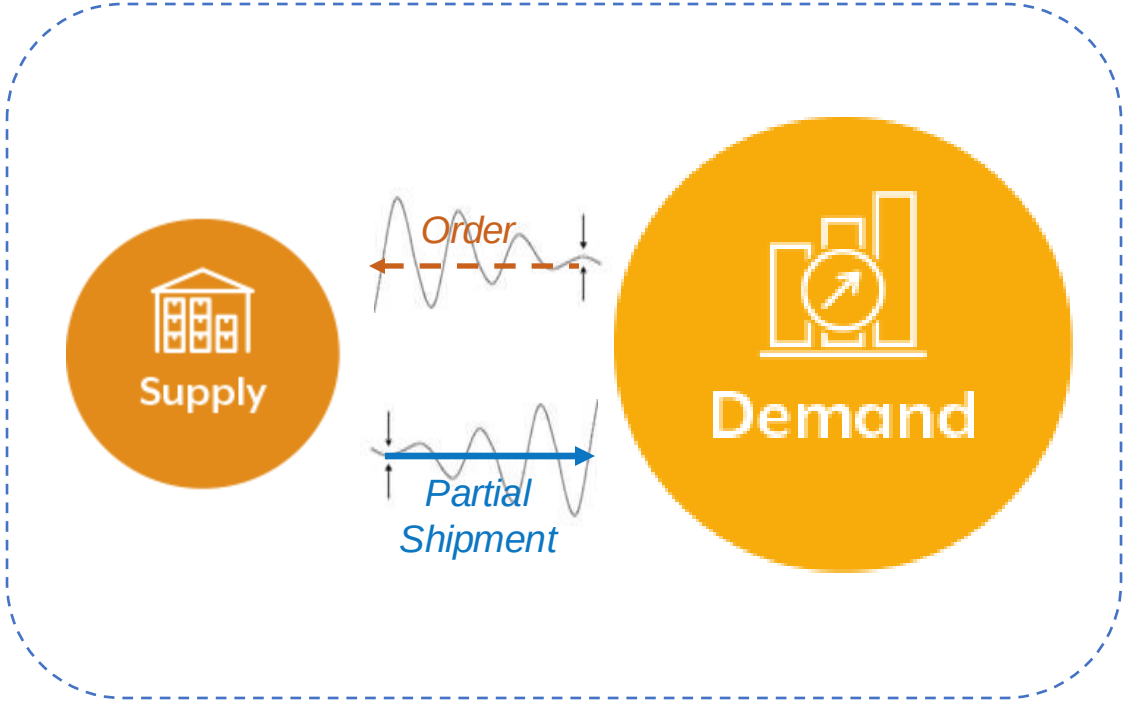
Week 3 – Session 2 – March 06th, 2025

Supply chains respond to changes and disruptions

Demand and Supply



Match

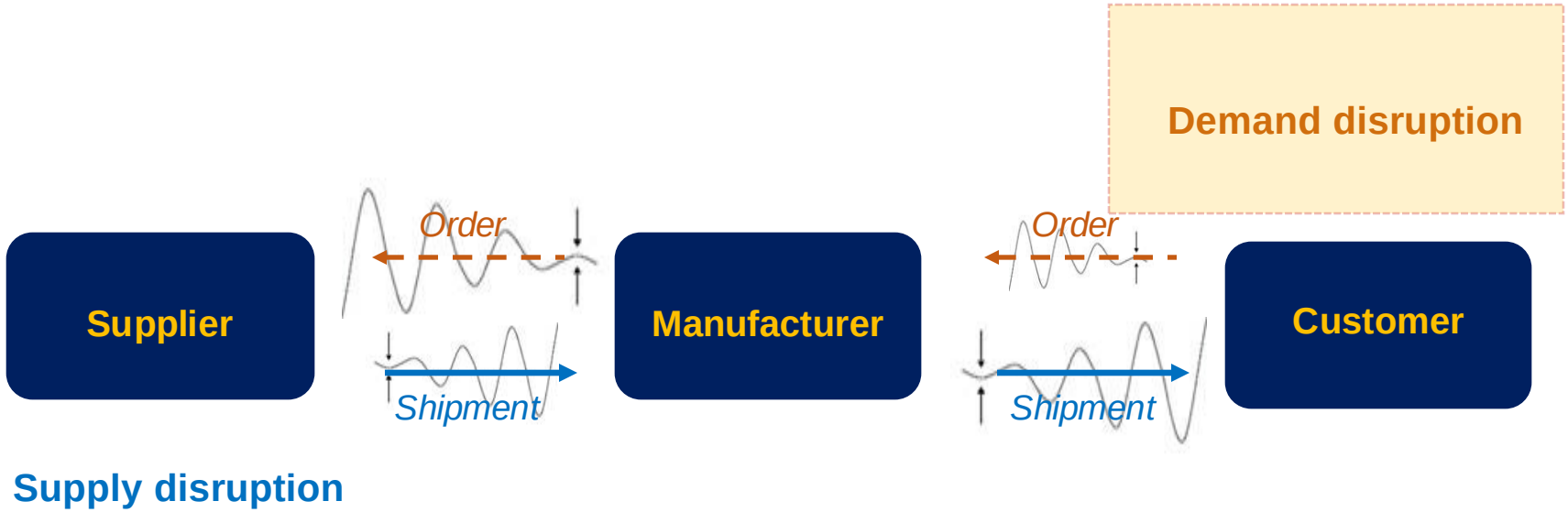


Mismatch

Demand and Supply – Mismatch

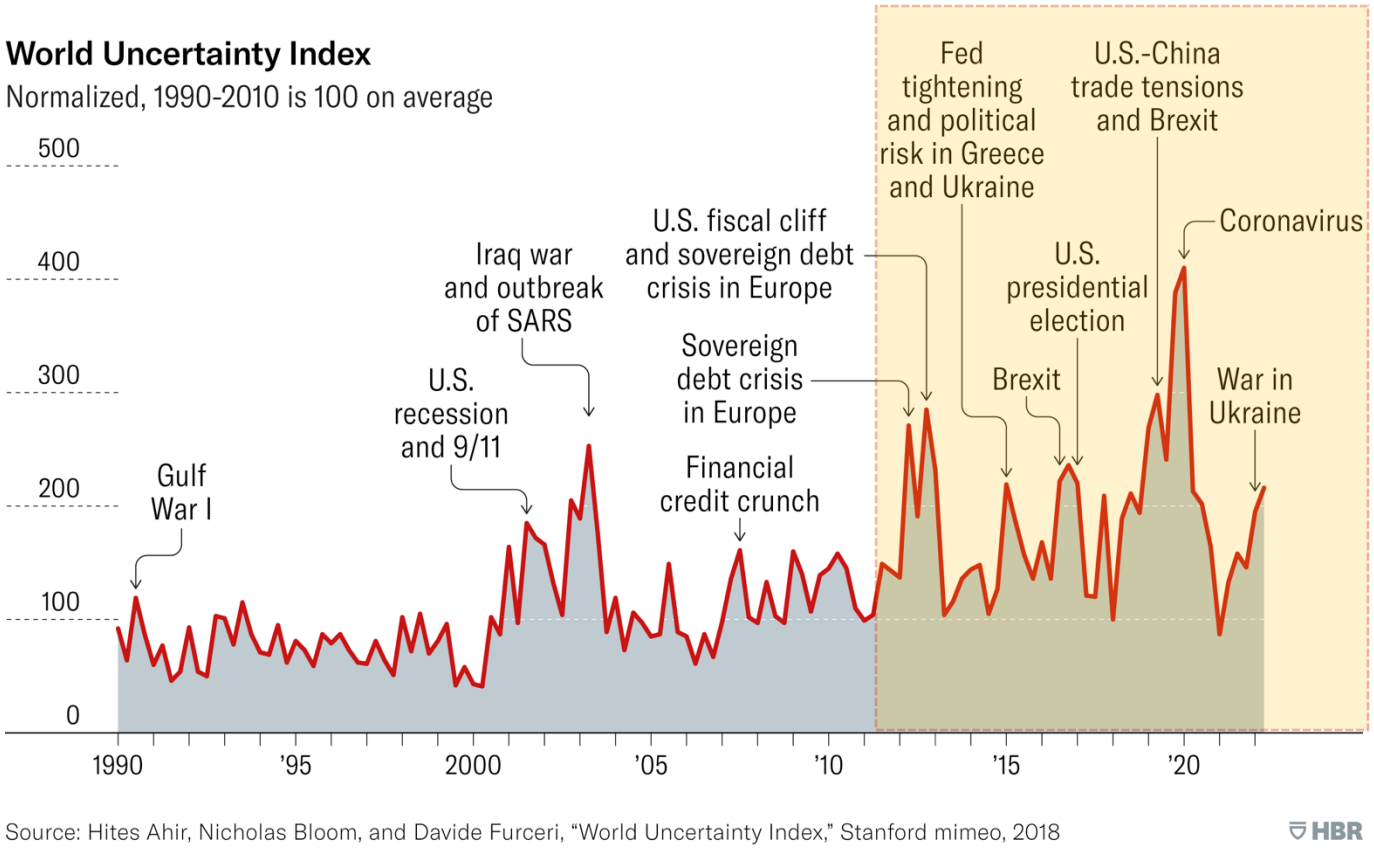
Source: GettyImage

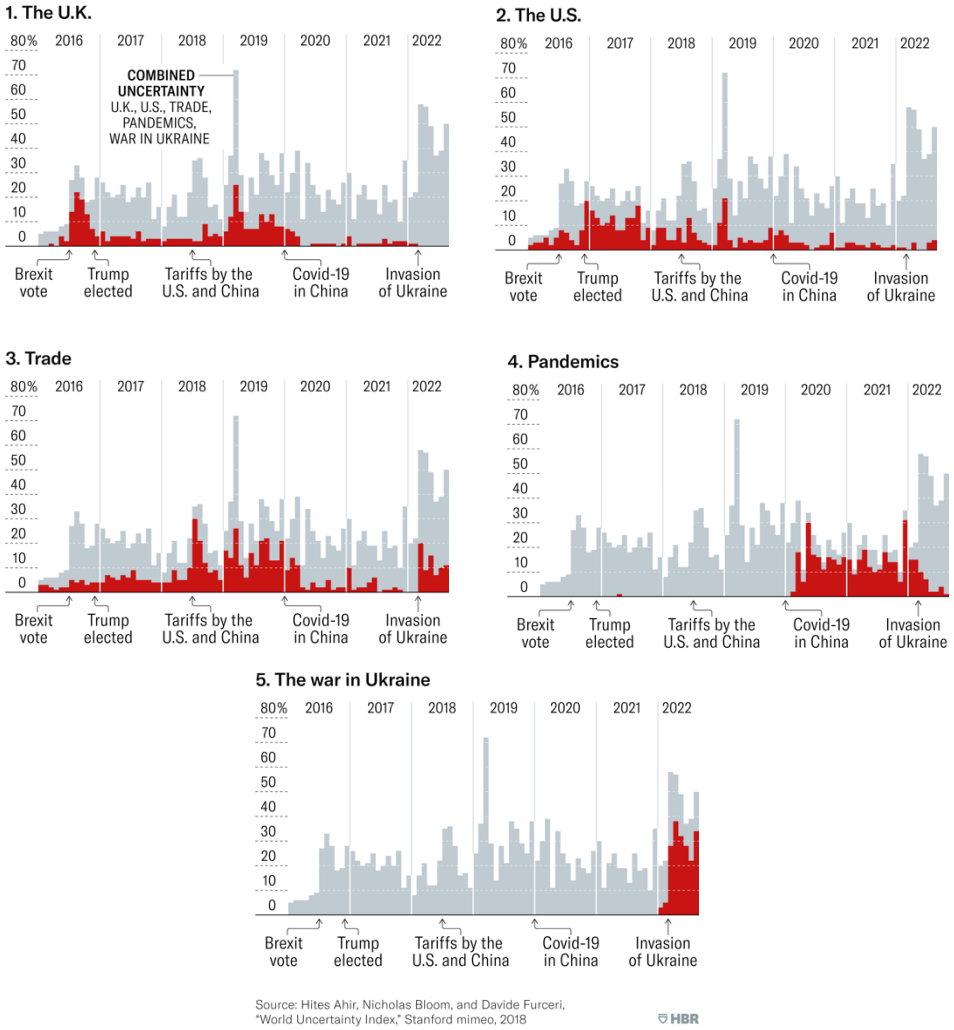
Simplified Supply Chain – Disruptions



Supply disruption

The Rise of Economic Uncertainty – The World Uncertainty Index



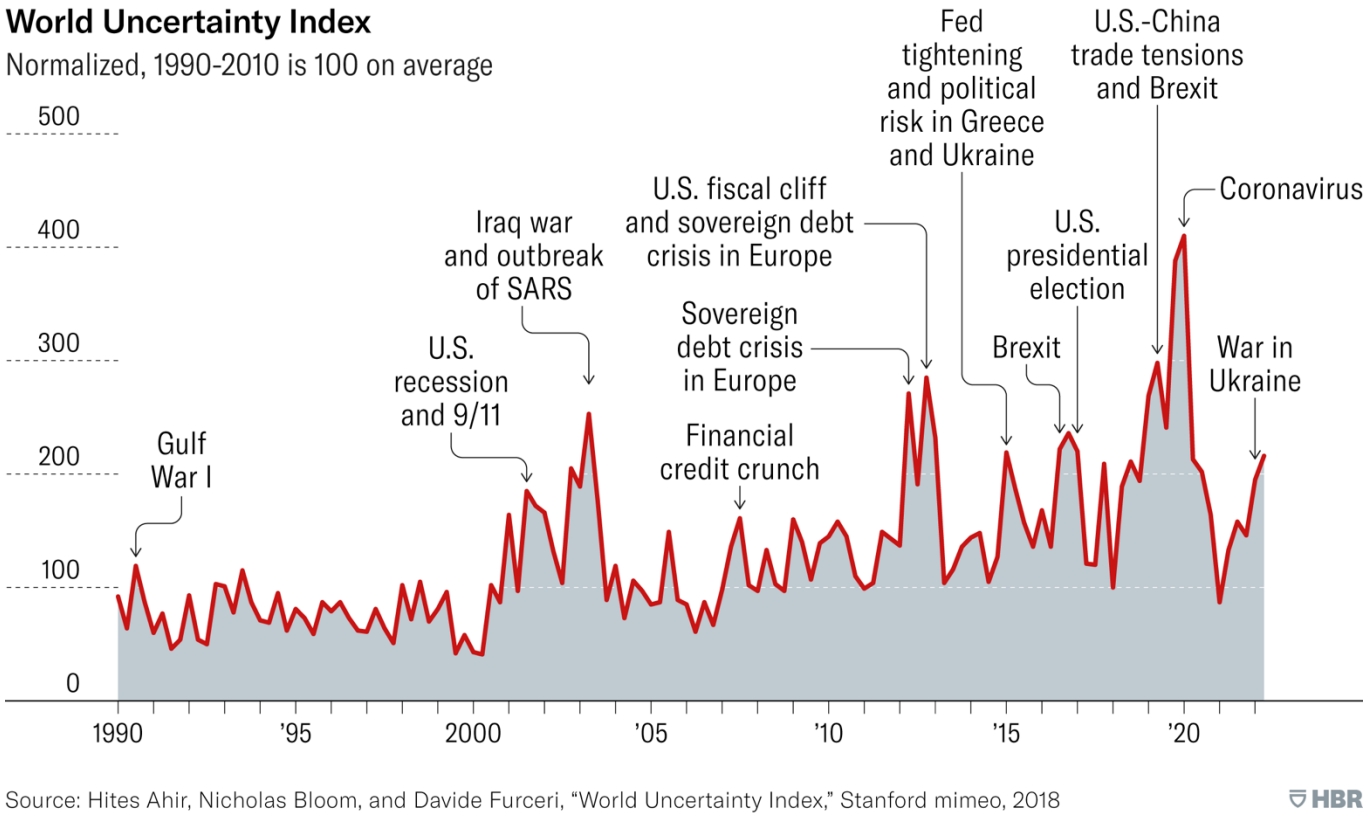


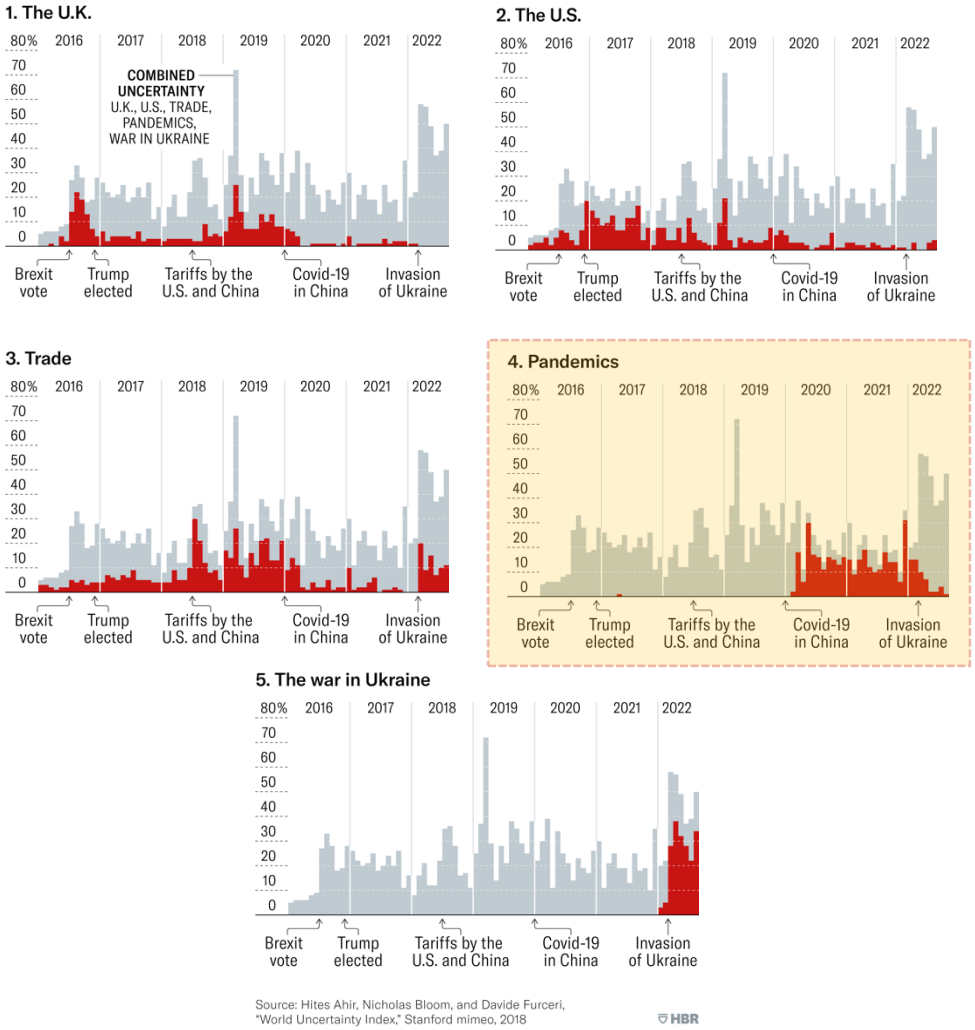
Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

Case 1:

