

# TECHNOLOGICAL INNOVATION FOR RESILIENT AND SUSTAINABLE MANUFACTURING STRATEGY IN THE COVID-19 PANDEMIC

*Keynote Speech  
Seminar & Workshop  
on Production Planning and Inventory Control  
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# OUTLINE

THE COVID-19

THE IMPACT  
OF COVID-19 ON  
SUPPLY AND  
DEMAND

MANUFACTURING  
RESILIENCE TO THE  
COVID-19  
OUTBREAKS

ENABLING  
TECHNOLOGIES FOR  
MANUFACTURING  
STRATEGY

PPIC CHALLENGES

CONCLUSION



# THE COVID-19



# THE COVID-19



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Recognized in Wuhan, China, in December 2019

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First reported on December 31<sup>st</sup> 2019

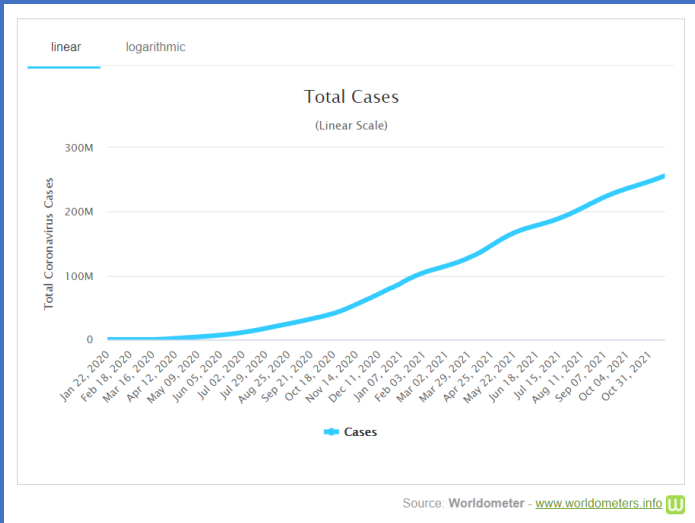
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February 2020 the World Health Organization (WHO) coined the name COVID-19

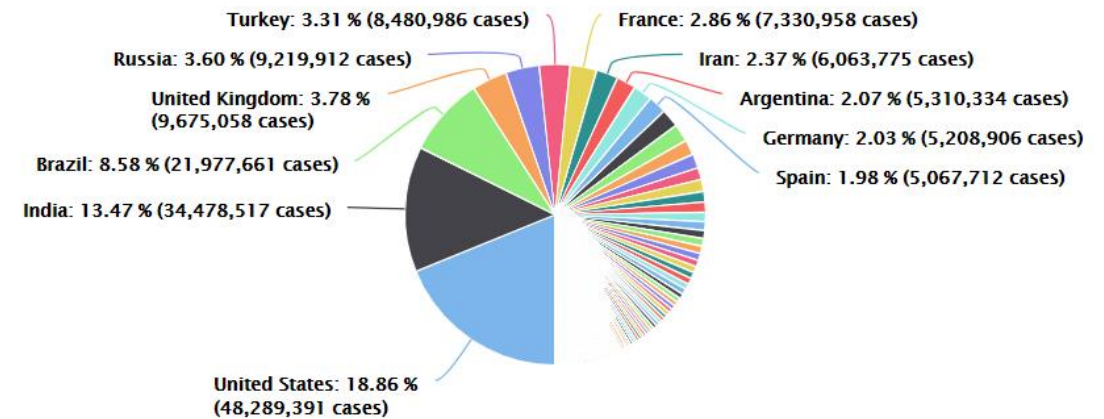
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On March 11, 2020, the World Health Organization (WHO) characterized COVID-19 as a pandemic





### Distribution of cases



Source: Worldometer - [www.worldometers.info](http://www.worldometers.info)

# COVID-19 CRISIS AND RECESSION

- One of the biggest shocks to manufacturing ecosystem.
- The worst global economic crisis since the Great Depression of the early 1930s.
- Unprecedented and geographically uneven economic impacts through the direct effects
  - Ill health and excess deaths
  - Drastic contraction or cessation of economic activity during lockdown
  - Reductions in the labor supply and consumption caused by the imposition of social distance ing measures,
  - Falling incomes, increasing uncertainty and loss of confidence that have the potential to reduce growth in the future
- The severity stems from the combined effects of both demand *and* supply-side shocks.

<i>Name</i>	<i>Time period</i>	<i>Type</i>	<i>Death toll</i>	<i>Reference</i>
<i>Spanish Flu</i>	1918-1920	H1N1	More than 50M	Barro et al. (2020)
<i>Asian Flu</i>	1957-1958	H2N2 virus	1.1M	Wikipedia
<i>Hong Kong Flu</i>	1968-1970	H3N2 virus	1M-4M	Wikipedia
<i>HIV/AIDS</i>	1981-present	Virus	32M (estimate, March 2020)	WHO (2020b)
<i>COVID-19</i>	2019-Present	Coronavirus	7127753 (10 June 2020)	WHO (2020c)

# MAIN PANDEMICS FROM THE 20TH CENTURY

- (Tasnim, 2020)