COVID-19 & Swiss Watch Industry

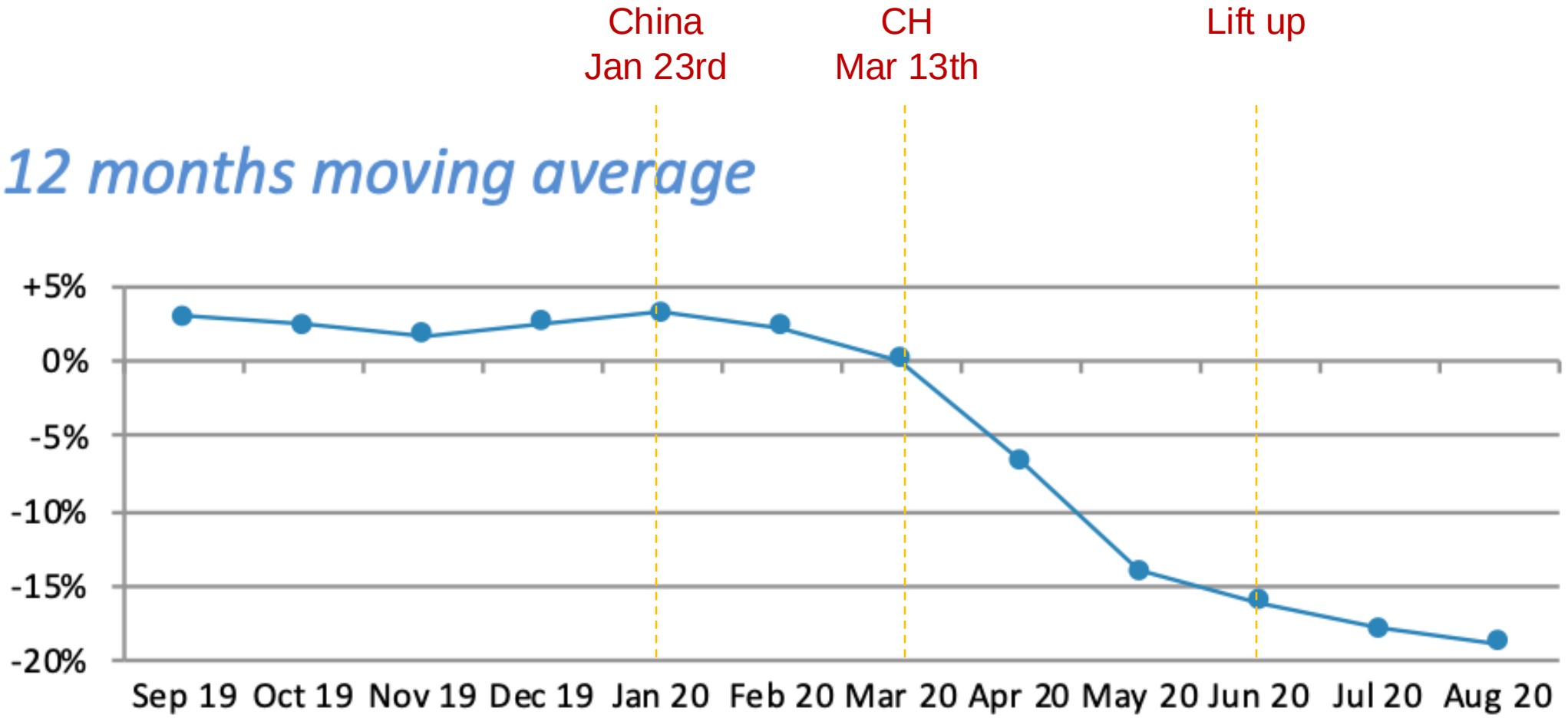
The Rise of Economic Uncertainty – The World Uncertainty Index





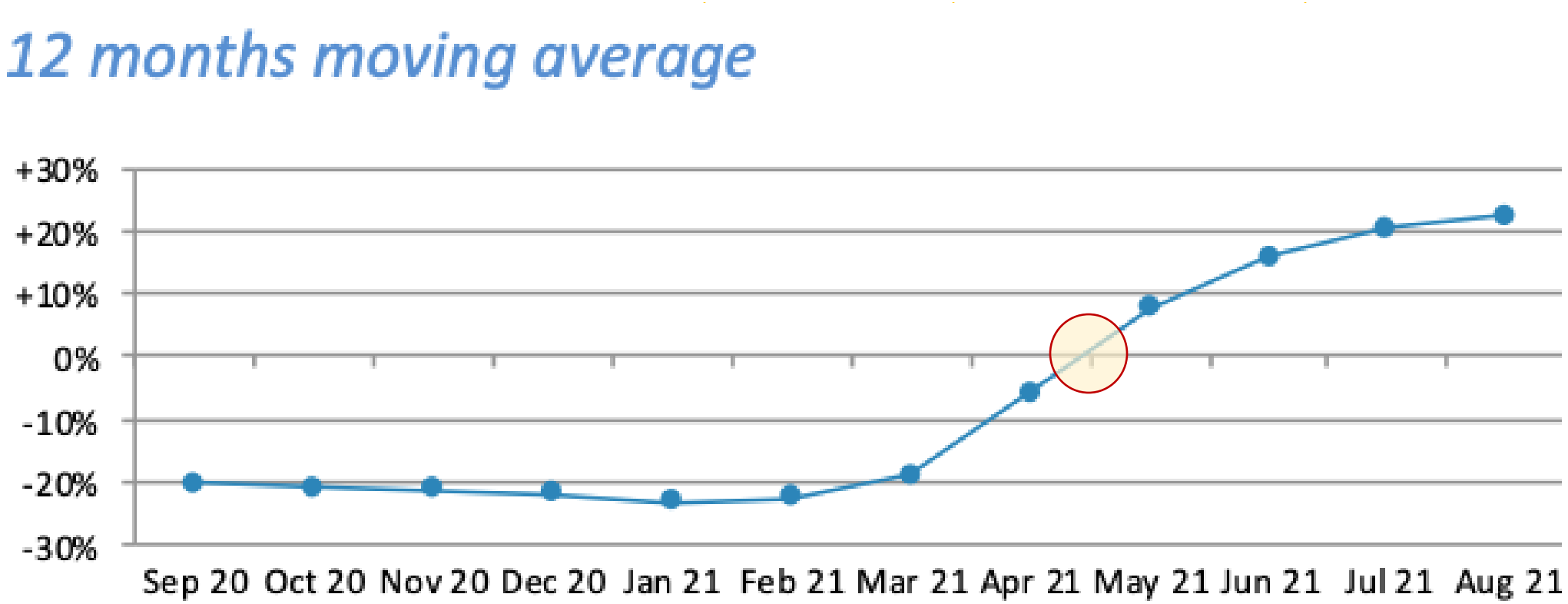
Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

The Swiss Watch Industry – Export During COVID-19 (Sep19-Aug20)



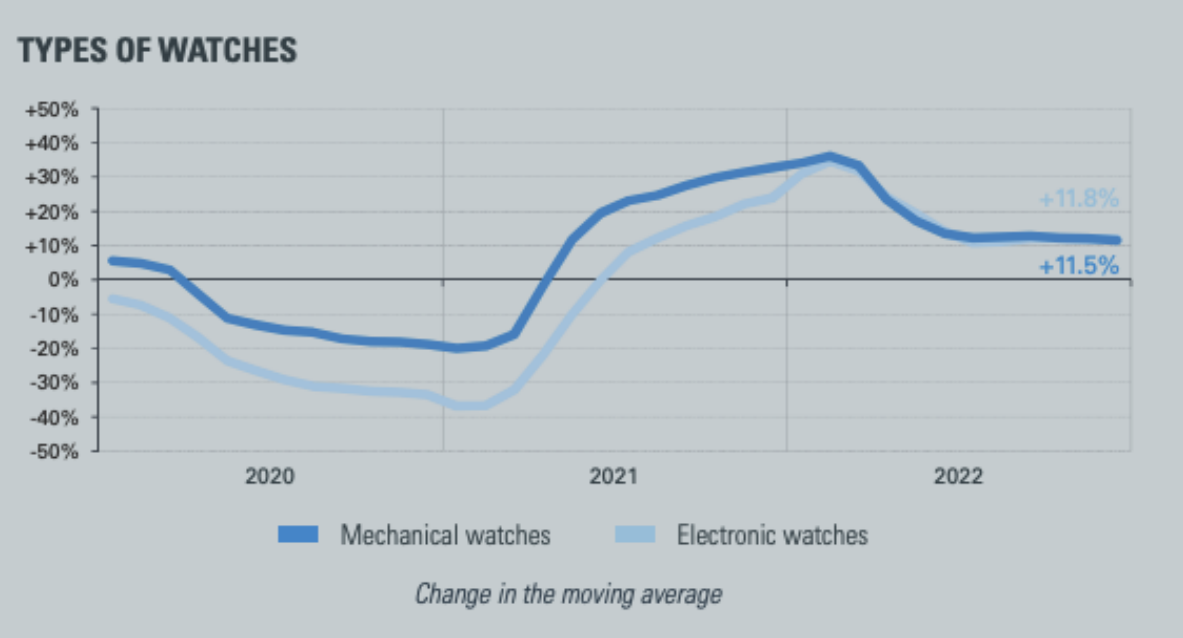
Source: Federation of the Swiss Watch industry FH: https://www.fhs.swiss/scripts/getstat.php?file=comm_200808_a.pdf

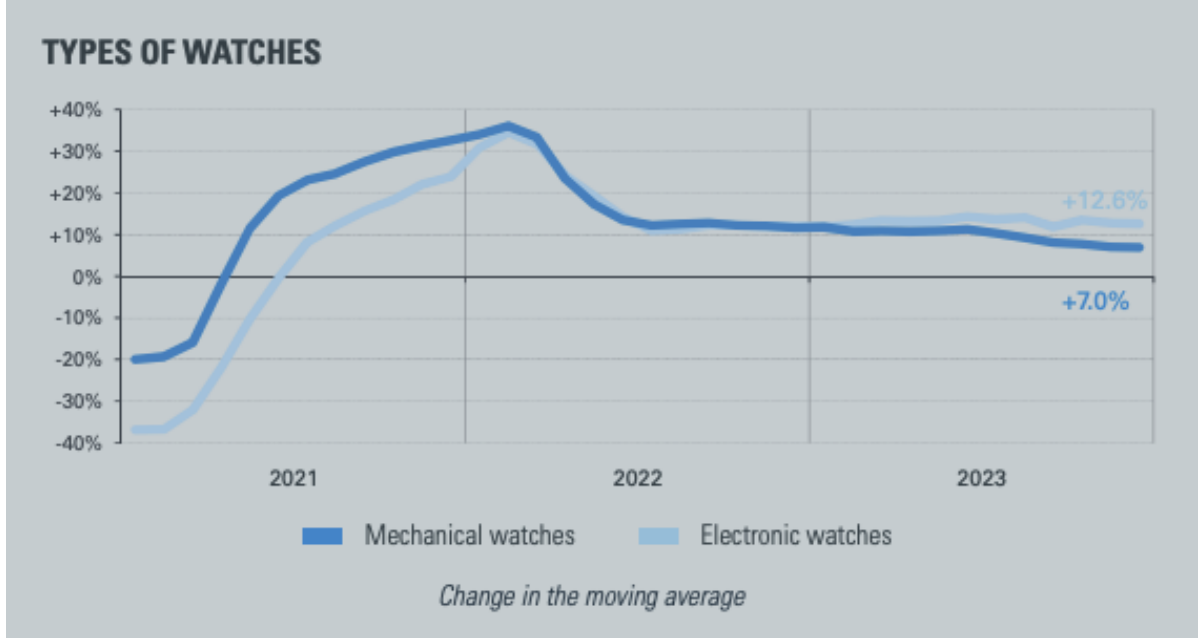
The Swiss Watch Industry – Export During COVID-19 (Sep20-Aug21)



Source: Federation of the Swiss Watch industry FH: https://www.fhs.swiss/scripts/getstat.php?file=comm_200808_a.pdf

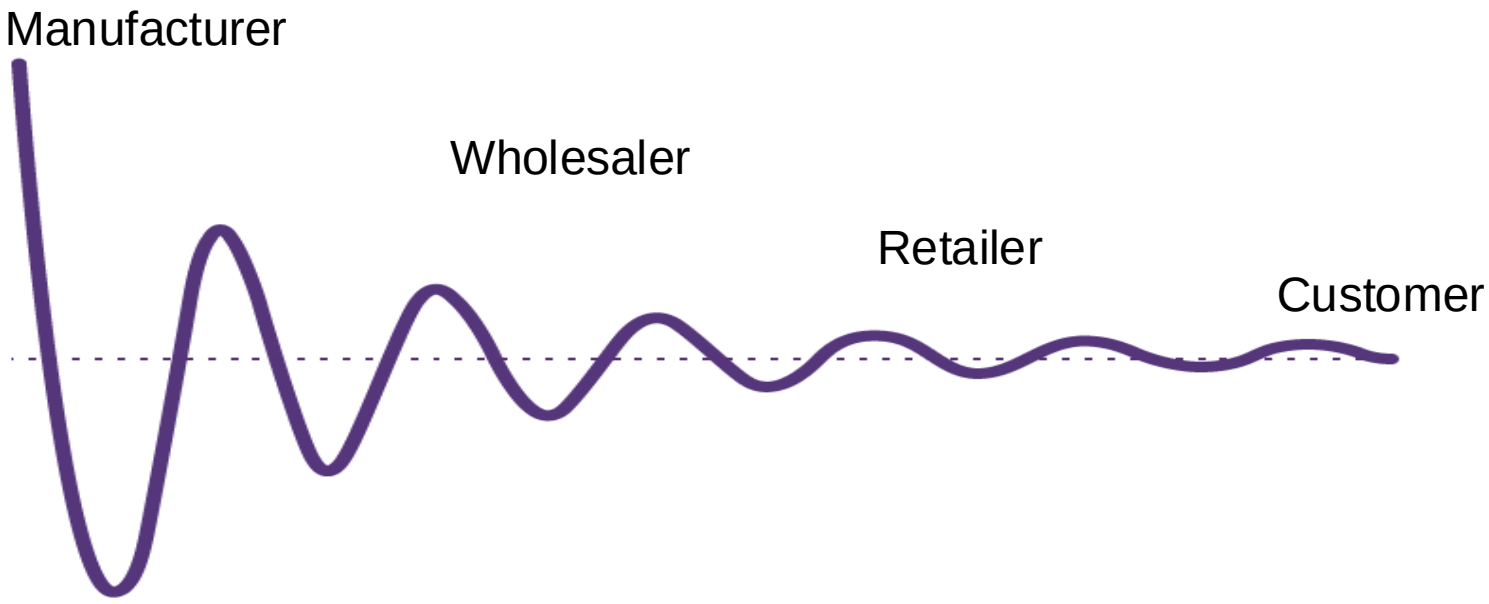
The Swiss Watch Industry – (2020-2023)





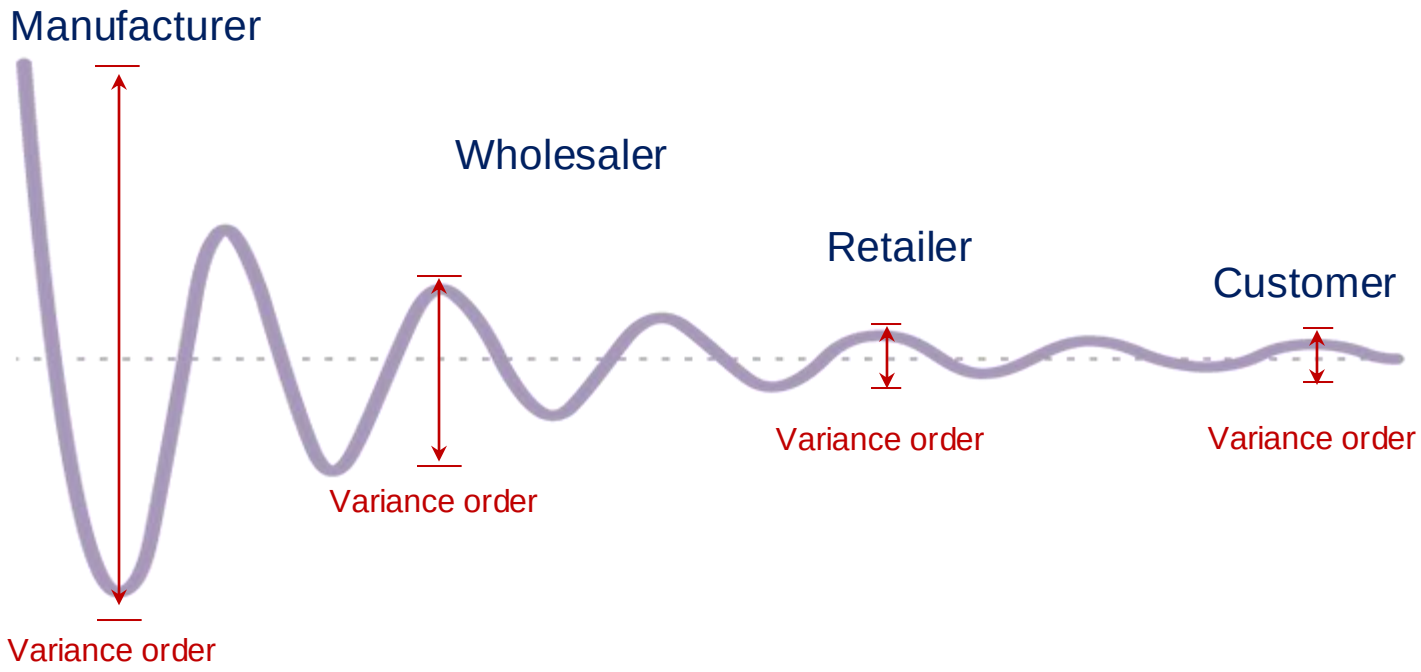
Source: Federation of the Swiss Watch industry FH: https://www.fhs.swiss/eng/statistics.html

Bullwhip Effect



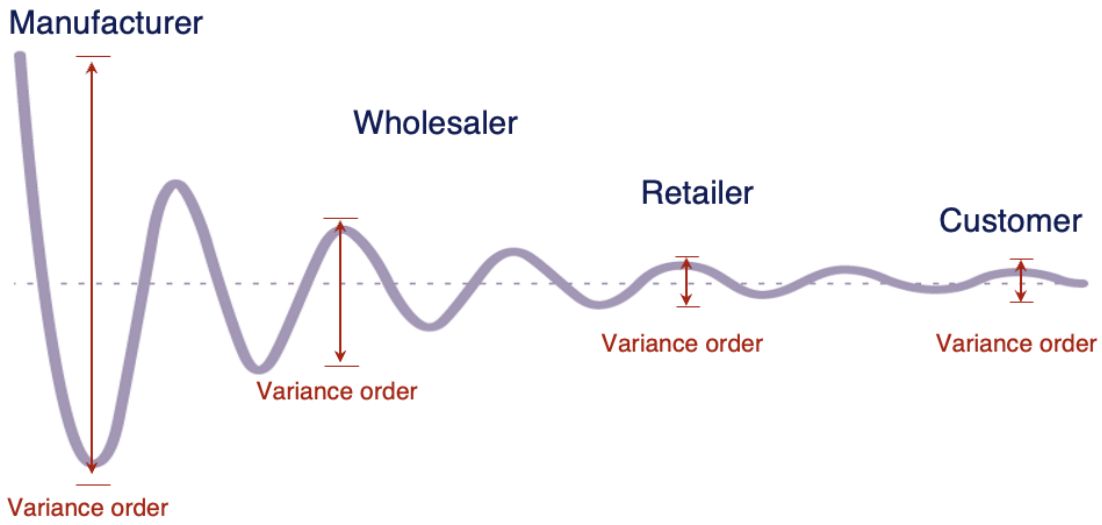
Bullwhip effect: The demand variabilities (amplification and oscillation) along the supply chain.

Measuring Bullwhip Effect



Bullwhip effect: The demand variabilities (amplification and oscillation) along the supply chain.

Measuring Bullwhip Effect



Note: This will be further explored in the Supply Chain Analytics module during Weeks 9 and 11.

1. Bullwhip Effect Formula for Each Echelon

For each stage in the supply chain, the **bullwhip effect (BWE)** is calculated as:

$$BWE_i = \frac{\text{Variance of Orders Received at Echelon } i}{\text{Variance of Orders Sent to Next Echelon } (i+1)}$$

Where:

- i represents an echelon (e.g., Manufacturer, Wholesaler, Retailer).
- A **higher BWE value** means greater demand amplification at that echelon.

2. Bullwhip Effect Formula for the Whole Supply Chain

To measure the **overall bullwhip effect** across the entire supply chain (from the customer to the manufacturer), we compare the **order variance at the manufacturer** with the **demand variance at the customer**:

$$BWE_{\text{Total}} = \frac{\text{Variance of Orders Received by Manufacturer}}{\text{Variance of Customer Demand}}$$

Where:

- **Numerator:** Captures the variance at the manufacturer (which is the most volatile in the chain).
- **Denominator:** Represents the demand variance at the customer (which is the source of the orders).

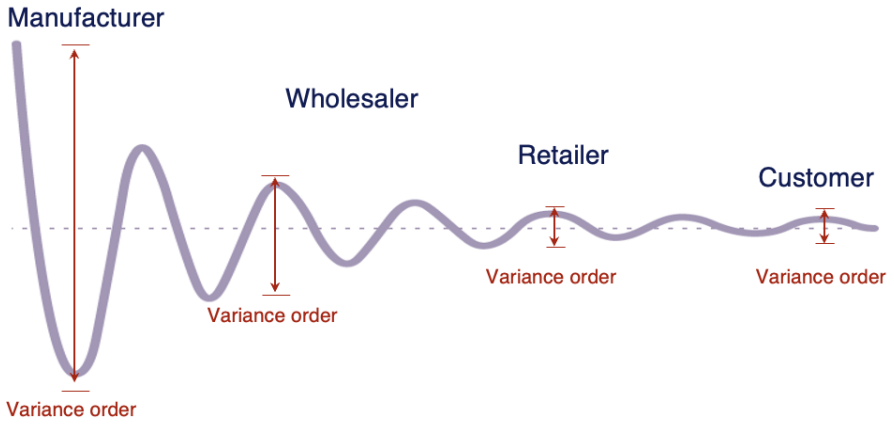
3. Alternative Approach: Multiplicative Form Across Echelons

Since the bullwhip effect accumulates across multiple echelons, we can also express it as:

$$BWE_{\text{Total}} = BWE_{\text{Wholesaler}} \times BWE_{\text{Retailer}} \times BWE_{\text{Manufacturer}}$$

This approach assumes each echelon amplifies the variance, and the total effect is the product of individual echelons' bullwhip ratios.

Demand Disruption – Causes of Bullwhip Effect



Operational Reasons

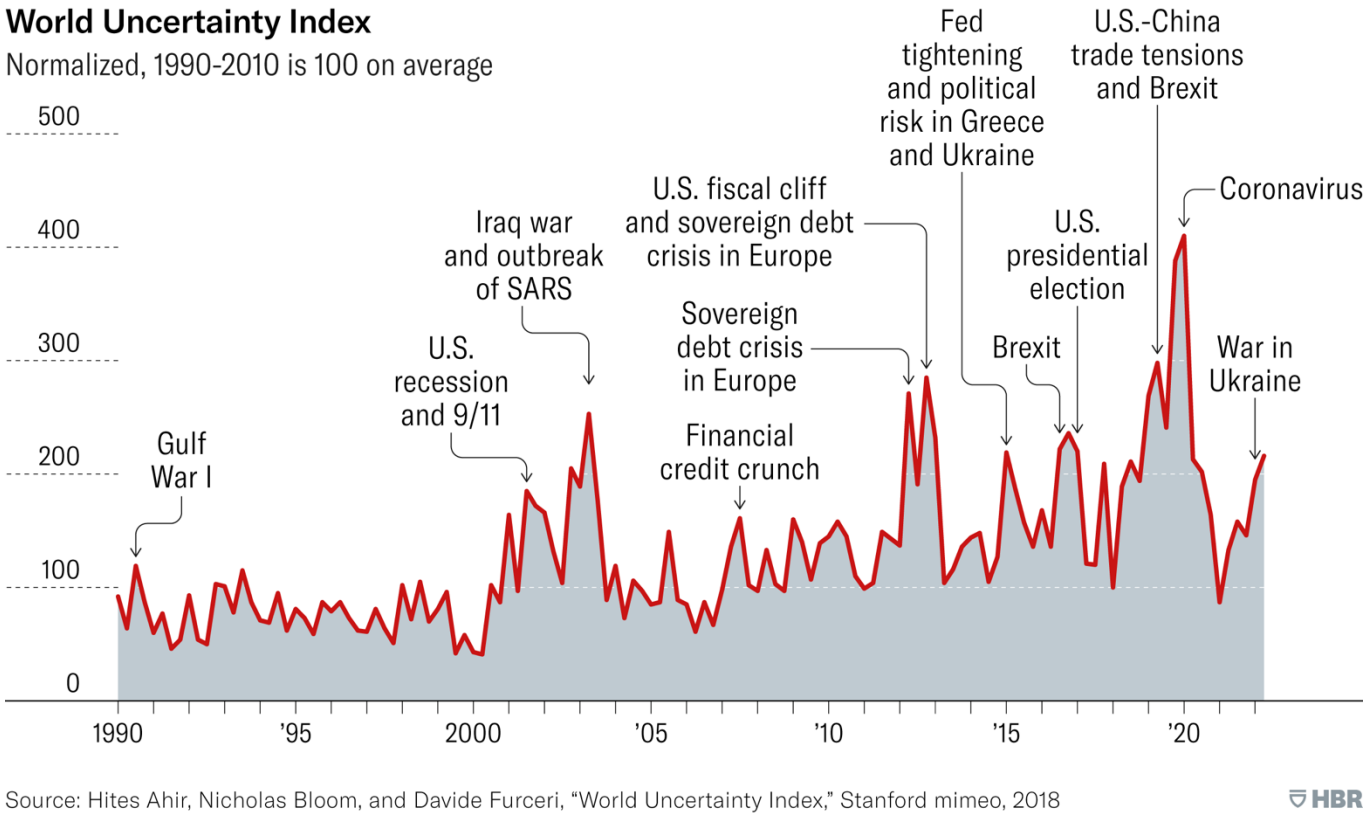
- Demand processing (forecast errors)
- Leadtime variability
- Lot-sizing
- Promotions and forward buying

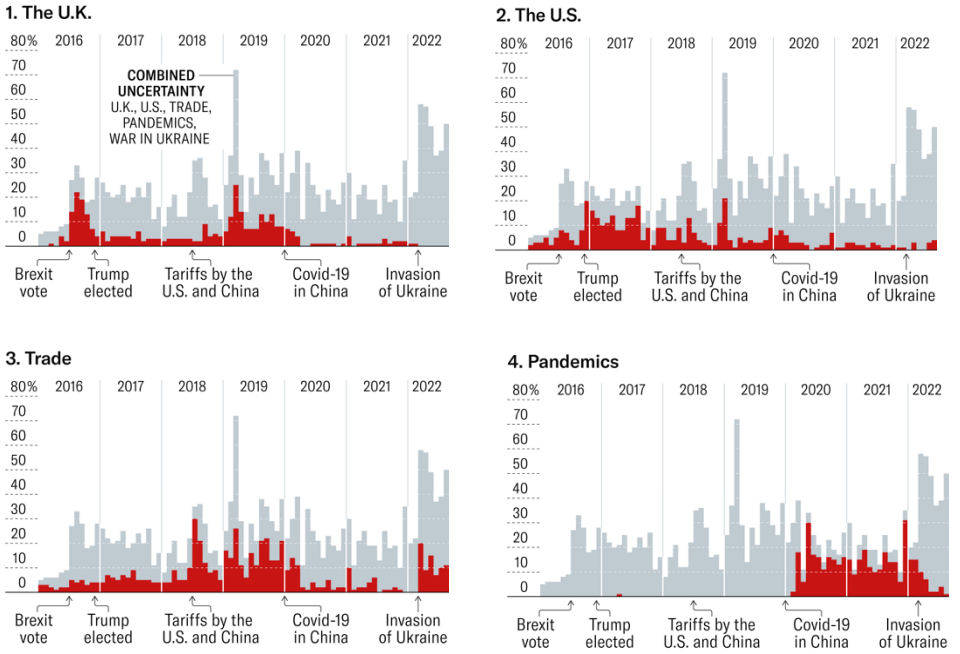
Behavioral Reasons

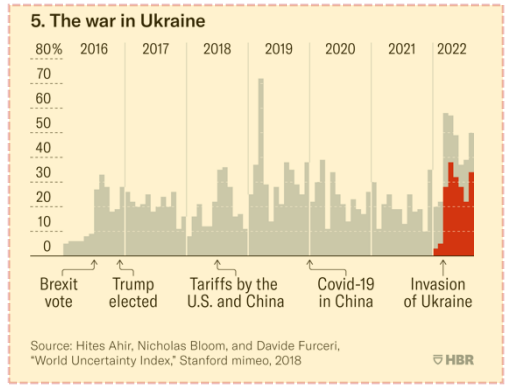
- Trust
- Mis-perceptions of feedback and time lags
- Panic ordering after unmet demand
- Perceived risk of bounded rationality of others

Case 2:
Geopolitics (War in Ukraine)

The Rise of Economic Uncertainty – The World Uncertainty Index



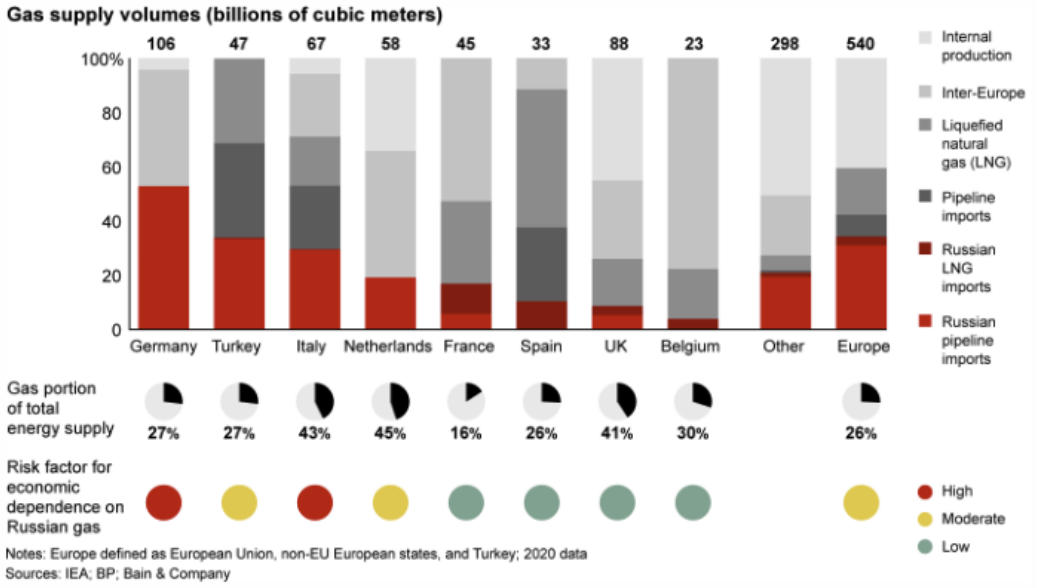




Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

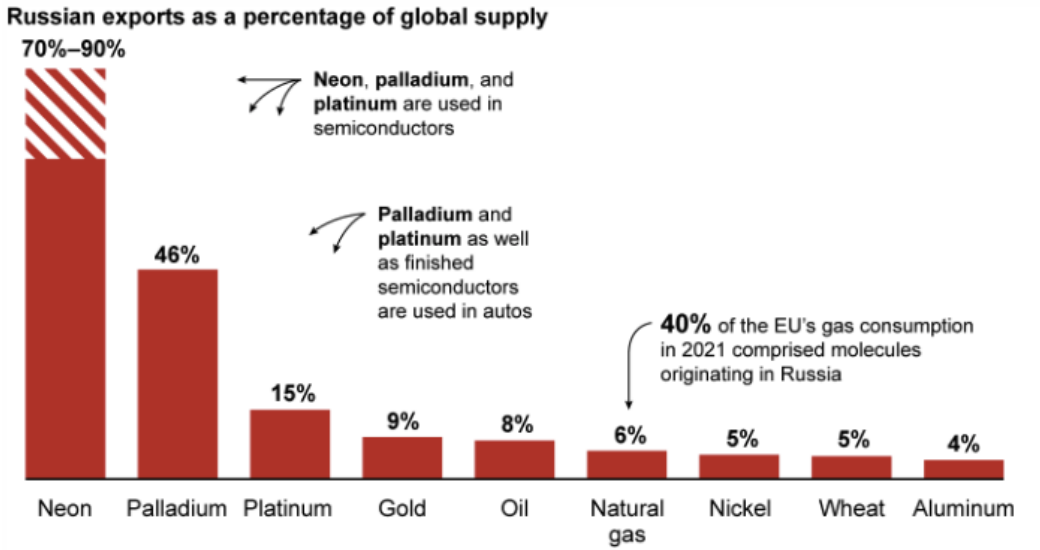
How Should Your Supply Chain Respond to the Crisis in Ukraine?

Europe counts on Russia for a third of its natural gas supply, with Germany most dependent



Notes: Europe defined as European Union, non-EU European states, and Turkey; 2020 data
Sources: IEA; BP; Bain & Company

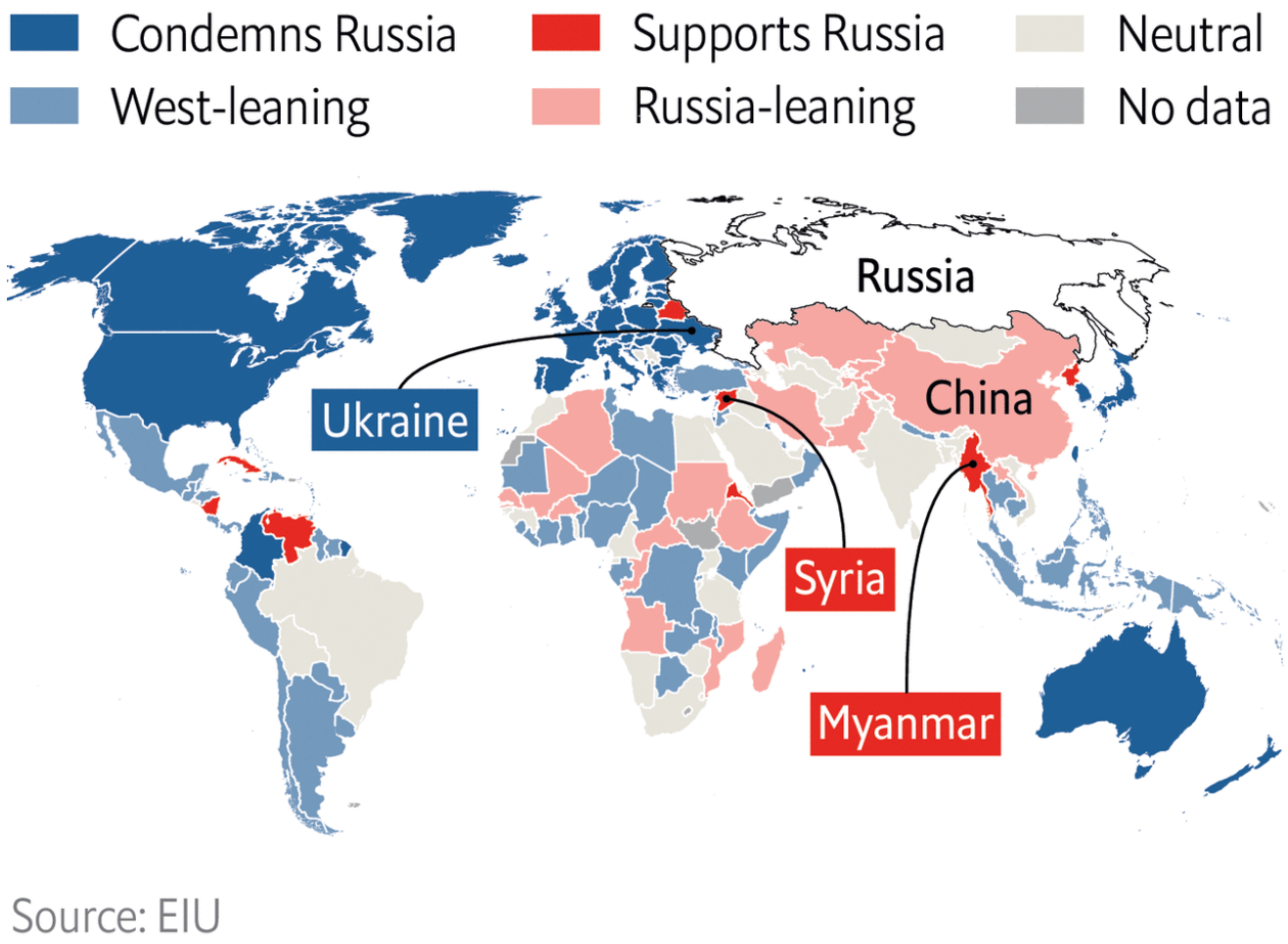
Makers of semiconductors and automobiles have relied on Russia for some commodities



Notes: US semiconductor-grade neon is produced in Russia as a byproduct of steelmaking and purified in Ukraine; 2021 data
Sources: JPMorgan; Eurostat; Reuters; CNBC; Techcet CA LLC; Bain Macro Trends Group

Source: *https://www.bain.com/insights/how-should-your-supply-chain-respond-to-the-crisis-in-ukraine/*

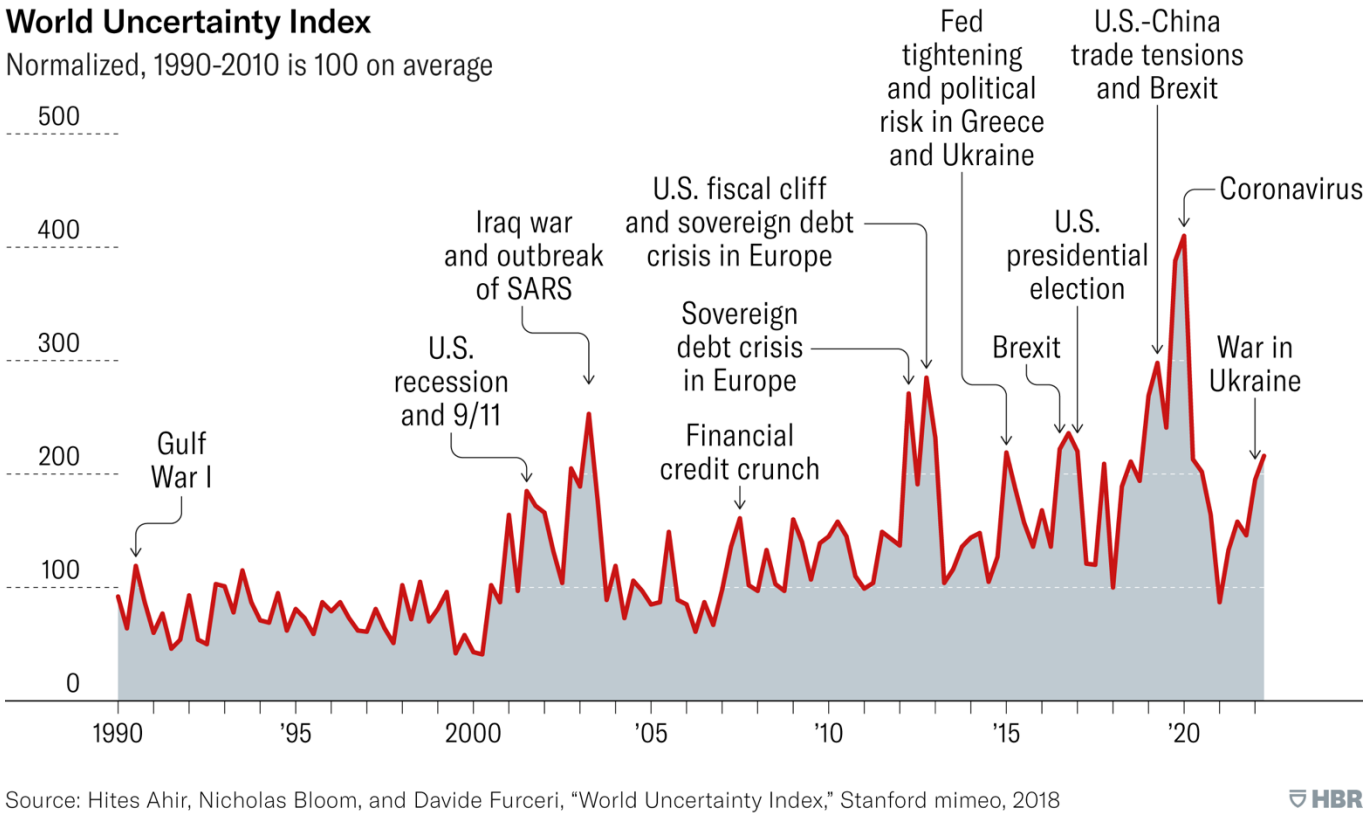
A Divided World – Government Responses to Ukraine War, 2022