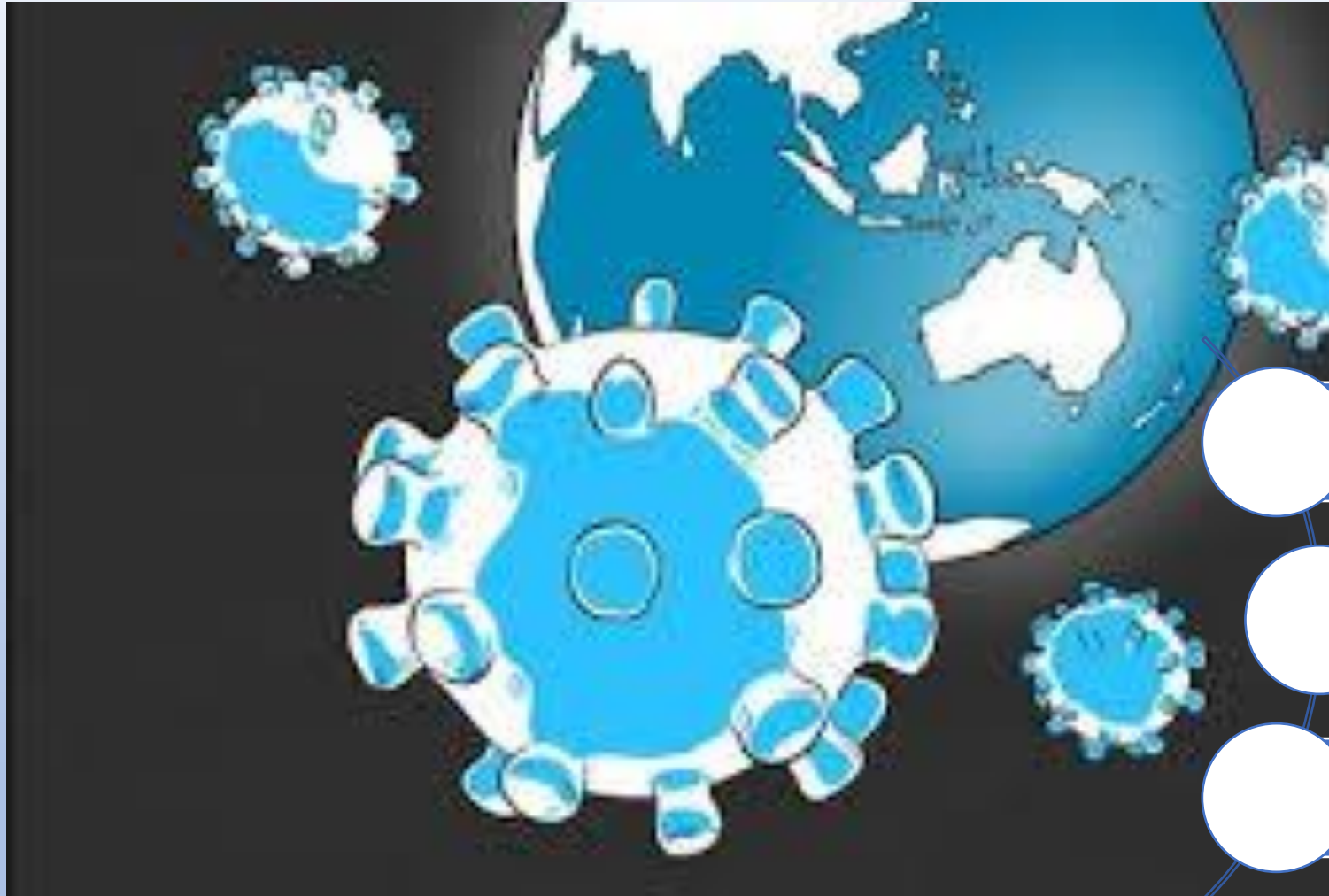
# KEY MAJOR STEPS TO PROTECT AGAINST THE INFECTION (WHO)

- Social distancing
- Use of Masks/Face- Shields
- Frequent Washing of Hands with soap & water or Sanitisation with proper sanitisers containing min. 70% Alcohol.
- Segregation of staff in essential & non-essential at manufacturing site.
- Non-essential staff to work from home





# THE IMPACT OF COVID-19 ON SUPPLY AND DEMAND



- Regional/city lockdown
- Social distancing

Order cancellation/postponed

Declined production capacity

Problem in procuring raw material

**chaotic supply chains**

# MAIN FACTORS AFFECTING THE INDUSTRIES

Low production

Distributors looking for an opportunity to make a profit when there is a growing shortage

More employee stopped working, reducing the level of activity with the impact on quality, cost and product reforms, negative effects of turnover

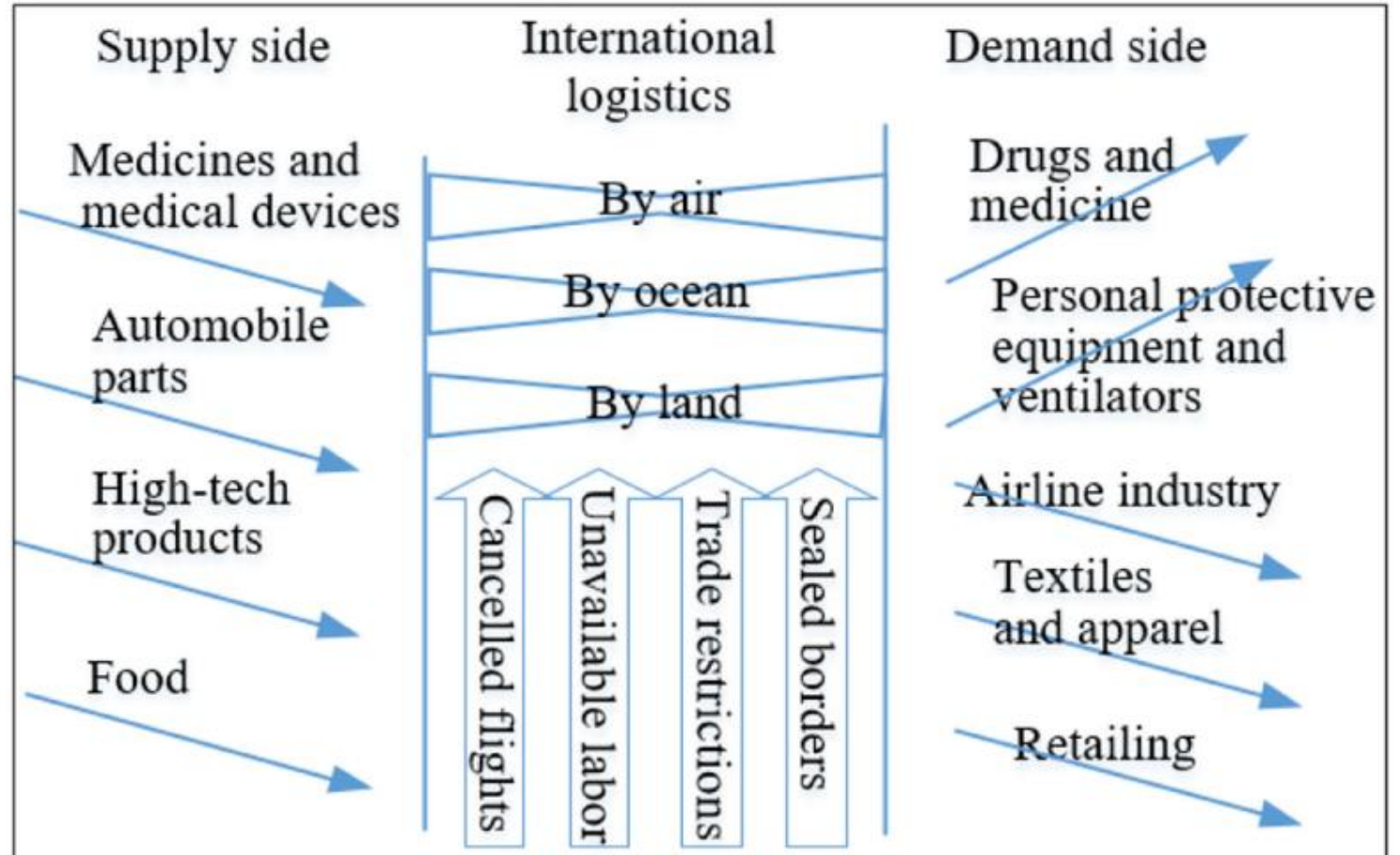
Uncertainty on logistics

Slower rate of banking operation, shorter working hours, jams and overloaded communication lines can delay money transactions and increase monetary risk.