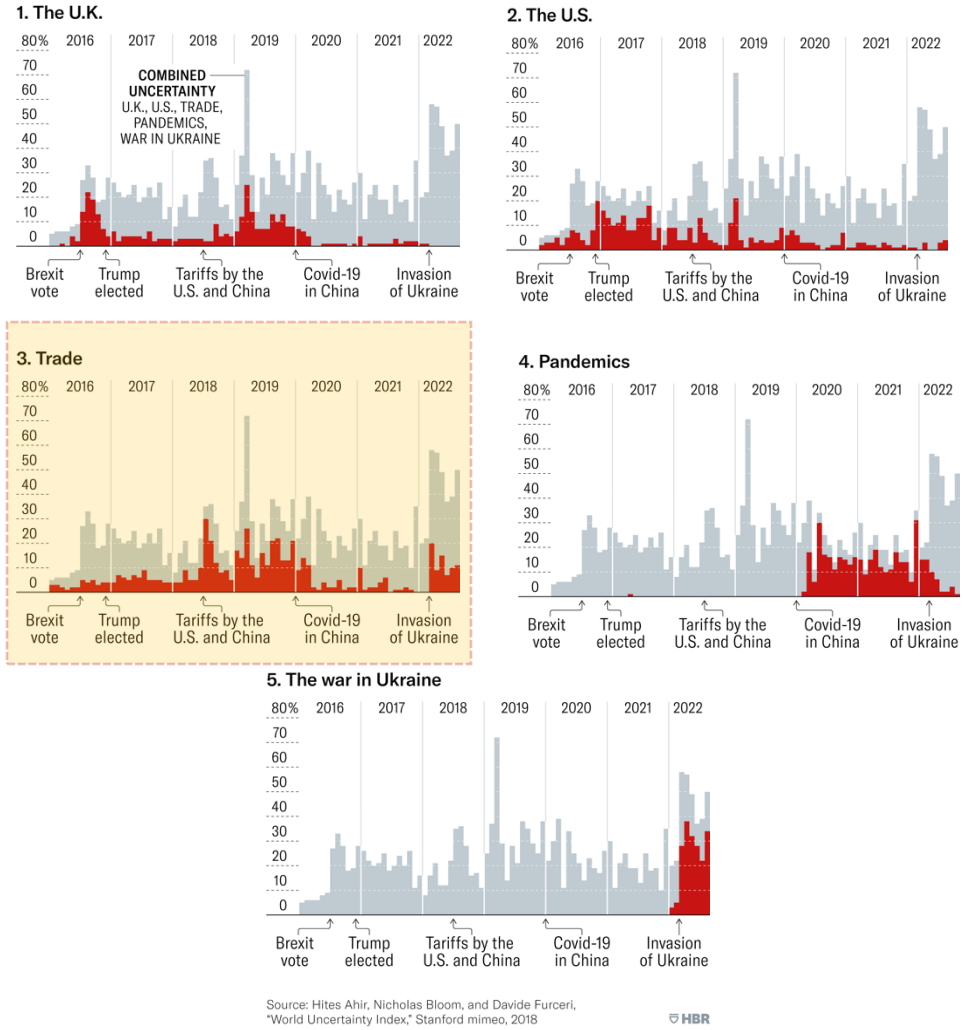


Source: *EIU (https://www.eiu.com/n/)*

Case 3:
Geography Concentration Risks

The Rise of Economic Uncertainty – The World Uncertainty Index



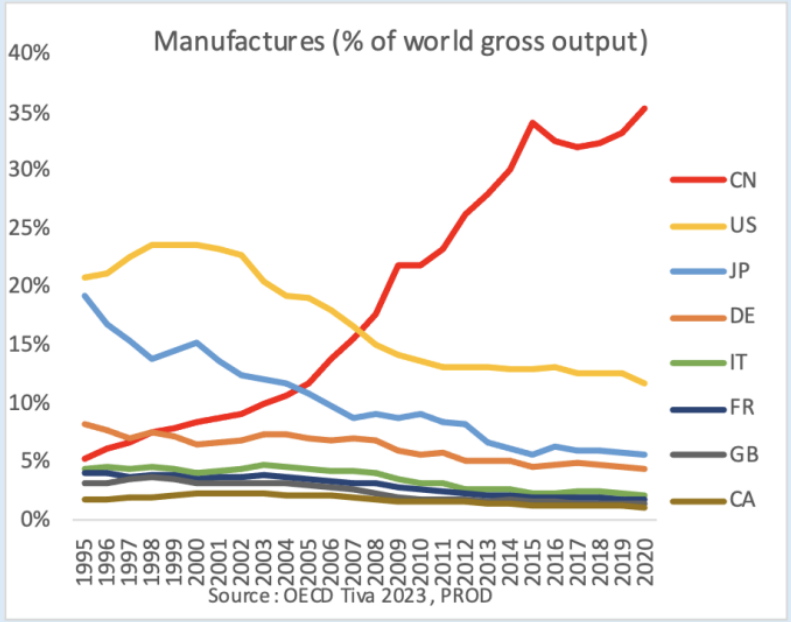


Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

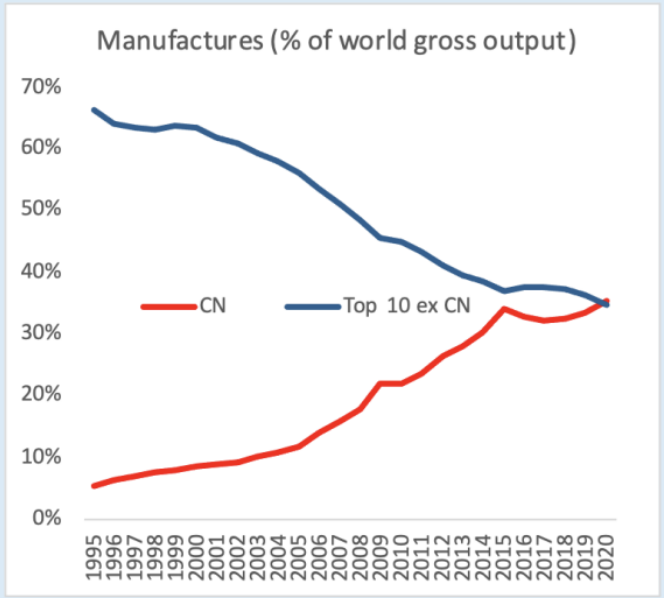
The Rise of the Factory of the World – China

World shares of gross production

G7 shares declined sharply (gross production)



China's share rose sharply (gross production)

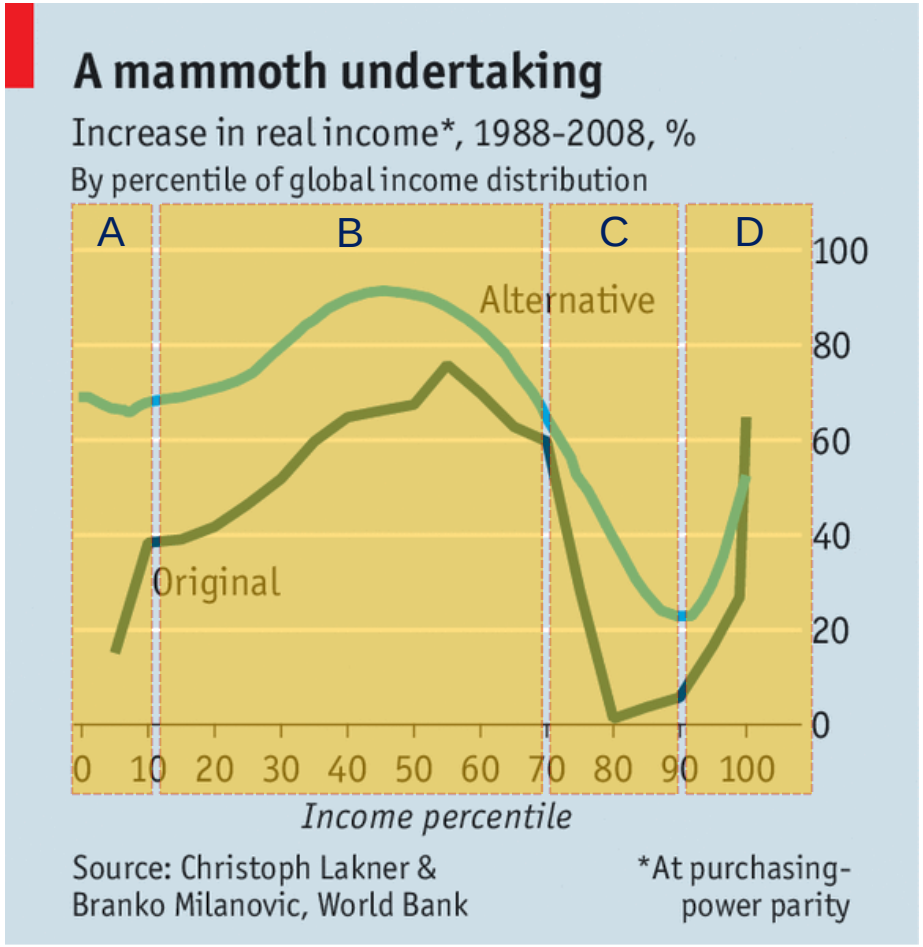


2 Source: Author's elaboration of OECD TiVA database 2023, charts based on PROD for all manufacturing sectors.

IMD

Source: *https://cepr.org/voxeu/columns/china-worlds-sole-manufacturing-superpower-line-sketch-rise*

Global Income Growth – From 1988 to 2008



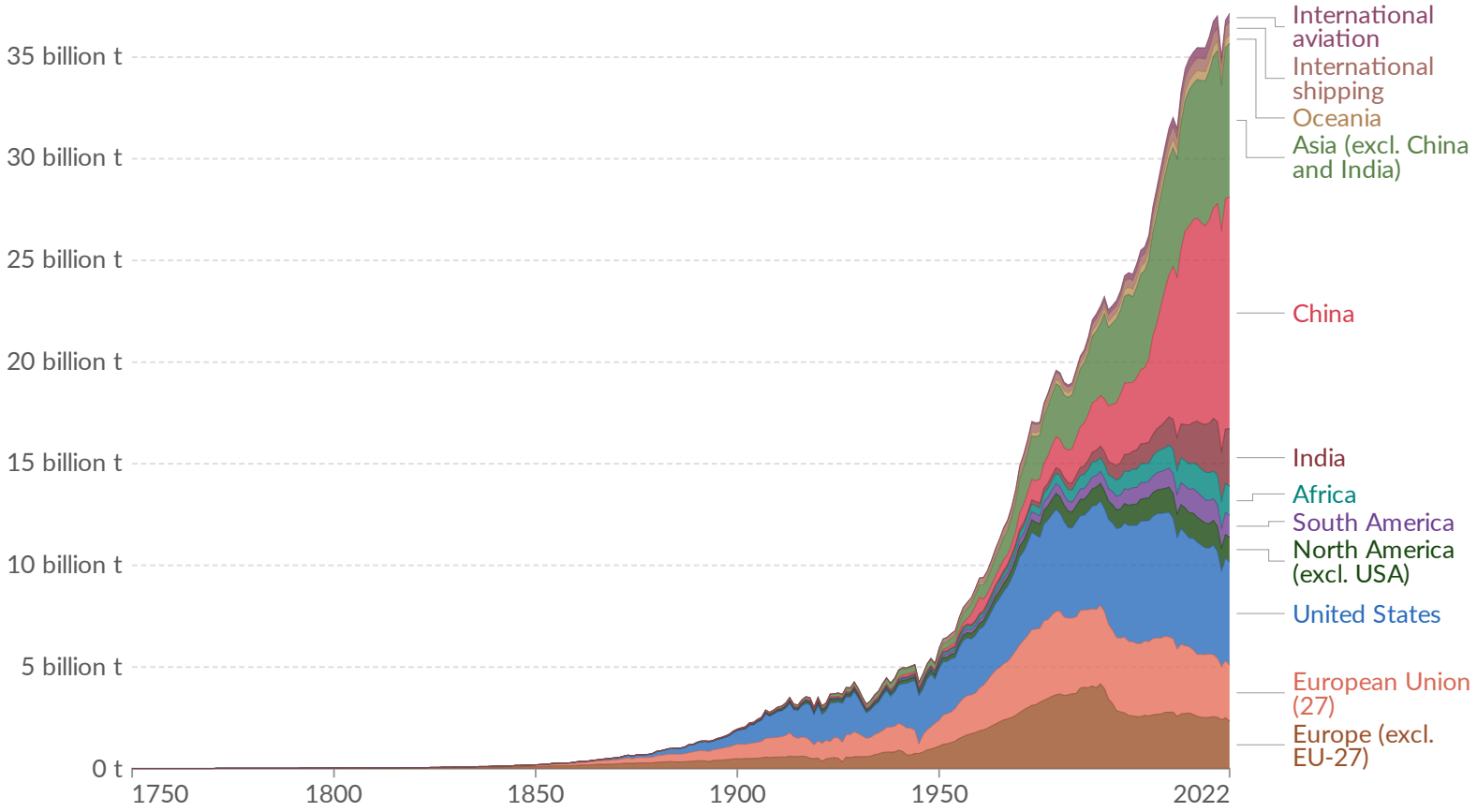
- **A:** Poorest locked out of growth
- **B:** Rising incomes in emerging economies – mainly China
- **C:** Decline of developed-world middle class
- **D:** Booming global elite

Source: *The Economist*, 2016 (*https://www.economist.com/finance-and-economics/2016/09/17/shooting-an-elephant*)

Annual CO_2 emissions by world region

Our World in Data

Emissions from fossil fuels and industry[1] are included, but not land-use change emissions. International aviation and shipping are included as separate entities, as they are not included in any country's emissions.



Data source: Global Carbon Budget (2023)

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

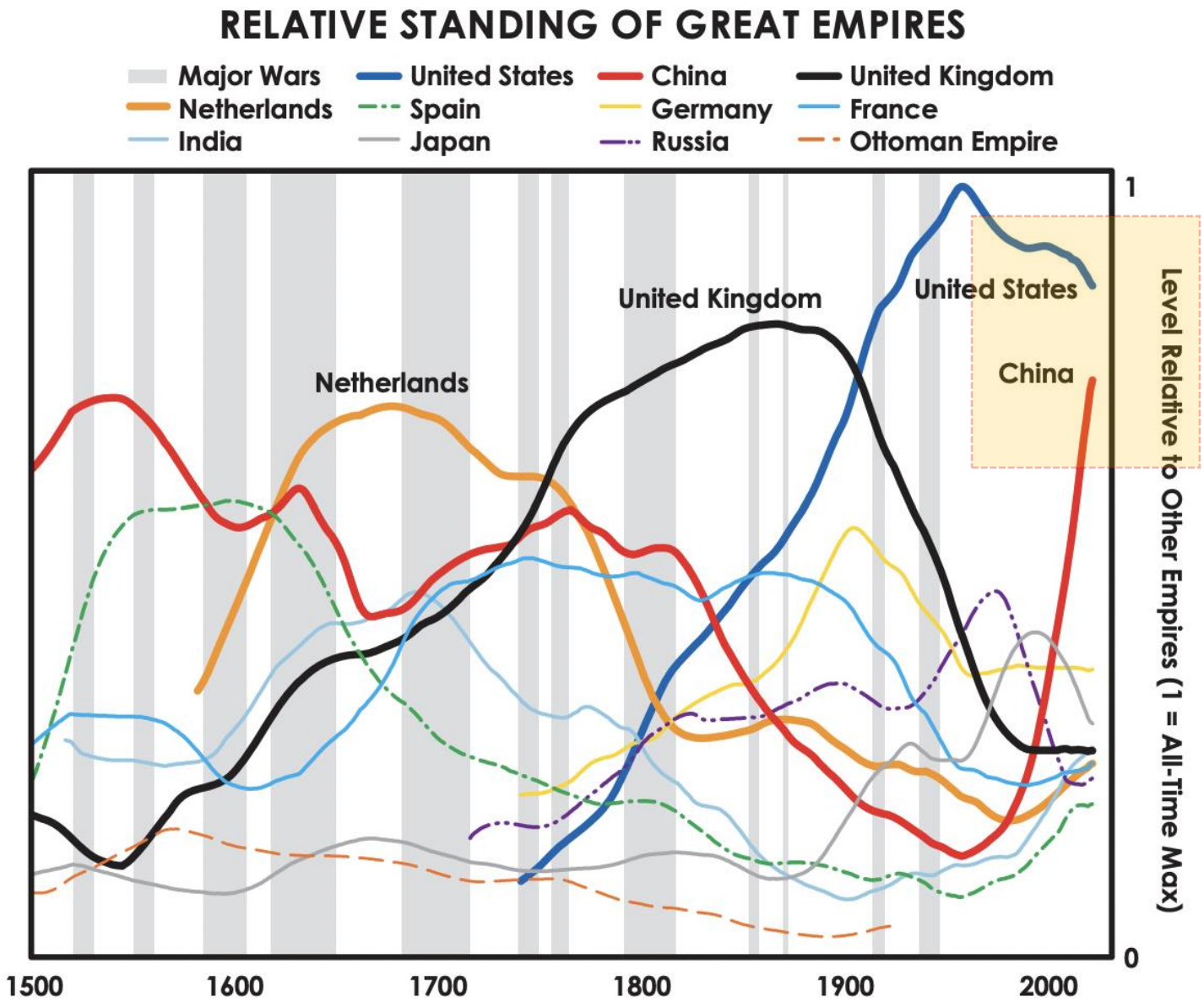
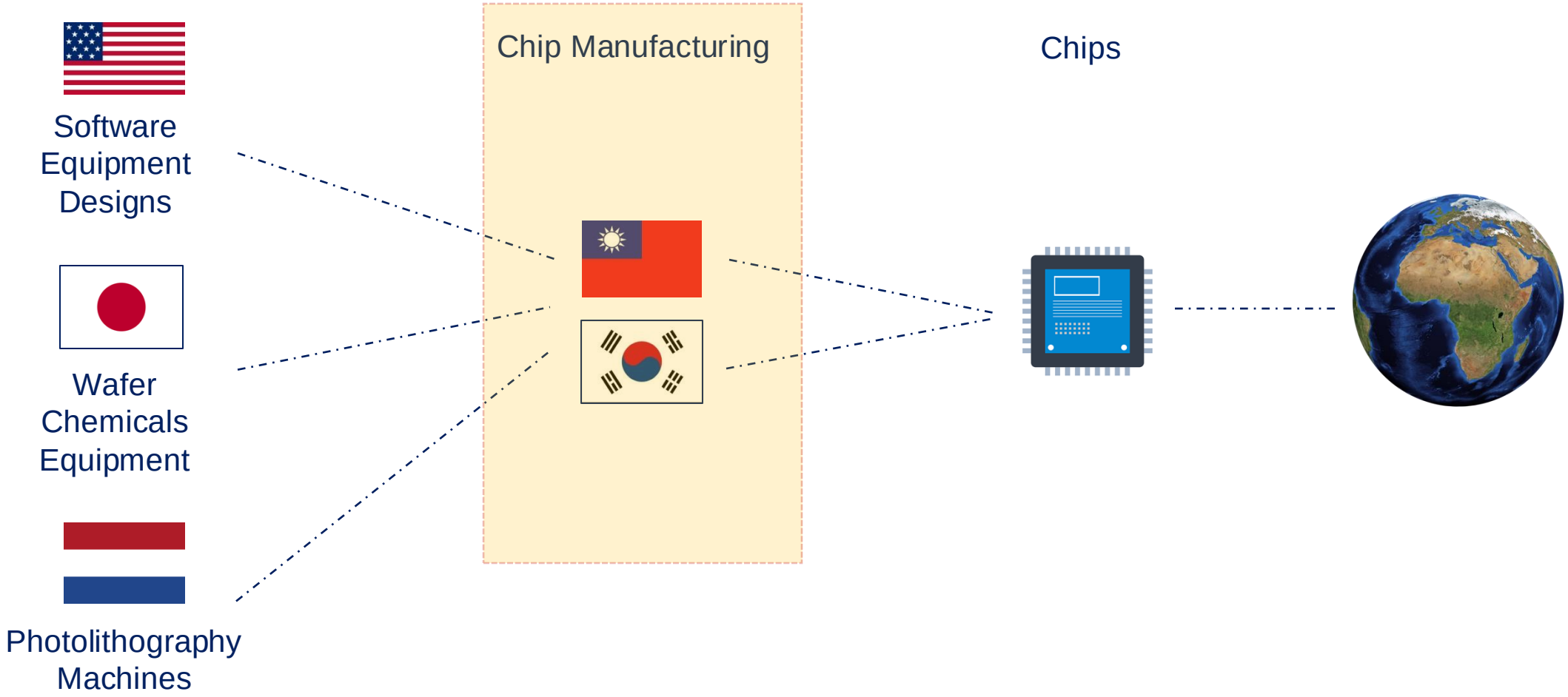
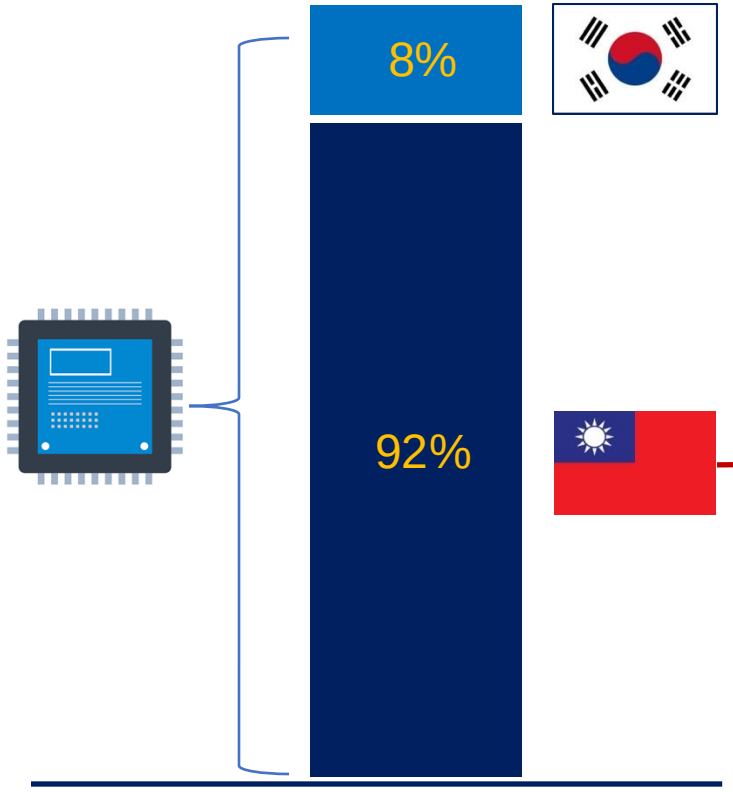


Chart Source: *Changing the world order, Ray Dalio, 2021*

Simplified Chip Supply Chain



Making of Advanced Chips – Less than 10 nm



©2017 The Sankei Shimbun / JAPAN Forward

We are getting into new era of tension, distrust, and multi-sourcing!