Suppliers to large producers feel pinched, and broken; play safe to protect their interests due to far less risk averse than their larger customers

# Global Supply Chains Disrupted By the Covid-19 Pandemic

(Xu *et al*, 2020)





# PRODUCT CATEGORIES

Functional  
Products

Innovative  
Products



# High-Tech Products:

Smartphones, virtual reality headsets, and other tech accessories: shortages of various parts.

- Apple had to postpone deliveries of its new products to the market due to the shutdown of Foxconn plants in China
- Samsung and LG suspended production in their factories in South Korea and India.
- Tesla Motors closed its factories in Shanghai, California, and New York.
- Airbus, Boeing, and Lockheed halted production activities at some of their plants in Europe and the US.

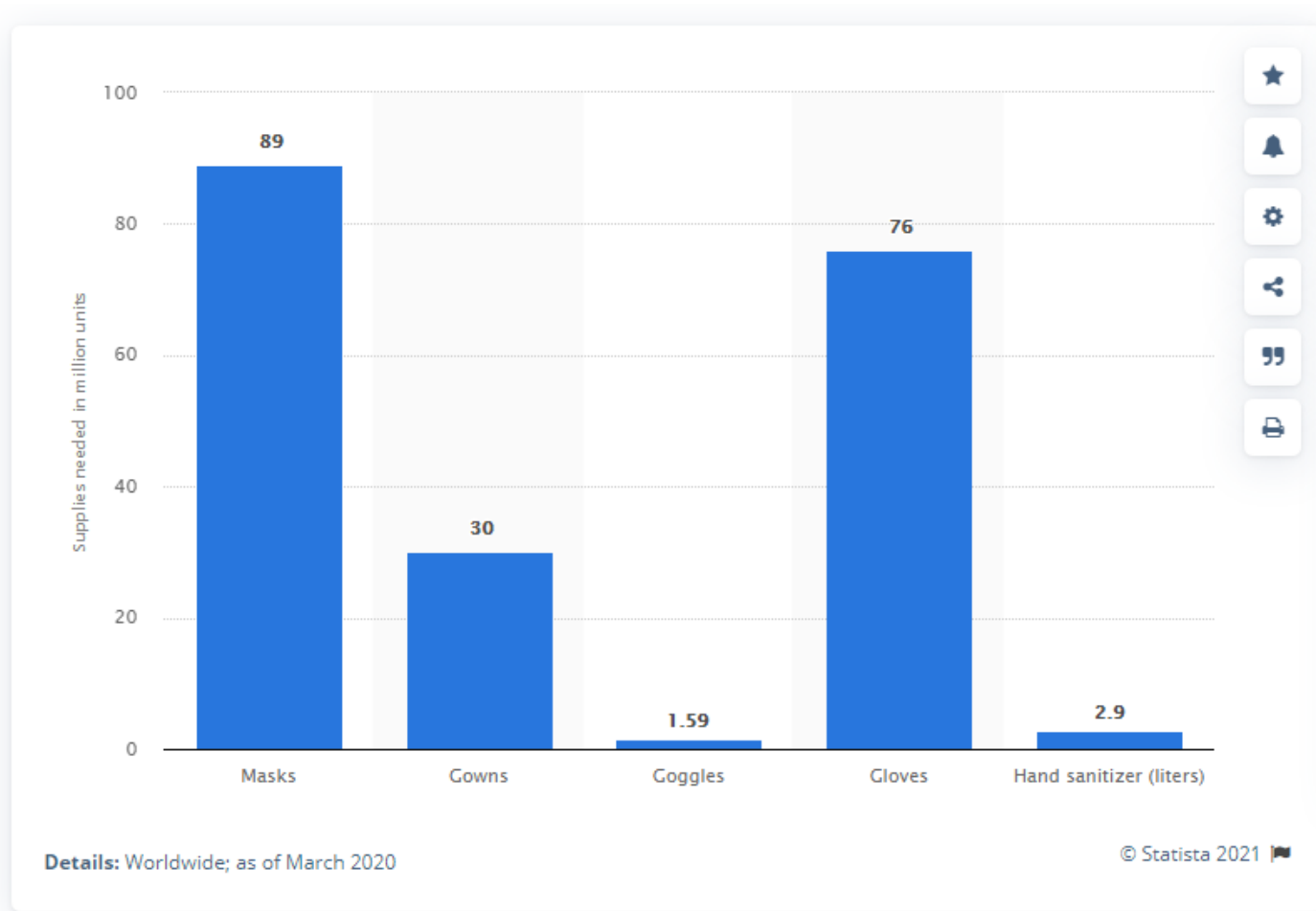
# Automotive Parts:

- Most of the main automobile manufacturers are experienced production shutdowns in some of their plants in China and other countries.
- The global output for the automotive industry is expected to drop by 13%.
- Volkswagen shut down its automotive plants in China due to travel restrictions and lack of parts.
- General Motors restarted its Chinese plants but at a very low production rate for basically the same reasons.
- Hyundai shut down its assembly plants in South Korea, mainly due to shortages of parts from China.
- Nissan factories in Asia, Africa, and the Middle East halted their production.

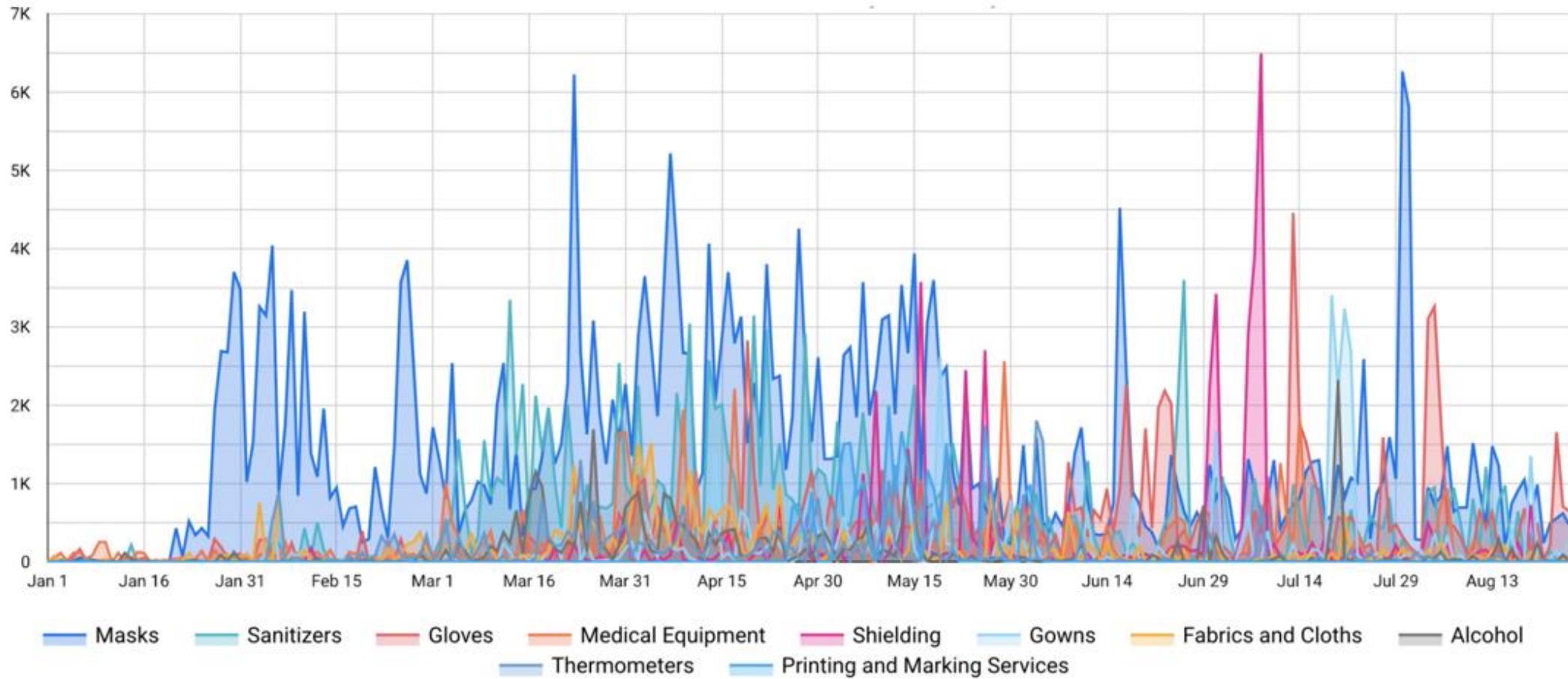
# Medicines and Medical Devices

- Chinese manufacturers:  $\pm$  40% of all active pharmaceutical ingredients (API) used worldwide.
- India: the third-largest medicine exporting country in the world
- Indian pharmaceutical companies faced severe shortages of materials because of the suspended production of their suppliers in China.
- The current global shortage of personal protective equipment (PPE), particularly of medical masks, respirators, protective gear, footwear, gowns, and goggles is severely affecting the containment of the virus.
  - front-line healthcare workers are at a high risk of being infected, and hundreds of medical and paramedical staff died in Spain, Italy, and the US.
- Global demand is not only driven by COVID-19 cases but also by misinformation, fake news, panic buying, and product stockpiling, which will undoubtedly further aggravate global shortages.

# PPE Needed Every Month by Frontline Healthcare Workers Worldwide *(in million units)*




# Thomas COVID-19 Response System Top PPE-Related Sourcing Activities\* 2020



\*Aggregated Use Activities: Such as Company Profile Views, Weblink Clicks, Phone Calls and Request for Information Submissions.

Source: Thomasnet.com®





# MANUFACTURING RESILIENCE TO THE COVID-19 OUTBREAKS

# MANUFACTURING INDUSTRY

The engine of economic growth and key for a country's development

Typically characterized by high knowledge content and significant opportunities for technological advances

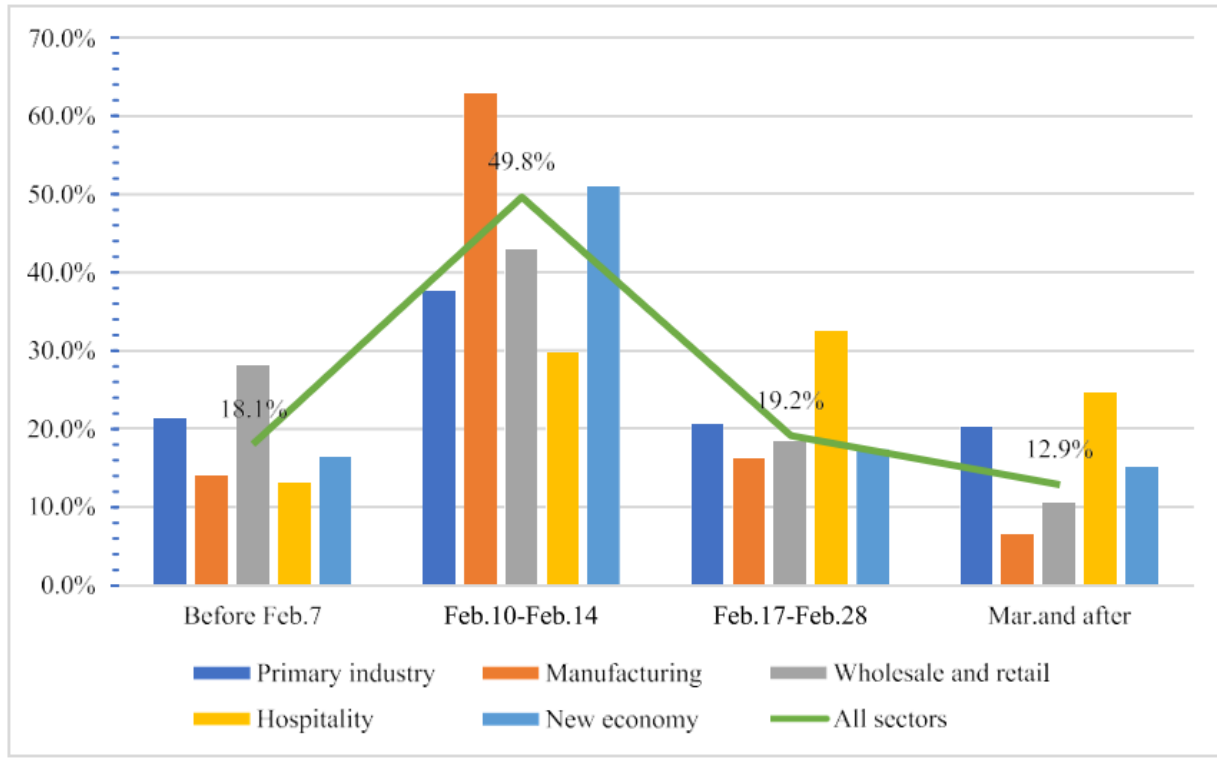
The most innovation-intensive sector in the economy.