Simplified Supply Chain – Disruptions

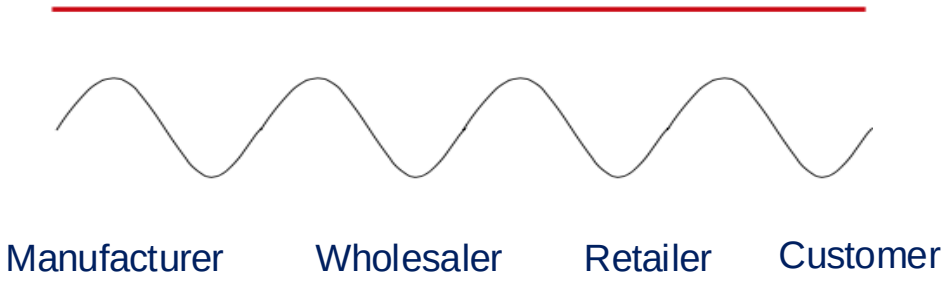
Demand disruption

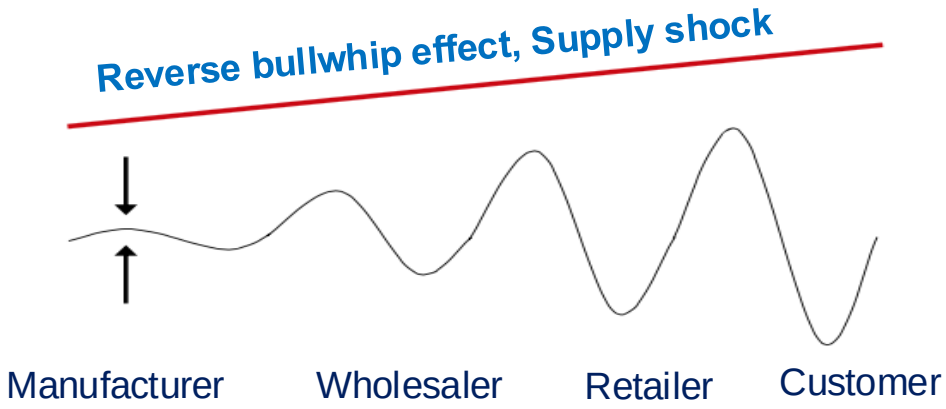
1. Demand processing (forecast error)
2. Leadtime variability
3. Order batching (lot-sizing)
4. Promotions and forward buying (Price variation)
5. Behavioral reasons

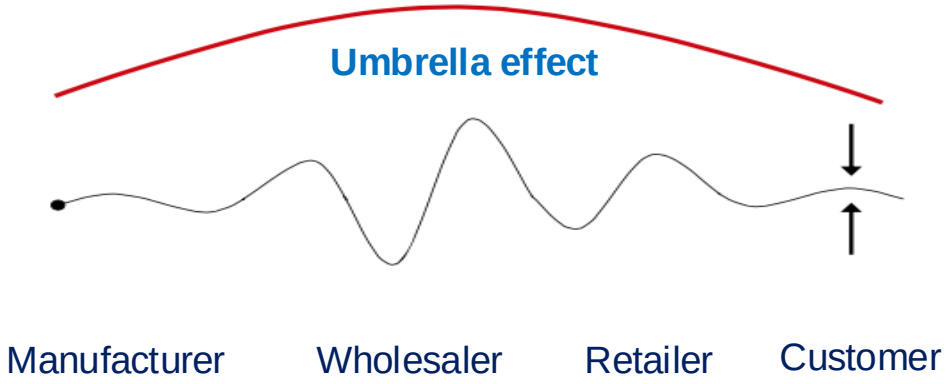
Supply disruption

1. Pandemic
2. Natural disaster
3. Capacity limitation
4. Delivery prioritization
5. Behavioral reasons

Bullwhip Effect – Types





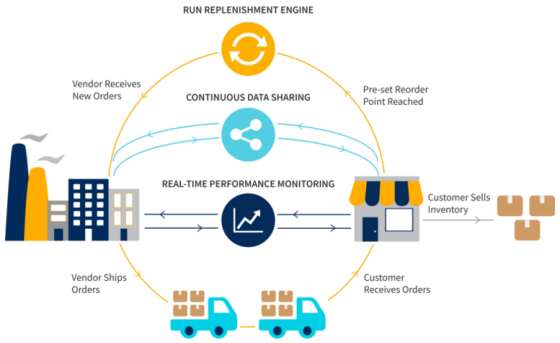


Bullwhip Effect – How to Tame it

Information sharing

Just in Time (JIT)

…

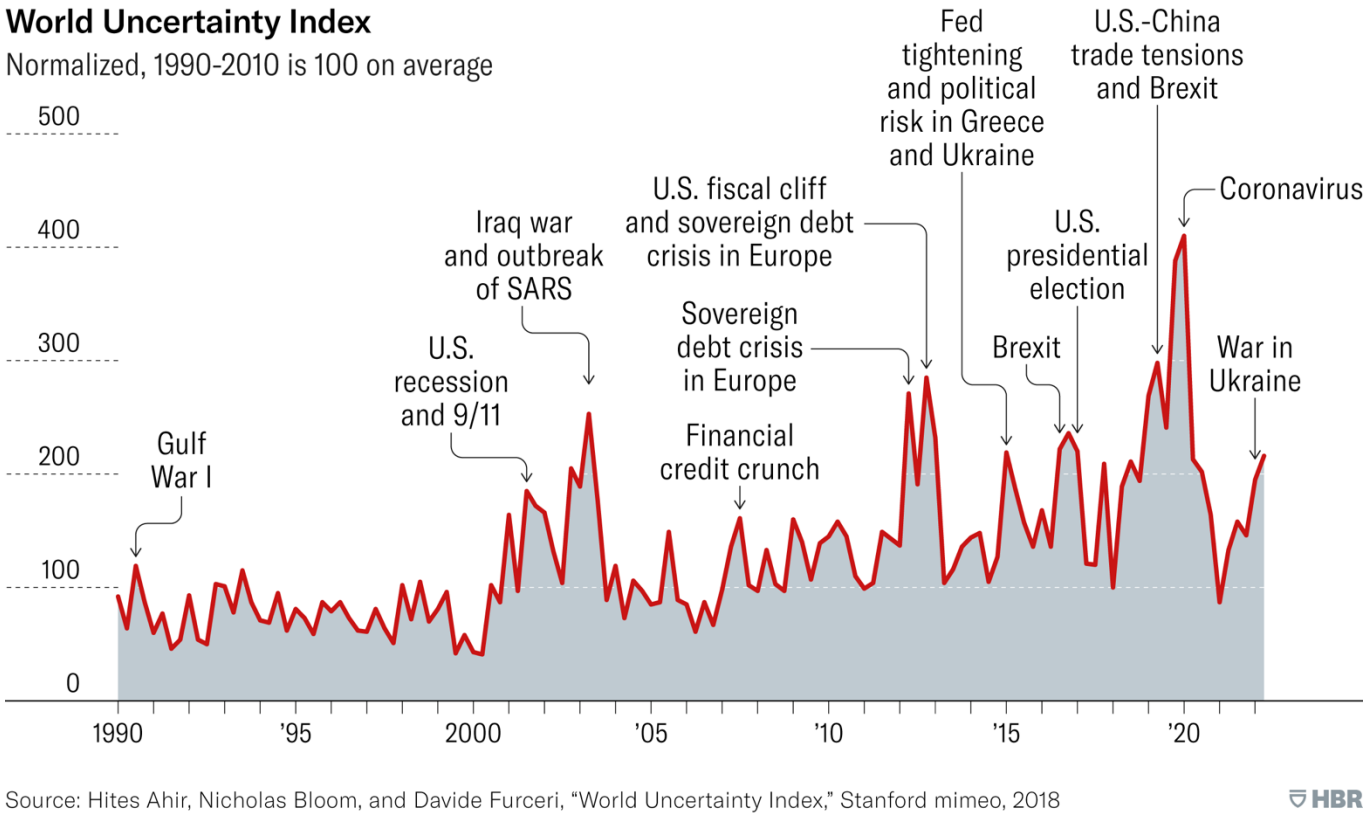


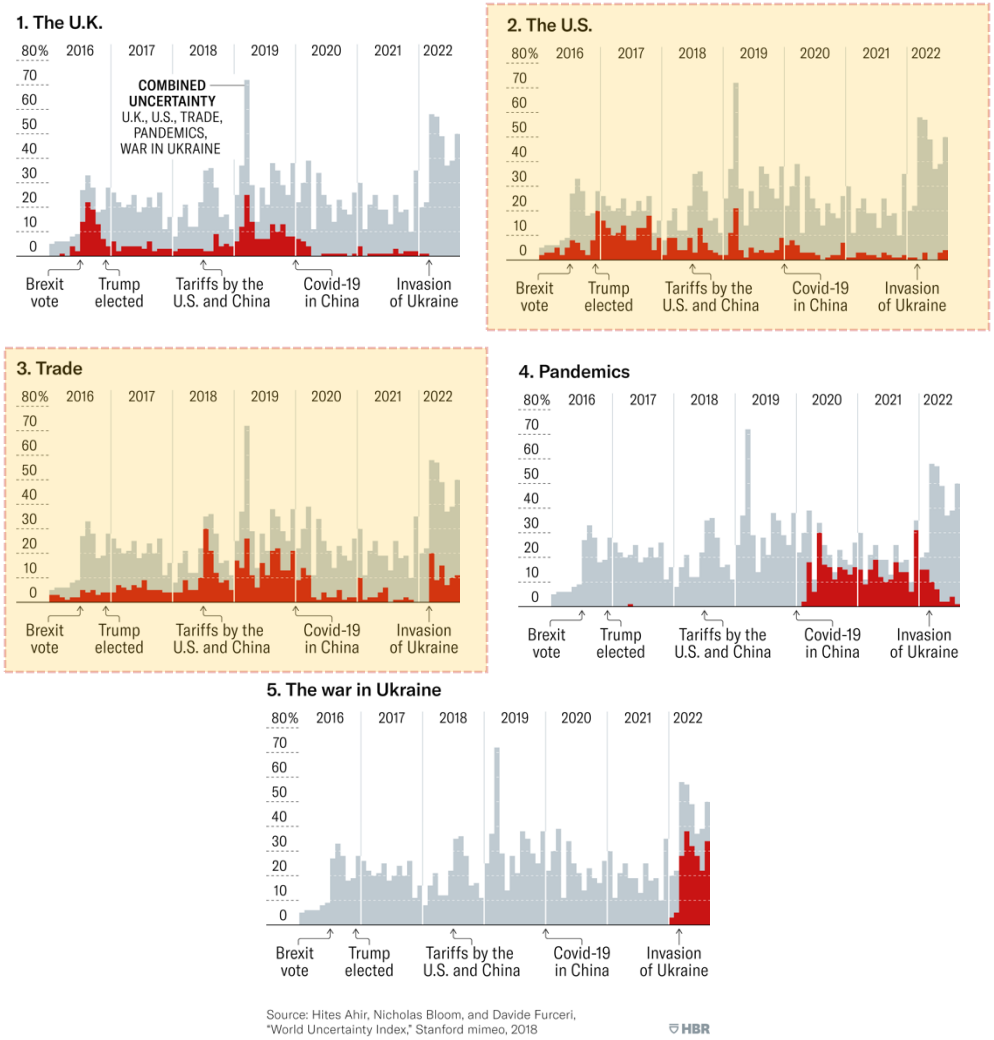
Vendor Managed Inventory (VMI)

Avoiding price games

Case 4:
Tariffs

The Rise of Economic Uncertainty – The World Uncertainty Index





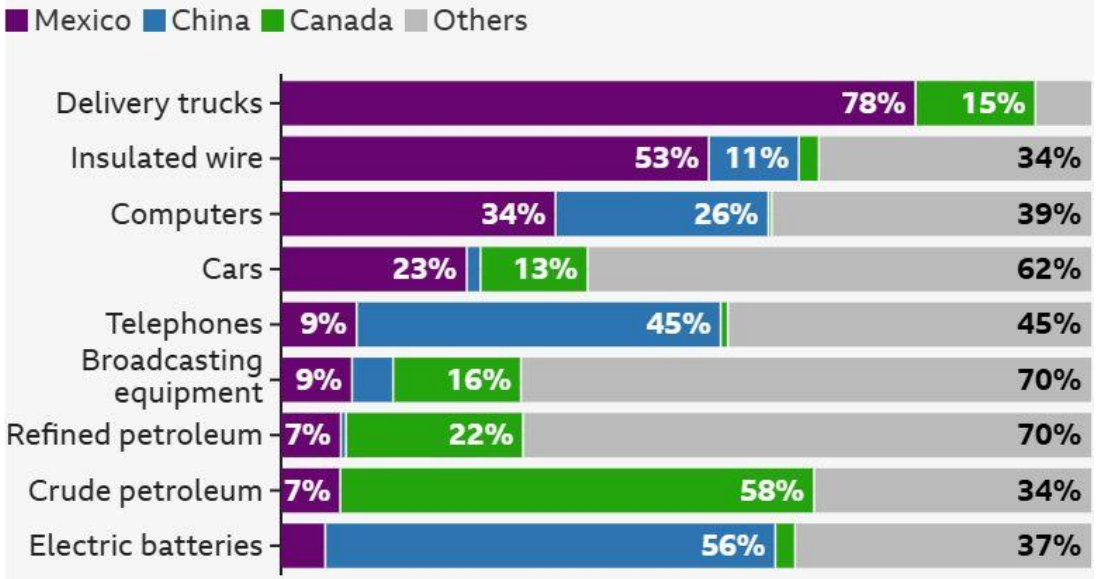
Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

US politics & policy

Trump warns tariffs will cause ‘a little disturbance’ in defiant speech

Trump's tariffs: Which products will be affected?

Key items imported to the US from Mexico, China and Canada in 2024

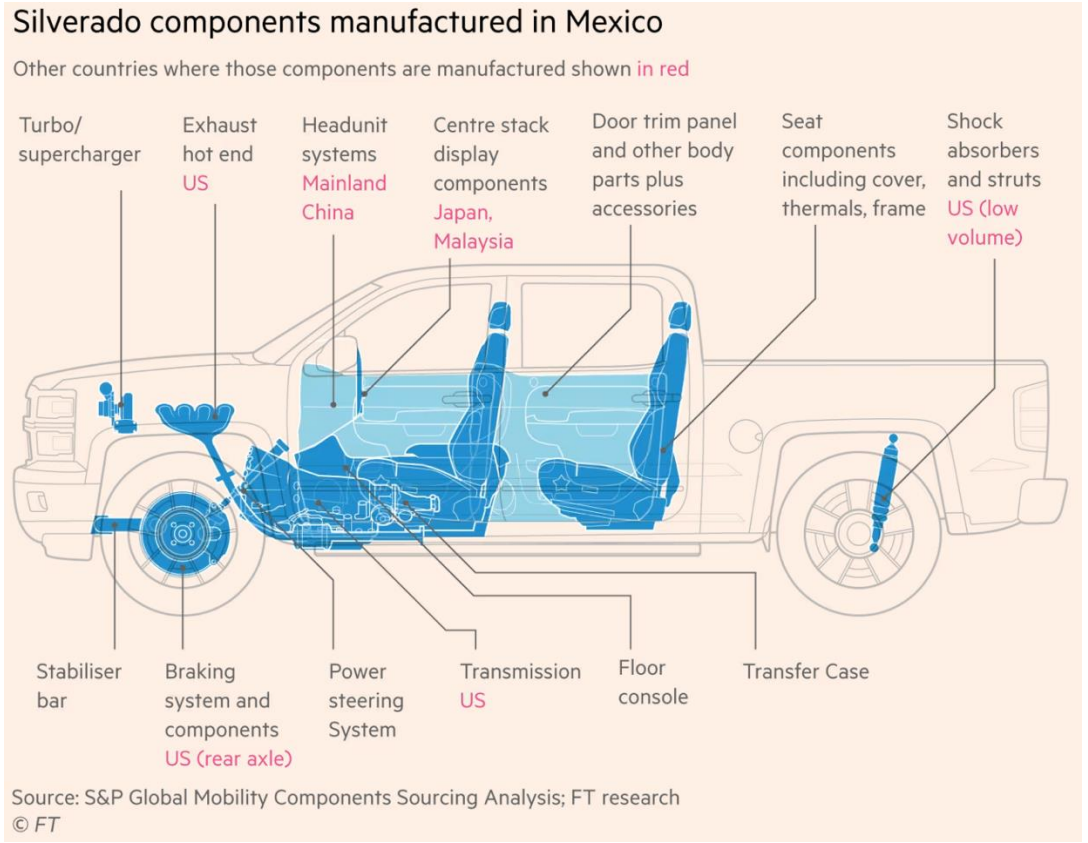


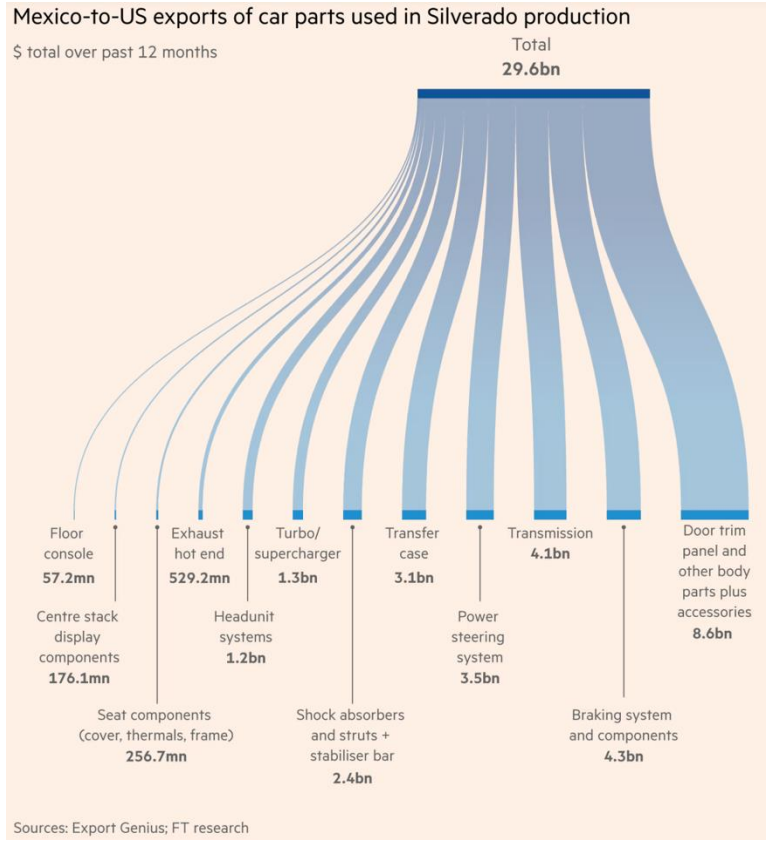
Source: US Census Bureau • BBC calculations based on item's customs value in US$
2024 data through November

BBC

How Donald Trump’s Tariffs Threaten an Iconic US Pick-up Truck

The Chevrolet Silverado remains one of America’s most popular pick-up trucks © https://www.chevrolet.com/trucks/silverado/1500