Creates and sells goods to other sectors (Pharma, agriculture machinery, capital goods, etc.) and in turn, buys materials and services from them

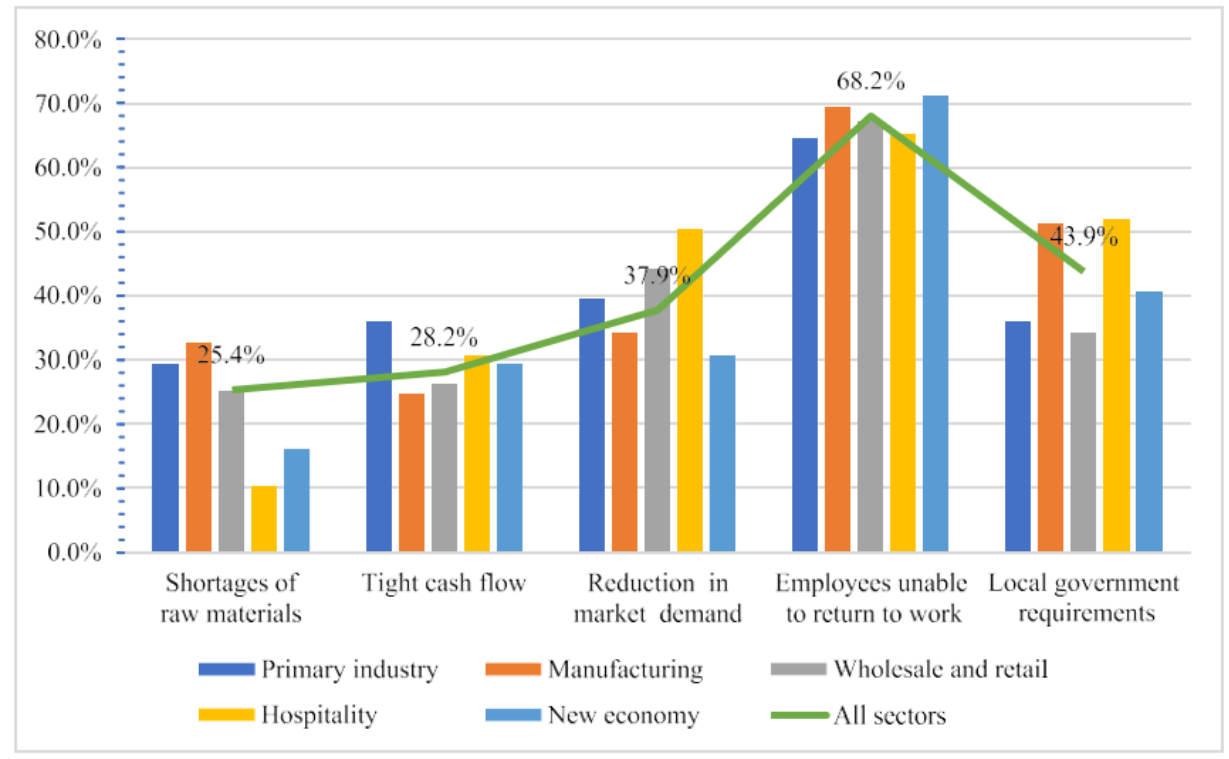
Offers employment opportunities directly or indirectly

Manufactures goods account for a majority of international trade

# CHINA



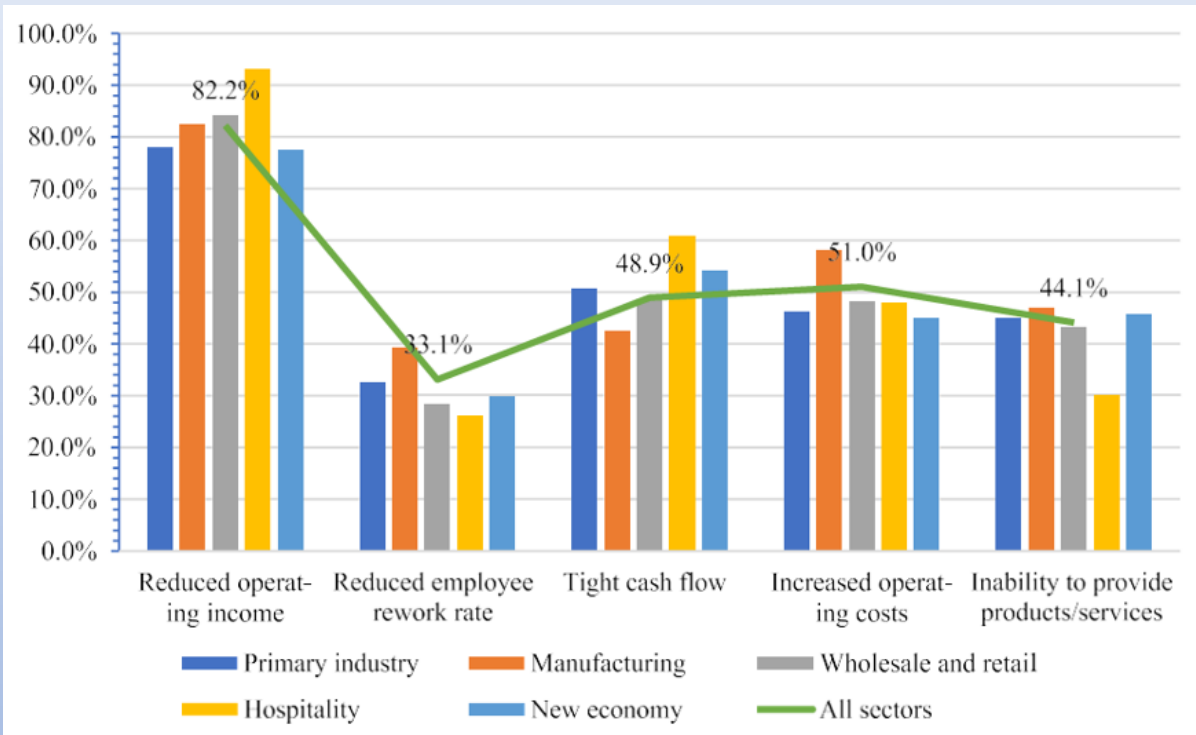
Work resumption plan by sector



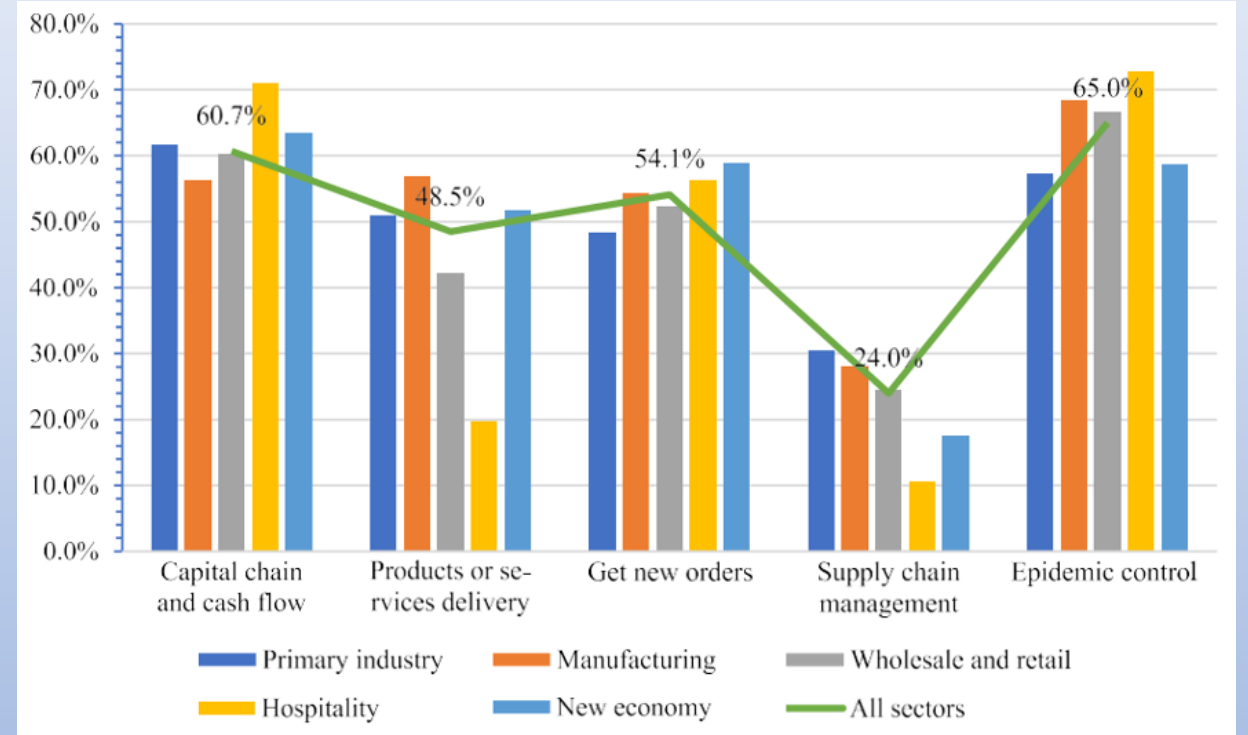
Main reasons for delayed work resumption by sector

(Lu et al., 2021)

# CHINA



Main impacts of the pandemic by sector



Main pressures on the SMEs by sector

(Lu et al., 2021)

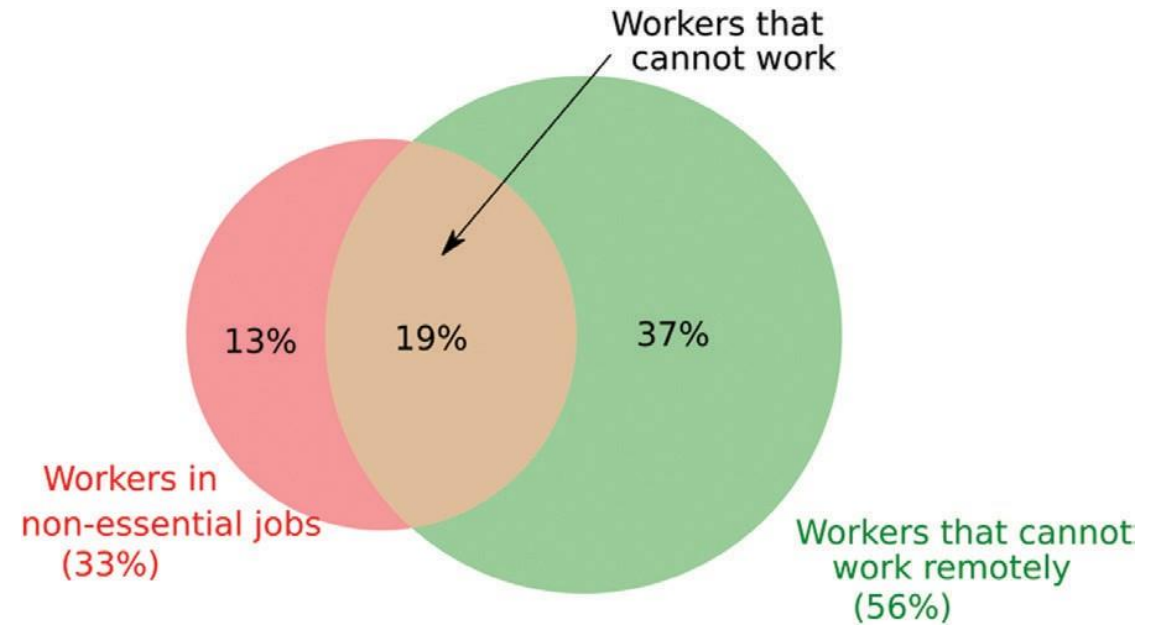
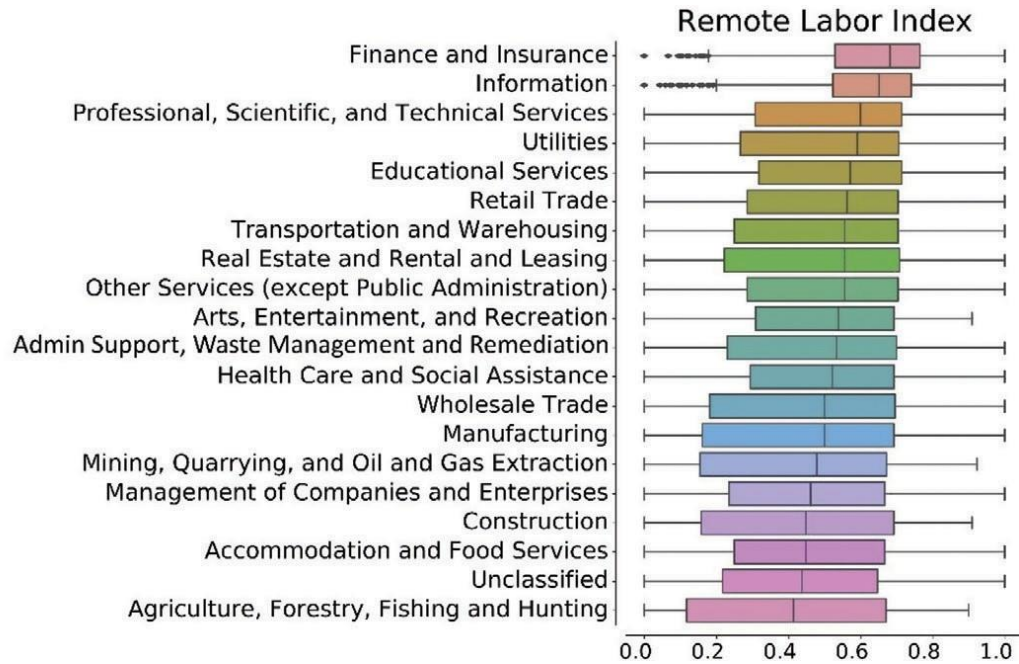
# CHANGES IN UK MANUFACTURING OUTPUT BY SECTOR

(ONS, 2020)

Production industries (index of production), main sectors and manufacturing subsectors growth, seasonally adjusted, April 2020

	Percentage change month on month
Index of production	-20.3
Transport equipment	-50.2
Textiles wearing apparel and leather products	-49.6
Rubber and plastics products and other non-metallic mineral products	-40
Machinery and equipment n.e.c	-36.2
Other manufacturing and repair	-31.5
Wood and paper products and printing	-27.7
Basic metals and metal products	-27.4
Electrical equipment	-25.8
Coke and refined petroleum products	-24.7
Manufacturing industries	-24.3
Computer electronic and optical products	-17.5
Mining and quarrying	-12.2
Food products beverages and tobacco	-10.9
Electricity and gas	-9.5
Chemicals and chemical products	-9.5
Water supply and sewerage	-5.3
Basic pharmaceutical products and pharmaceutical preparations	4.7