Source: *https://www.ft.com/content/fb55f297-7e29-4215-a67f-4217e1a026d6*

Copper smelting industry reels from threat of tariffs and China rivals

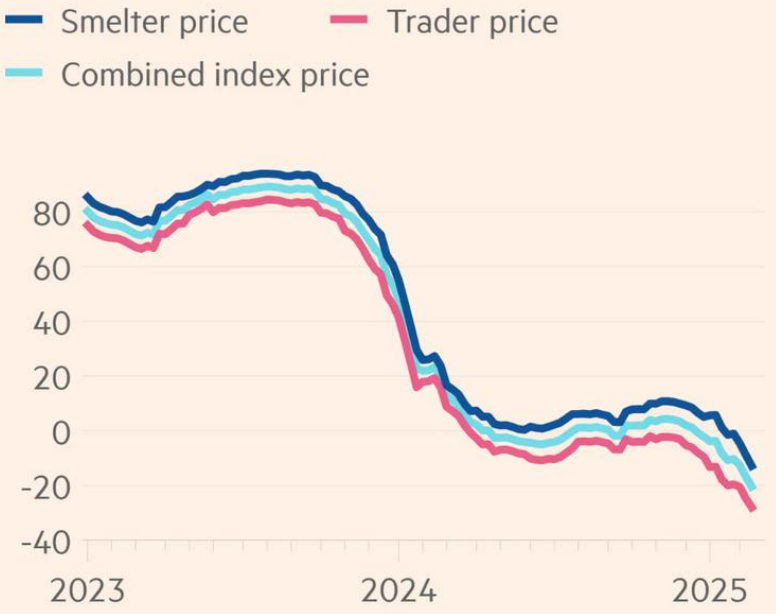
Fees charged to transform ore have fallen to all-time lows as Glencore halts operations at Philippines plant

Global copper smelters are struggling to compete with rivals in China, which have rapidly built facilities and control about half of smelting capacity worldwide © Oliver Bunic/Bloomberg

Camilla Hodgson in London 3 HOURS AGO 2

Copper processing fees have fallen to all-time lows

Spot market price ($/tonne)

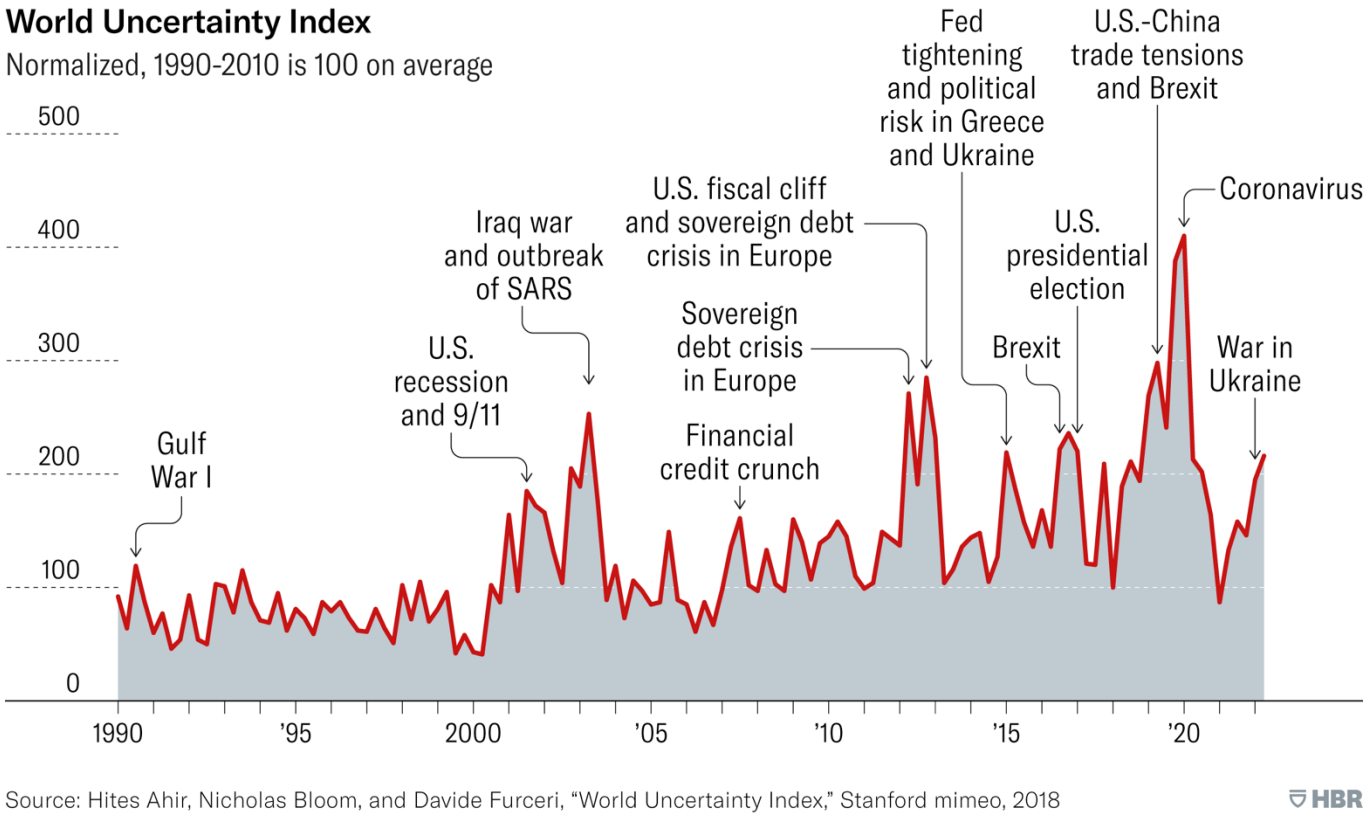


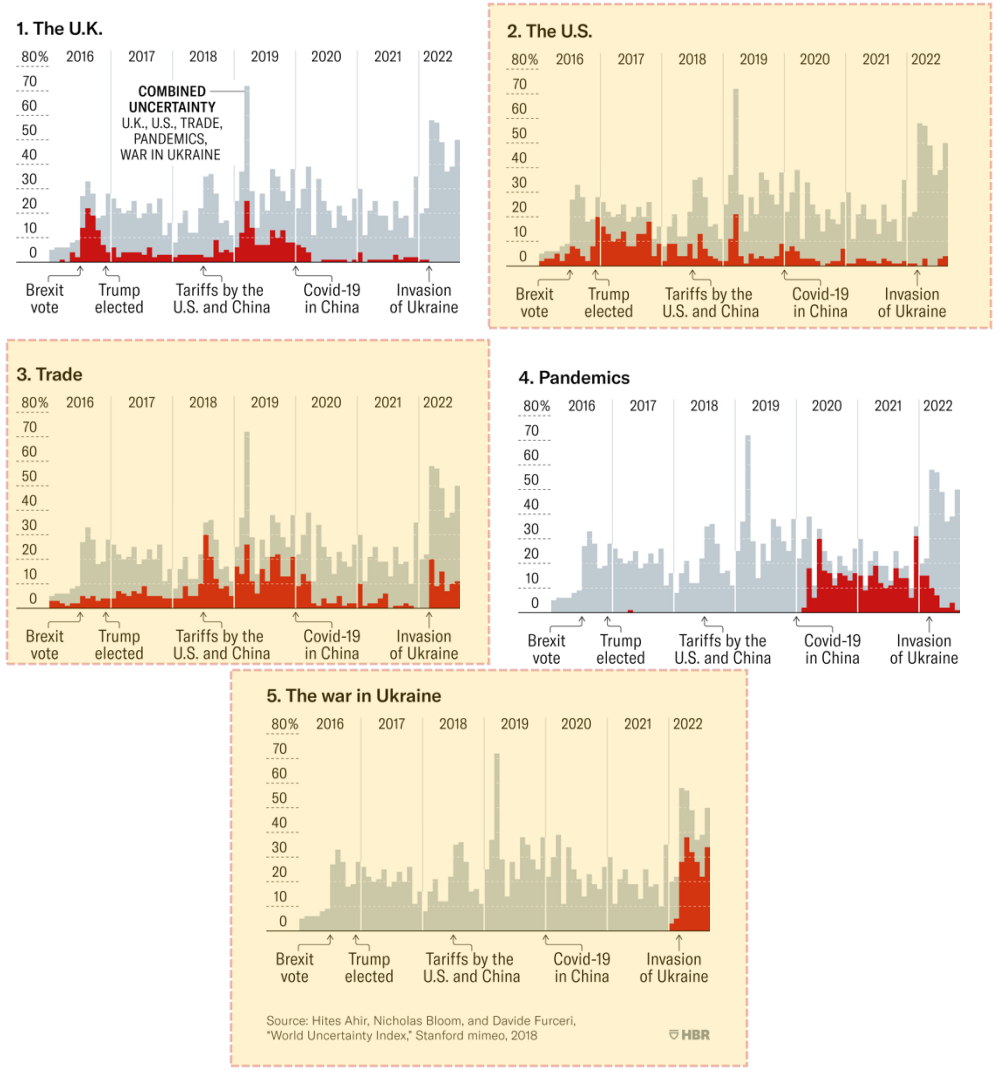
Copper concentrates treatment charge index. Smelter and trader buying prices and midpoint index
Source: Fastmarkets

Source: *https://www.ft.com/content/a4631d66-0d73-42fc-9e76-dfc6172c97d9*

What’s Next?

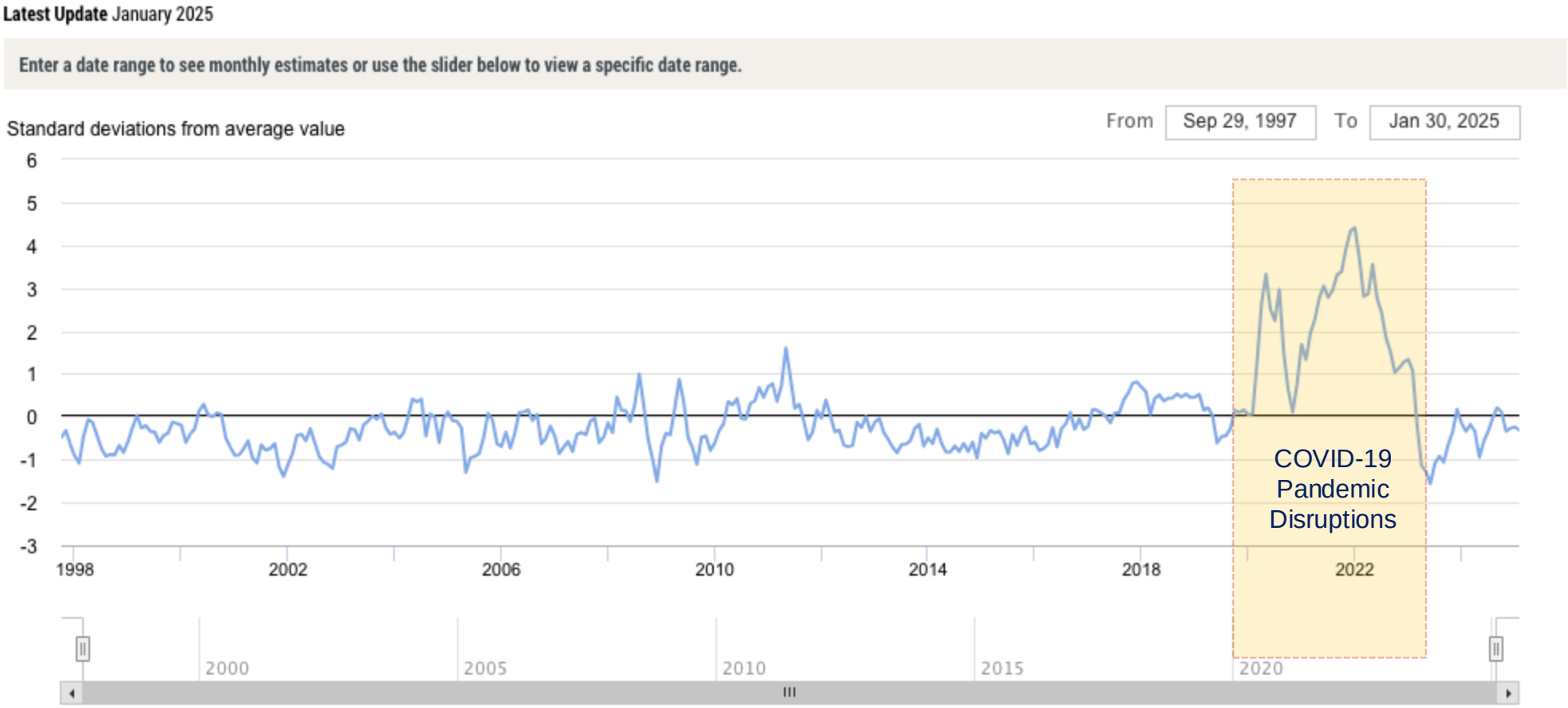
The Rise of Economic Uncertainty – The World Uncertainty Index





Source: *Harvard Business Review, 2022 (https://hbr.org/2022/09/visualizing-the-rise-of-global-economic-uncertainty)*

Global Supply Chain Pressure Index (GSCPI)



Data Source: *Bureau of Labor Statistics; Harper Petersen Holding GmbH; Baltic Exchange; IHS Markit; Institute for Supply Management; Haver Analytics; Refinitiv; authors' calculations.*

Chart Source: *Federal Reserve Bank of New York, 2025 (https://www.newyorkfed.org/research/policy/gscpi#/overview)*

Sustainable Products & Supply Chains (ME-203)

Rethinking Supply Chain for Greater Efficiency, Resilience, Sustainability

Amin Kaboli

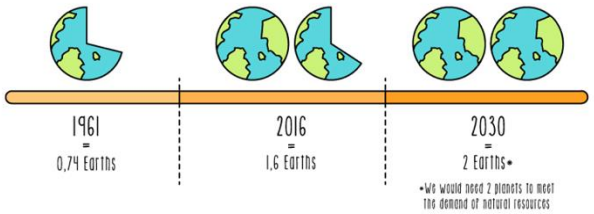
Week 3 – Session 3 – March 06th, 2025

Efficiency

Using the least number of inputs to achieve the highest amount of output.

Environmental Impact of Products & Supply Chains

60%



of earth's resources that it can regenerate every year; meaning we are using about 1.6 earths yearly.

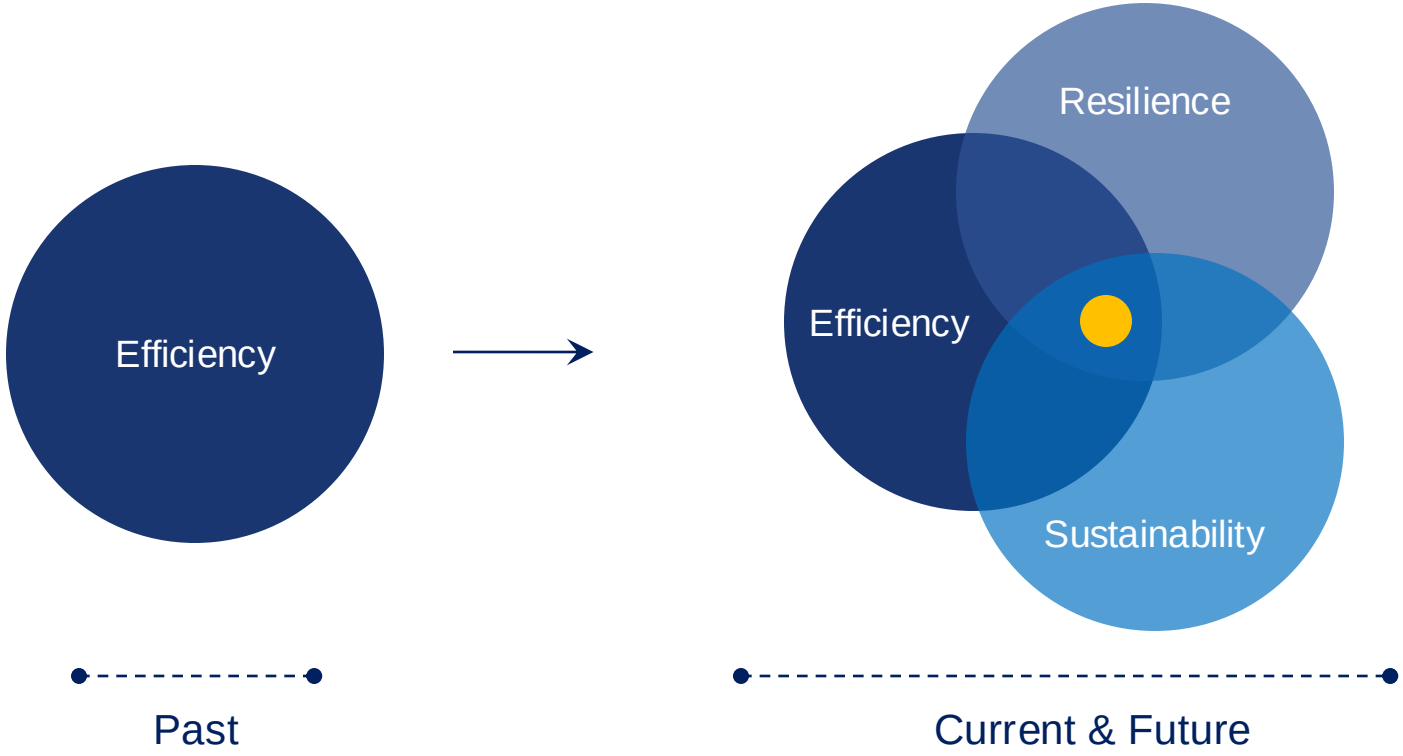
Source: WWF World Wildlife Fund

2 Billion tons

Solid waste yearly produced in the world and it is expected to grow to 3.4 billion tons by 2050. About one-third of that waste is not managed properly!

Source: THE WORLD BANK

Supply Chain Challenges – Past, Present, Future



Resilience

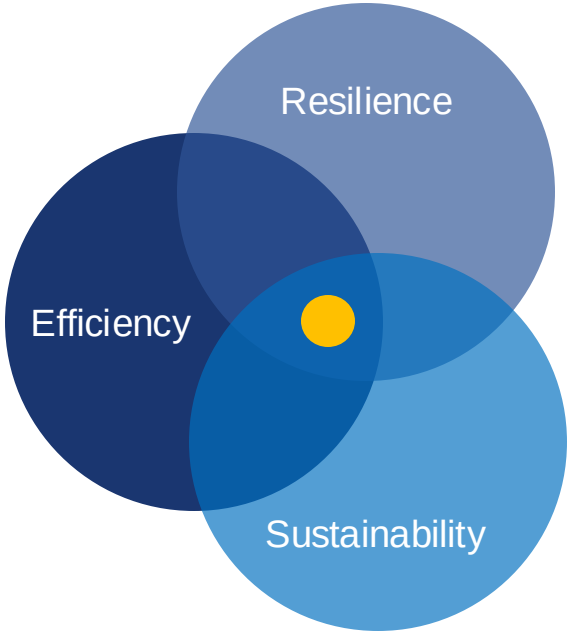
The capacity to withstand or to recover quickly from difficulties.