# REMOTE LABOR INDEX ACROSS INDUSTRIES

- (Rio-Chanona et al., 2020)

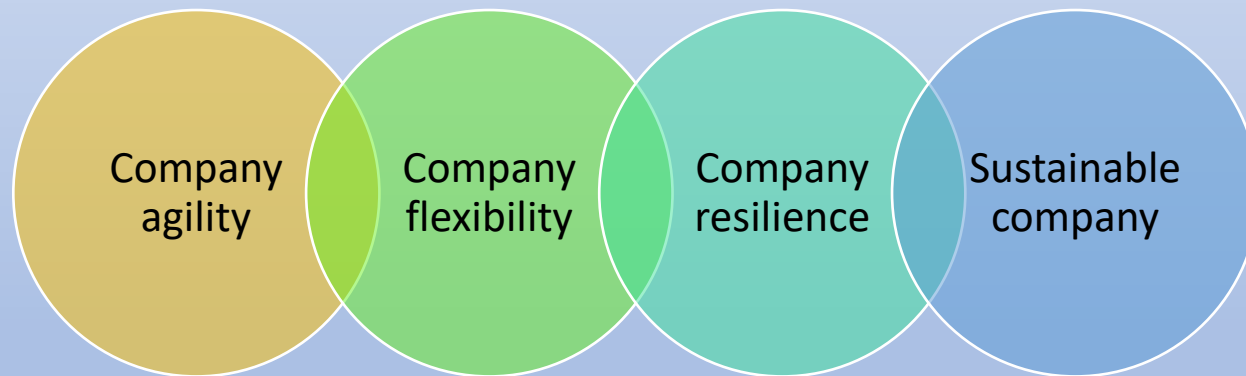
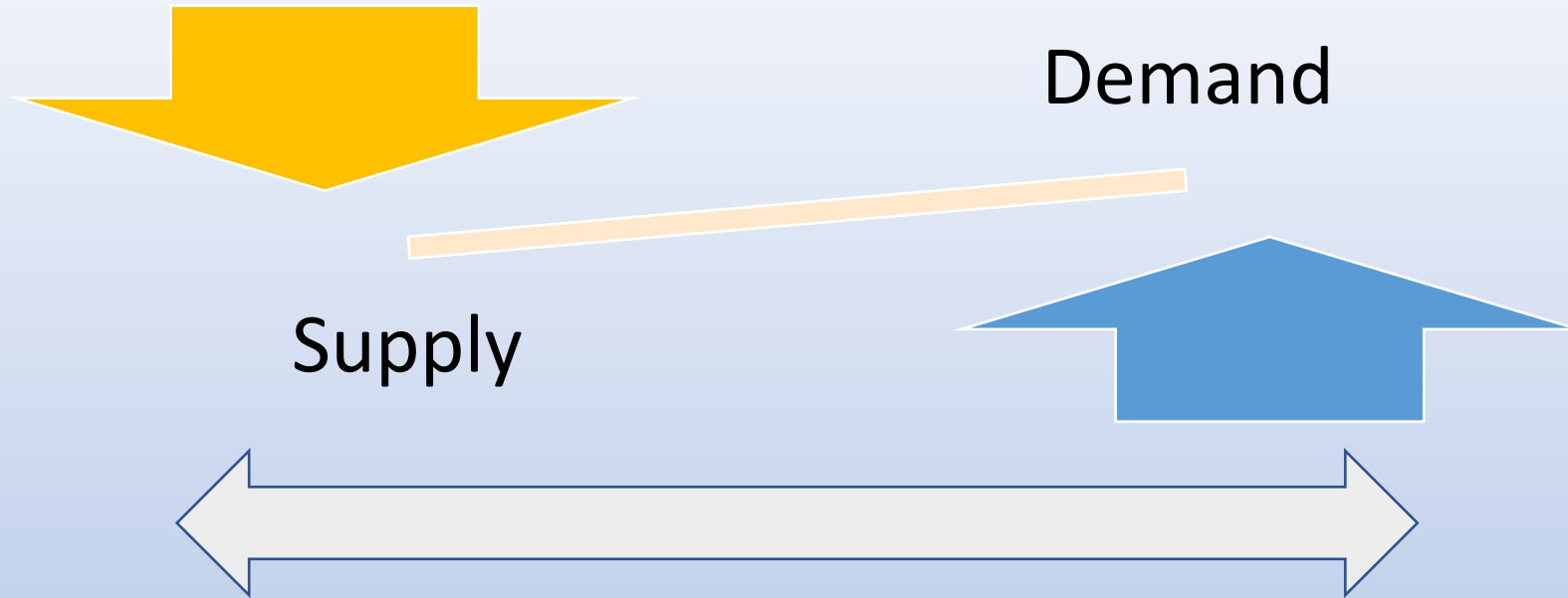
**Table 3.** Descriptive statistics for 10 North American Industry Classification System Industry subsector that had the highest outbreak-associated incidence rates for coronavirus disease, Los Angeles County, California, USA, March 19–September 30, 2020\*

Subsector	Sector	No. (%) outbreaks	No. (%) outbreak-associated cases	Average no. employed annually†	Outbreak-associated incidence‡	Median no. outbreak-associated cases (min–max)
Food manufacturing	Manufacturing	71 (10.2)	1,592 (20.9)	40,088	3,971.3	11.0 (3–277)
Warehousing and storage	Transportation and Warehousing	35 (5.0)	621 (8.1)	21,765	2,853.2	10.0 (3–125)
Apparel manufacturing	Manufacturing	15 (2.1)	595 (7.8)	27,223	2,185.7	16.0 (3–184)
Beverage and tobacco product manufacturing	Manufacturing	6 (0.9)	99 (1.3)	6,357	1,557.3	10.5 (5–50)
Electrical equipment, appliance, and component manufacturing	Manufacturing	7 (1.0)	130 (1.7)	8,694	1,495.3	7.0 (3–68)
Plastics and rubber products manufacturing	Manufacturing	10 (1.4)	92 (1.2)	11,476	801.7	7.5 (3–22)
Furniture and related product manufacturing	Manufacturing	11 (1.6)	97 (1.3)	12,263	791.0	7.0 (4–24)
Chemical manufacturing	Manufacturing	9 (1.3)	141 (1.8)	19,656	717.3	8.0 (3–58)
Couriers and messengers	Transportation and Warehousing	14 (2.0)	213 (2.8)	32,195	655.4	16.0 (5–31)
Justice, public order, and safety activities	Public Administration	37 (5.3)	443 (5.8)	72,265	611.6	6.0 (3–67)

\*Only rates for subsectors with  $\geq 20$  cases are included. Max, maximum; min, minimum.

†Denominator data were derived from 2019 Quarterly Census of Employment and Wages for Los Angeles County.