Sustainability

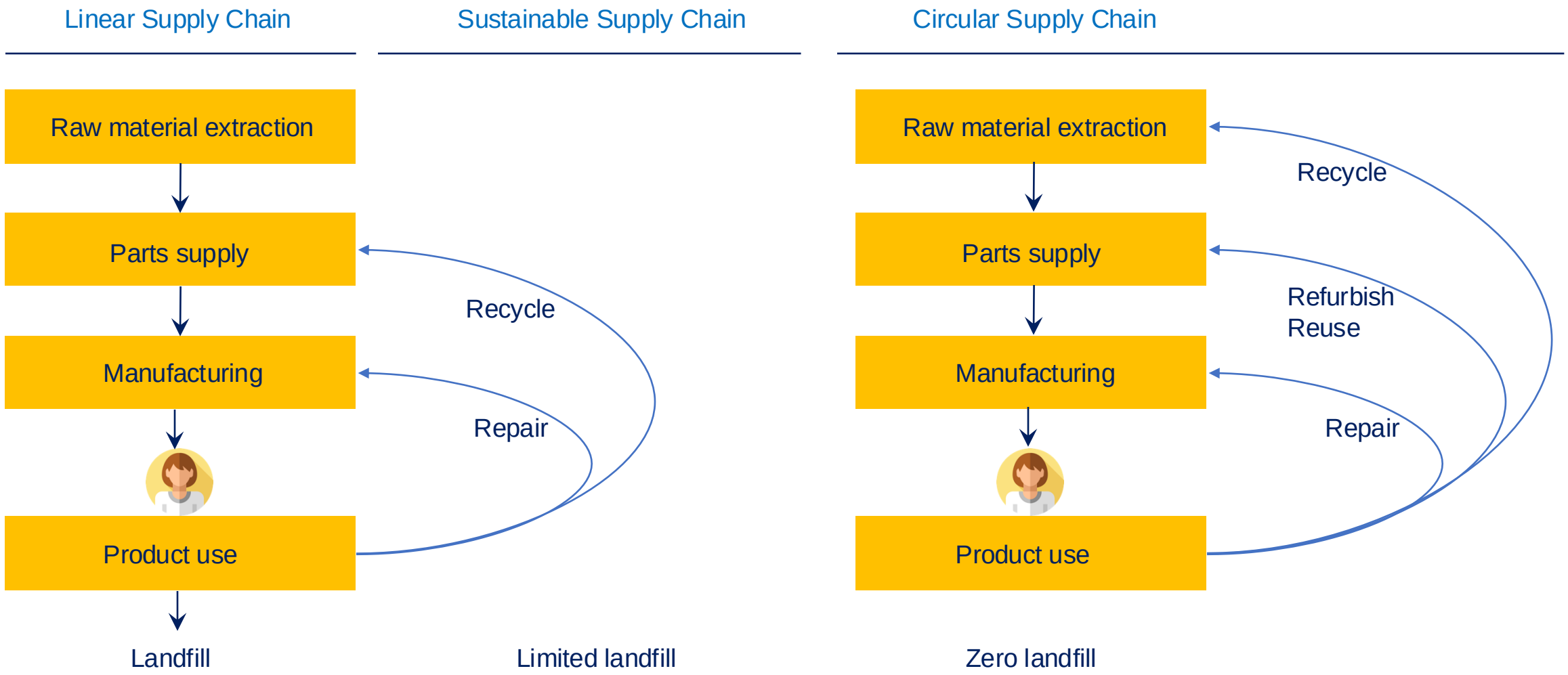
Meeting present needs without compromising the ability of future generations to meet their own needs (Brundtland Report, 1987). Main dimensions: environmental, social, and economic.

Note: **sustainability** is the goal—a state of balance while **sustainable development** is the process—the actions taken to achieve sustainability.

How can supply chains be redesigned to enhance efficiency, resilience, and sustainability?



From Linear, Sustainable, Circular Supply Chains

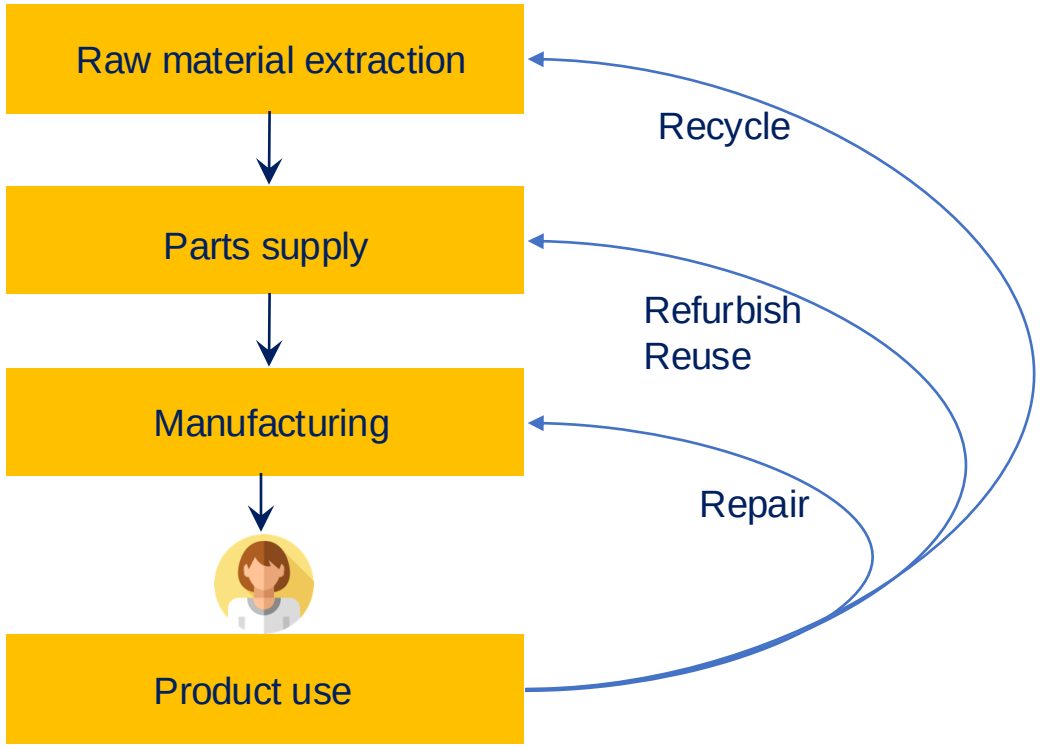


Circular Supply Chains

Circular supply chain management is the integration of **circular thinking** into the management of the supply chain and its surrounding industrial and natural ecosystems.

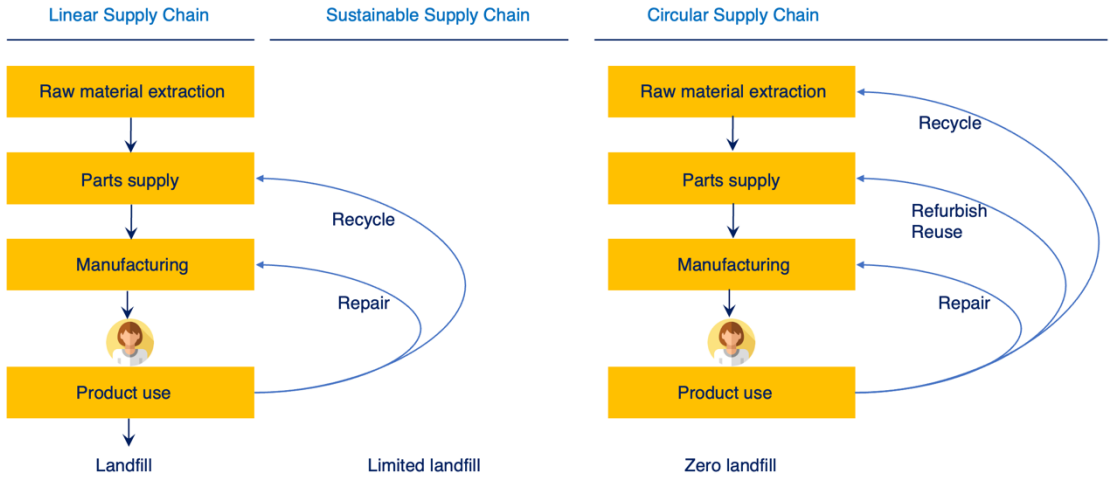
It systematically **restores** technical materials and **regenerates** biological materials toward a zero-waste vision through system-wide innovation in business models and supply chain functions from product/service design to end-of-life and waste management , involving all stakeholders in a product/service lifecycle including parts/product manufacturers, service providers, consumers, and users.

Source: *https://www.sciencedirect.com/science/article/pii/S0959652619314003*



Zero landfill

From Linear, Sustainable, Circular Supply Chains



Aspect	Traditional Supply Chains	Sustainable Supply Chains	Circular Supply Chains
Strategy	Focus on component price	Cost of ownership approach	Leasing and service-based outcomes
Structure	Linear and open	Partially closed	Closed, short, and cascaded loops
Flow	Input-output	Mixed throughput	Biological and technical cycles
Focus	Efficiency-driven	Customer effectiveness	Collaborative value creation
Scale	High volume production	High to medium volume	Medium to low volume
Scope	Global reach	Global and regional	Regional and local

Source: *https://www.tandfonline.com/doi/full/10.1080/09537287.2018.1449244*

Clothing & Personal Equipment – Dutch Army (KPU)

DUTCH CIRCULAR INGENUITY

While there are almost endless possibilities for circular efficiencies for Member States' militaries, some are more obvious than others. One surprising source is soldiers' clothing and personnel items, as shown by the Dutch Defence Ministry.

Traditionally, any used workwear and gear would be incinerated to prevent misuse, which meant everything had to be entirely replaced. It was also expensive, costing the MoD €500 000 per year to destroy materials that still had re-use value in them. In 2017, the government's central procurement entity for clothing and personnel equipment, known as KPU, began applying circular principles to its purchases of uniforms, helmets, specialised gear, and other personnel equipment for the 60,000 personnel across the country's navy, army, air force, and military police. The goal was to extract re-useable materials, extend all the items' service life, and thus reduce waste.

KPU's textile recovery effort now generates additional annual revenues of €750,000 for the Ministry, while saving 14,500 tonnes of CO2 each year – a sterling example of smart procurement via closed-loop recycling.

Source: *https://eda.europa.eu/webzine/issue20/in-the-field/advancing-circular-economy-in-defence*

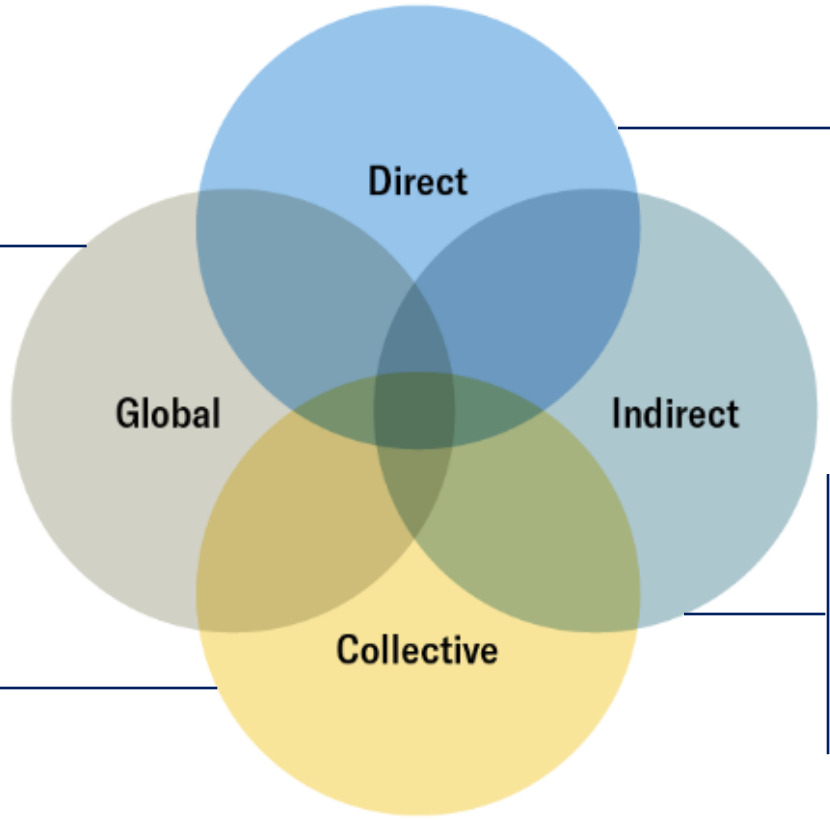
Strategies

1.

Establishing Long-term Sustainability Goals & Including Lower-tier Suppliers

Managing Lower-Tier Supplier Sustainability

- Work closely with relevant NGOs and international institutions interested in improving supply chain sustainability.
- Use tools and data that those organizations provide for dealing with suppliers (contracts and scorecards).
- Recognize suppliers that excel in programs sponsored by NGOs and international institutions.



- Evaluate first-tier suppliers by using sustainability performance indicators that capture their requirements for lower-tier suppliers.
- Survey suppliers on their environmental, health, safety, and labor practices and on their procurement practices.
- Work with major first-tier suppliers to map the firm's supply network.

- Commit to developing and complying with industrywide sustainability standards, and help suppliers become full members of industry organizations.
- Via industry organizations, share resources with competitors and major suppliers to achieve sustainability goals.
- Encourage first- and lower-tier suppliers to take advantage of sustainability training programs offered by industry organizations.

- Provide training and foster peer learning among first-tier suppliers to help them improve their procurement practices with lower-tier suppliers.
- Select high-performing suppliers to pilot new sustainability initiatives.
- Reward suppliers for cascading sustainability requirements to lower-tier suppliers.

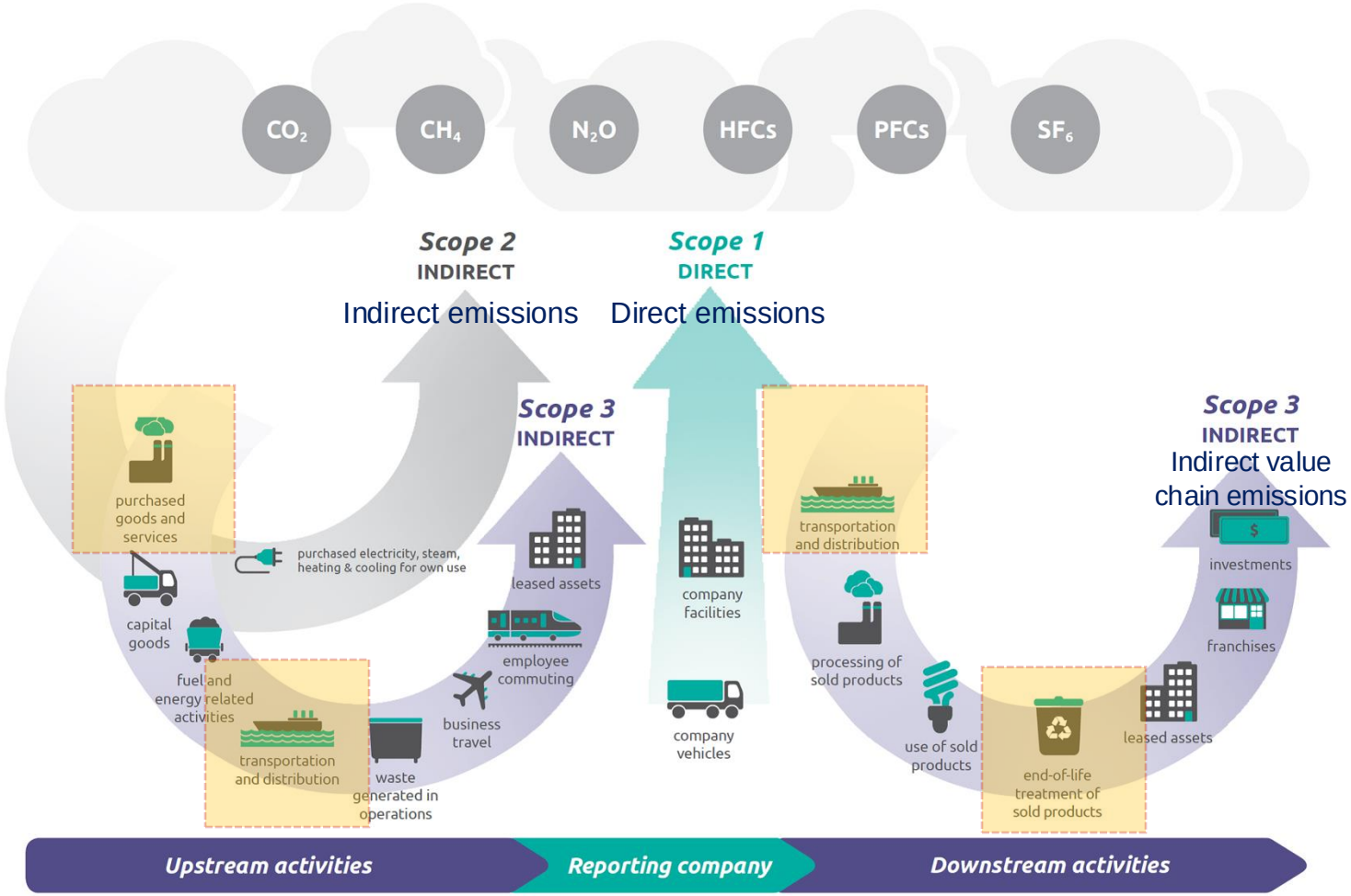
From: "A More Sustainable Supply Chain," by Verónica H. Villena and Dennis A. Gioia, March–April 2020 HBR

2.
Supply Chain Network Visibility


Control Tower
Planning
Sourcing
Production
Warehousing
Distribution
Sales
Data Transparency & Supply Chain Visibility

3.
Near-shoring
Friend-shoring

Near-shoring, Friend-shoring & Sustainability



Where Supply Chain is directly involved in scope 3.

- Scope 3 emissions represent **65-95%** of a company's carbon footprint, originating indirectly from vast networks like extensive **supply chains**.
- Addressing these emissions is complex due to **data availability, accessibility, and evolving regulations**, but it's crucial for both environmental and regulatory reasons.

Graphic Source: WRI/WBCSD Corporate Value Chain (Scope 3) Accounting and Reporting Standard (pdf)EXITEXIT EPA WEBSITE, page 5

Near-shoring, Friend-shoring

Near-shoring

a close relocation and refers to the practice of relocating business operations to a nearby country.

Friend-shoring

the act of manufacturing and sourcing from countries that are geopolitical allies, such as members of the same trade bloc or military alliance.

Near-shoring, Friend-shoring Decision

Product category (Geopolitically impacted, Market driven)

Cost of Production

Cost of Inventory

Cost of Transportation

Supply Risks

Regulations

Demand Risks

Near-shoring, Friend-shoring – Examples

Apple expands iPhone production in India in shift away from China

New Delhi has been working to lure companies seeking to diversify supply chains

Companies are seeking to diversify their production outside of China as geopolitical tension between Beijing and Washington rises
© Idrees Mohammed/EPA-EFE

John Reed in New Delhi SEPTEMBER 26 2022 86

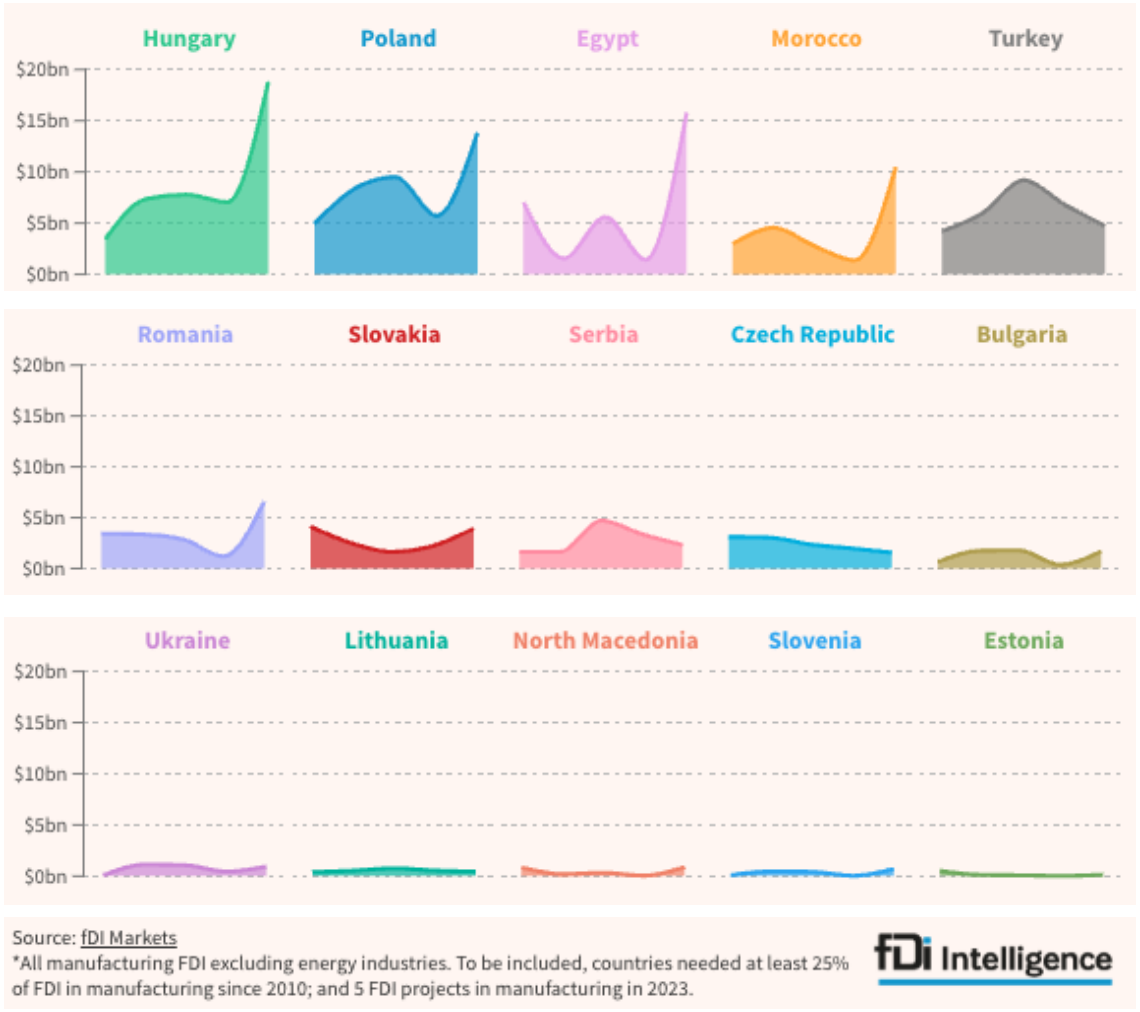
Focus: How global supply chains are falling out of fashion

By **Elisa Anzolin** and **Silvia Aloisi**

September 30, 2021 8:19 AM GMT+2 · Updated 3 years ago

[1/4] Posters offering special discount on Black Friday sales are seen in front of a United Colors of Benetton kid's fashion store, as the spread of the coronavirus disease (COVID-19) continues, in Zurich, Switzerland November 27, 2020.

EU Near-shoring, Friend-shoring Locations & Investments – 2014 to 2023

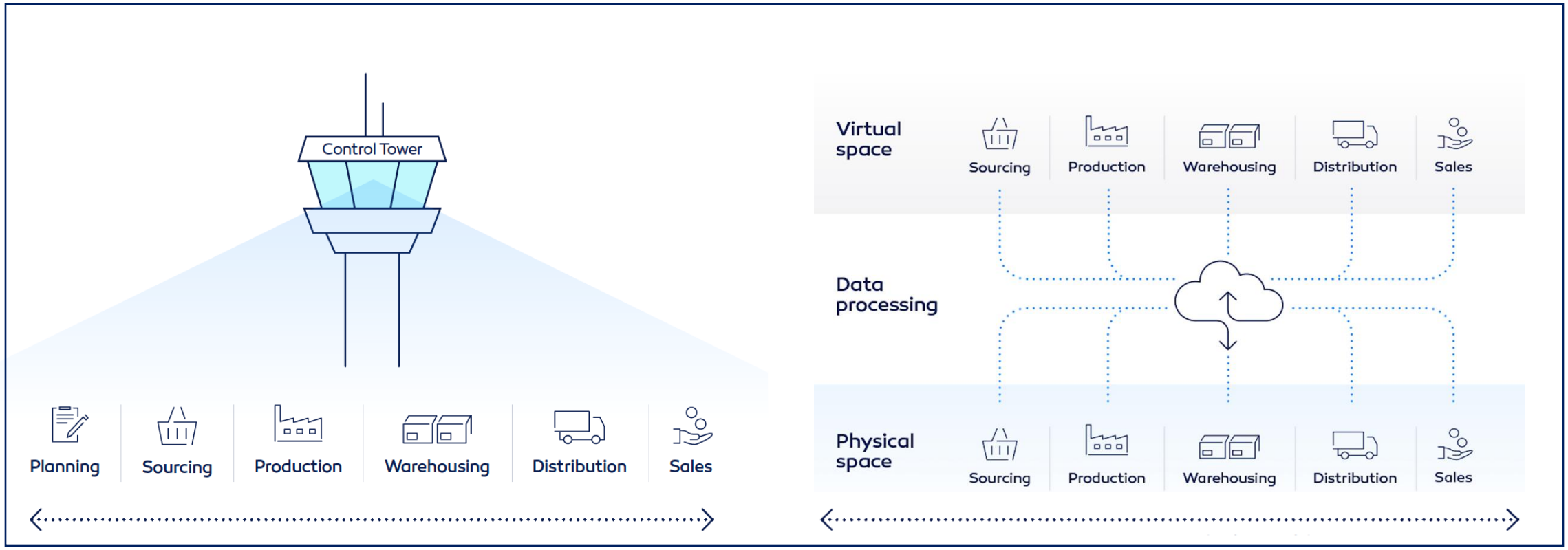


Source: fDI Markets
*All manufacturing FDI excluding energy industries. To be included, countries needed at least 25% of FDI in manufacturing since 2010; and 5 FDI projects in manufacturing in 2023.

fDi Intelligence

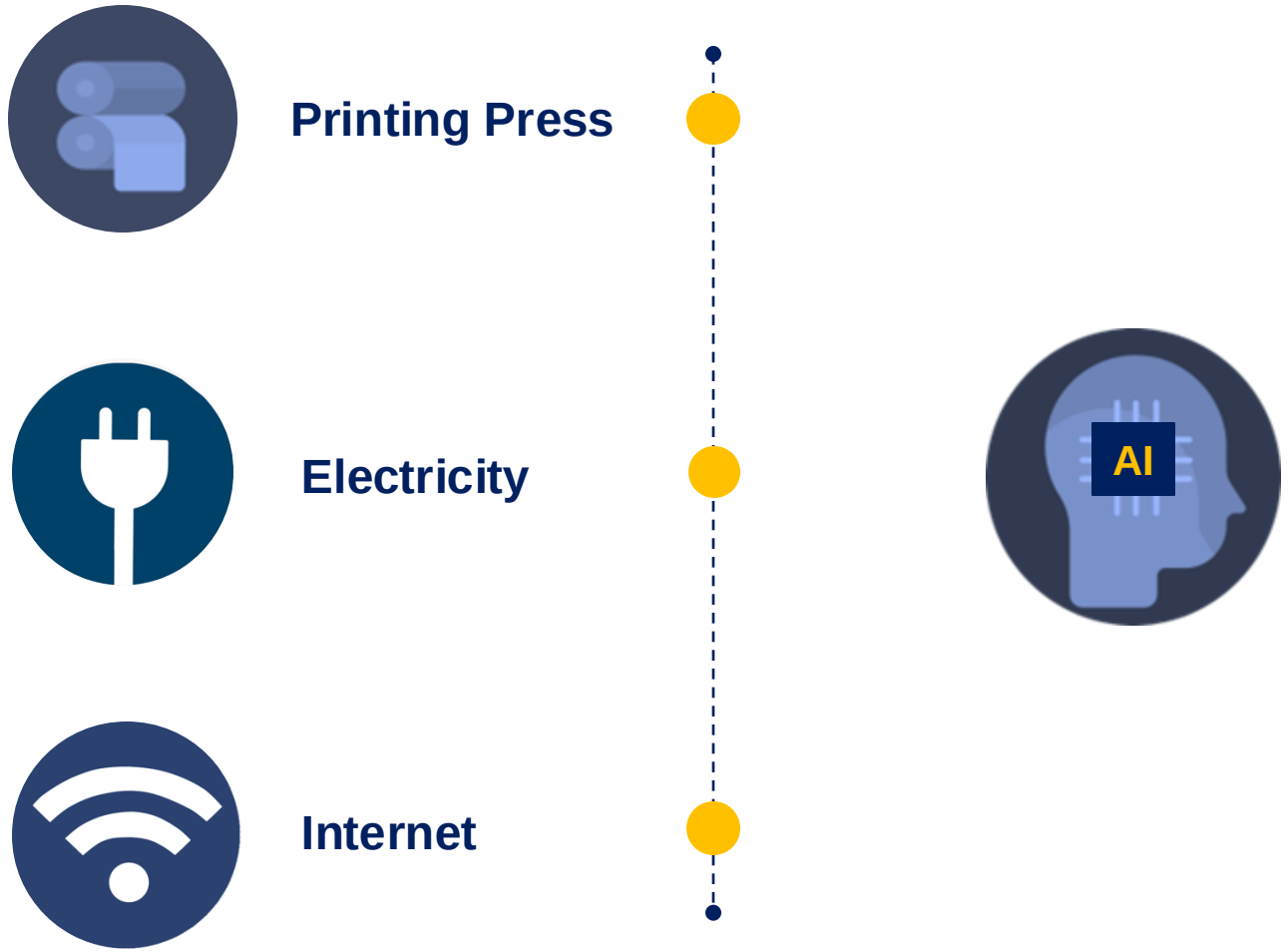
4.
Using Tech & AI

AI Enhances End-2-End SC Visibility & Transparency

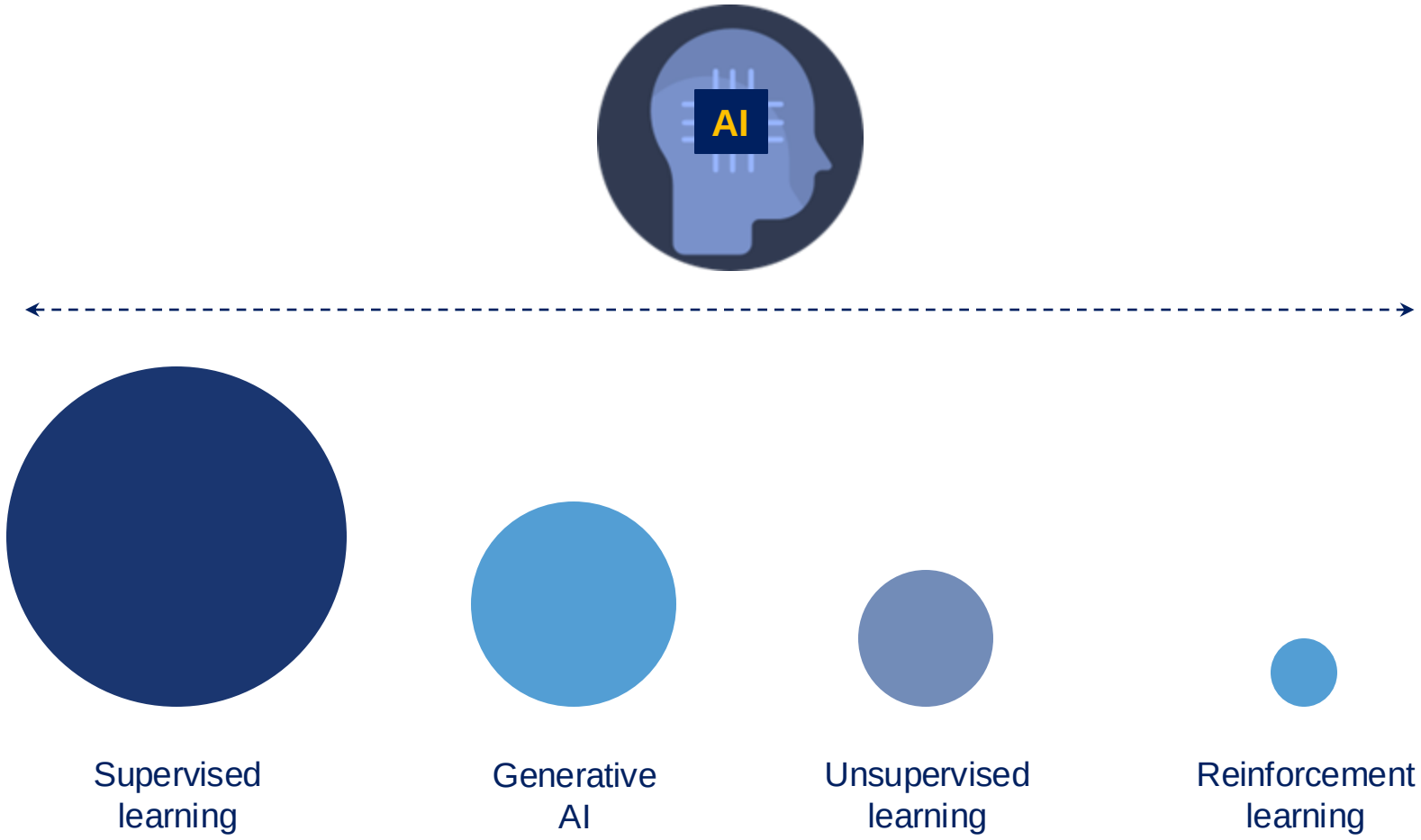


Examples: Tesla, Amazon, Haier

AI is a General-Purpose Technology



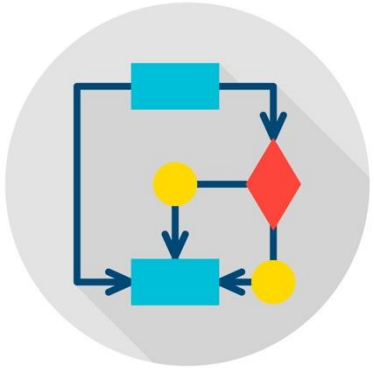
AI is a toolset



What's Driving AI Advances? – Synergies and Amplifying Effects

Data

Data from sensors in smartphones, industrial equipment, digital photos and videos, social media, …



Algorithms

Such as deep supervised learning, reinforcement learning, their results improve as the amount of training data they are given increases …

Hardware

GPU (Graphic Processing Units) used for neural nets

Its all about Speed & Scale!

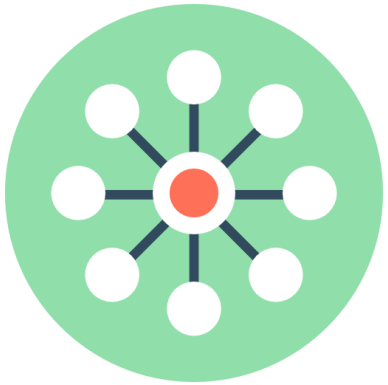
AI Drives Changes at Three Levels

Task & Occupations

Example: Machine vision to identify potential cancer cells

Business Processes

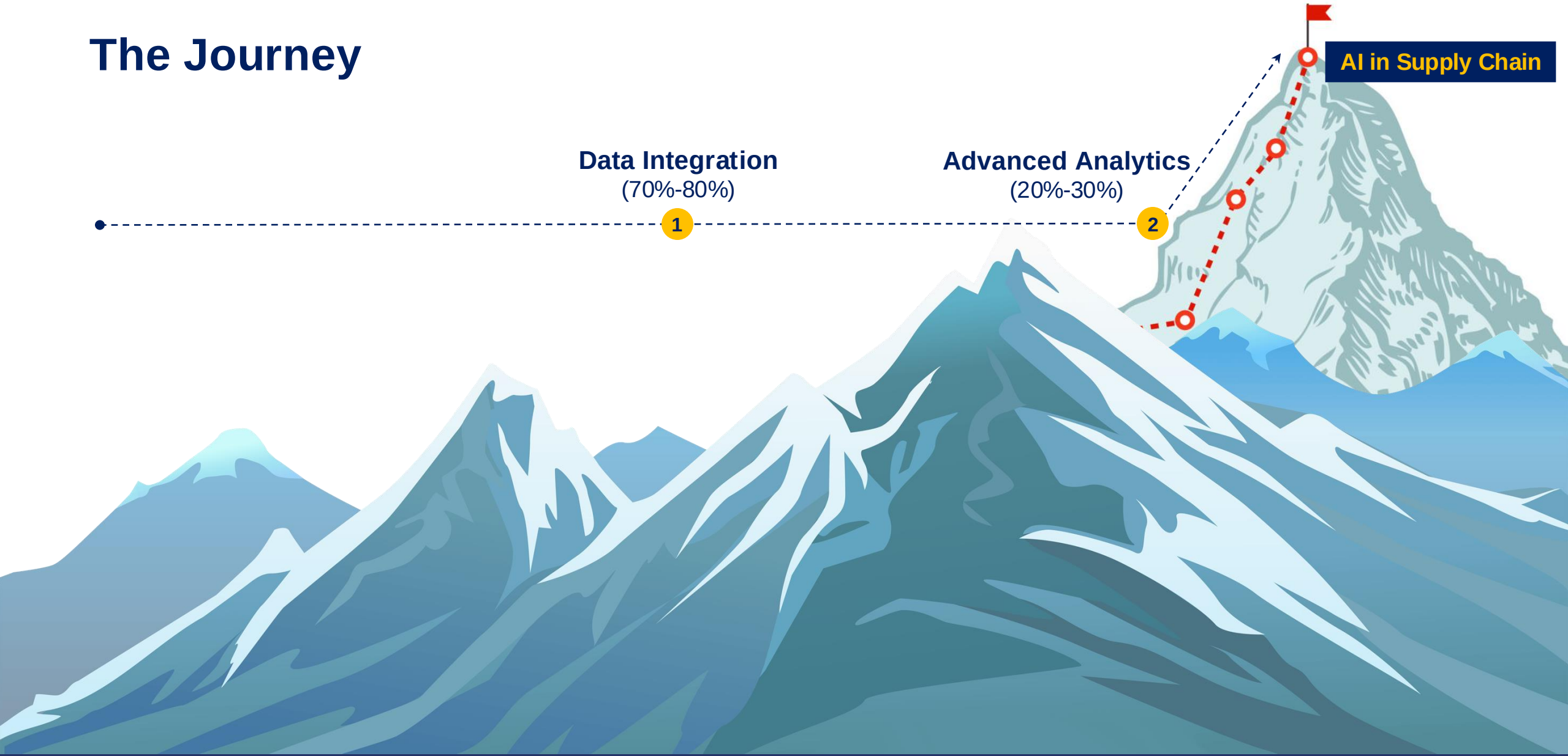
Example: Process redesign for supply chain network optimization and CO2 reduction



Business Models

Example: Experiencing music or movies personalized uniquely to your preferences

The Journey


Data Integration
(70%-80%)
1
Advanced Analytics
(20%-30%)
2
AI in Supply Chain

Case Study

Problem

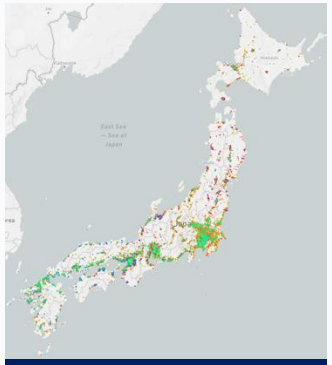
Acquisitions in Japan

DYFLEX

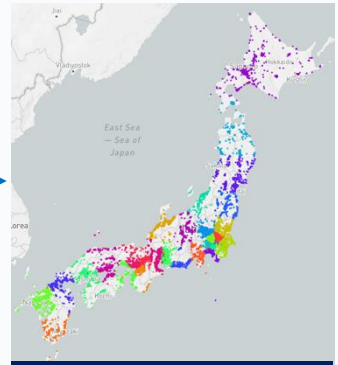
Sika®

Hamatite

Solution



Delivery / Day
84 Mio



Delivery / Day
13 Mio

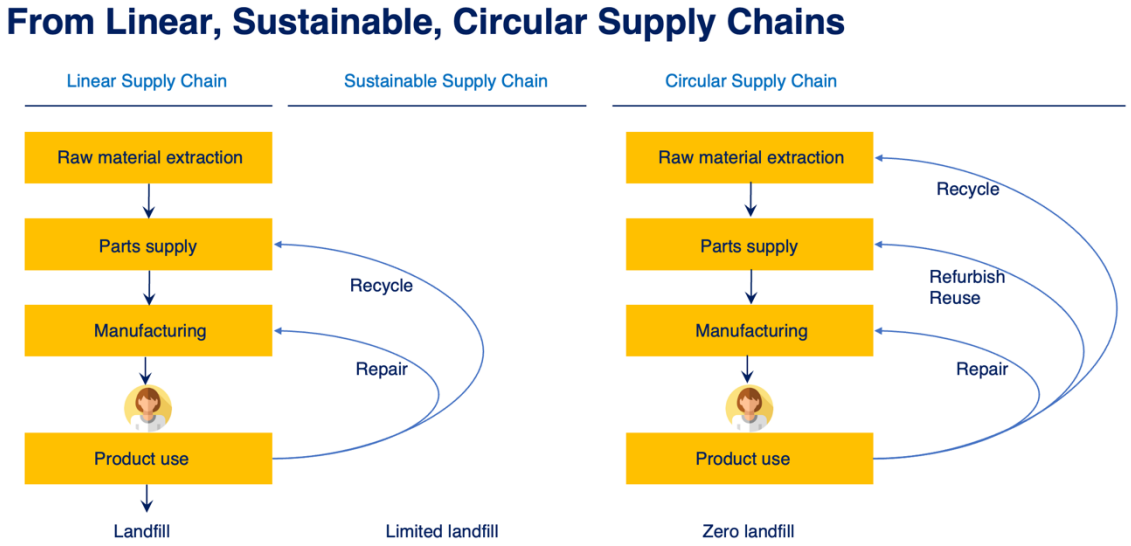
Impact

1 Month (instead of estimated 9 Months)

15% decrease in carbon footprint

20% cost saving (**$ 3 Mio**)

Why Are Circular Supply Chains So Rare?



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Source: *https://www.tandfonline.com/doi/full/10.1080/09537287.2018.1449244*

Assignment 2 – Evaluation of Current State of Your Products & Supply Chain

No.	Question
1	Describe and visualize the Bill of Materials (BoM) of your product group (from level 0 to level 4)
2	Describe and visualize the Value Adding Network (VAN) of your company including material flow and information flow (use schematic provided in slides)
3	How would you define **your supply chain—linear, circular, or in transition**? Provide evidence to support your evaluation.