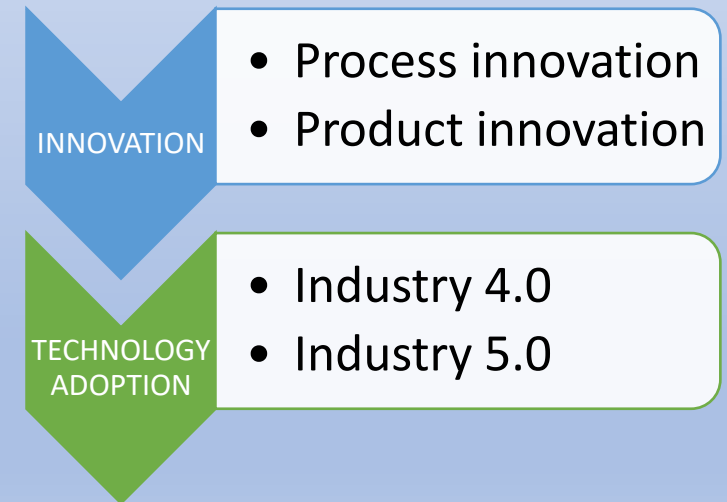
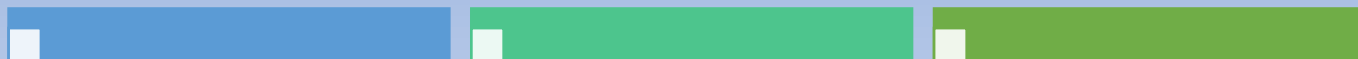
‡Per 100,000 persons. Incidence rate calculations excluded cases in nonemployees (n = 62).



Internal integration

Customer integration

Supplier integration



# STRATEGIES TO OVERCOME SURVIVABILITY CHALLENGES DUE TO COVID-19

Significant drop in operations and production levels



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graph TD; A[Significant drop in operations and production levels] --> B[A lot of waste and environment damages]; B --> C[Being lean, green, and resilient, and ensuring sustainability]; C --> D[Integration of Industry 4.0 technologies, resilience strategies, and sustainability];
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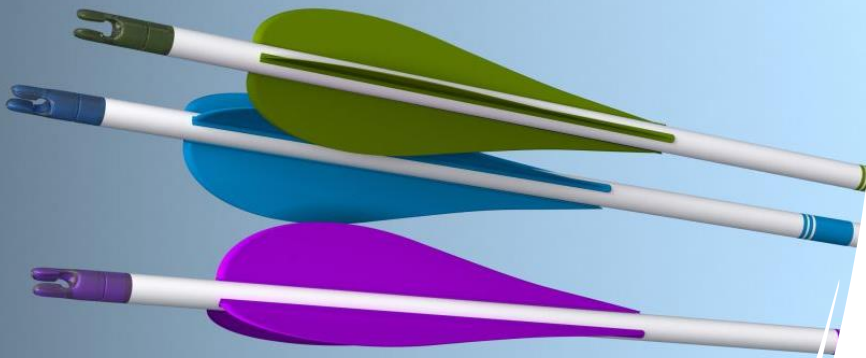
A lot of waste and environment damages

Being lean, green, and resilient, and ensuring sustainability

Integration of Industry 4.0 technologies, resilience strategies, and sustainability

# AGILITY

- The capability of the company to resolve the disruptions and return to normal conditions quickly in productive and cost-effective ways
- Balance supply and demand to improve operational performance
- Reduces instability and increases response to customers with rapid environmental changes
- Managers to know when to invest in resources, how much to invest, and where to invest



# COMPANY FLEXIBILITY

Company flexibility is the company's ability to adjust the internal to suit external changes.

## COMPANY FLEXIBILITY

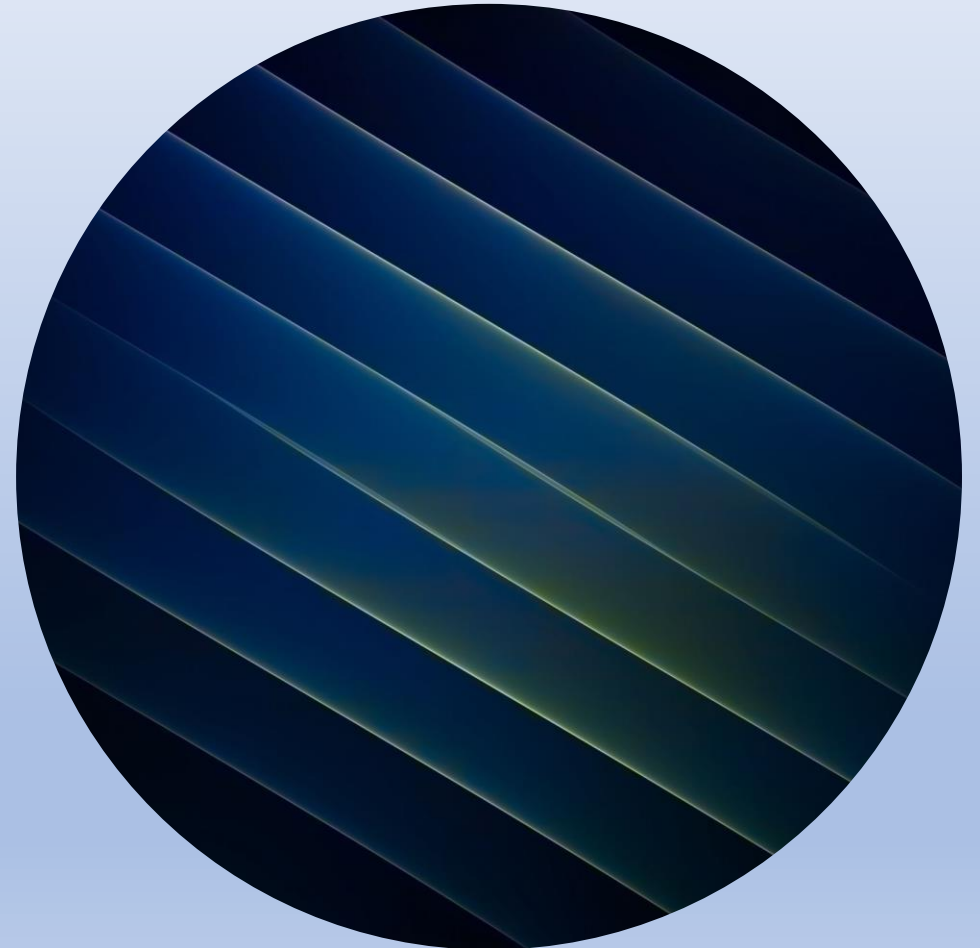
- Supplier's ability
- Collaboration with company partners
- Quickly and effectively communication

## MANUFACTURING FLEXIBILITY

- Production levels
- Create new products frequently

## BUSINESS FLEXIBILITY

- Flexible suppliers
- Flexible supply contracts
- Flexible manufacturing processes
- Flexible products
- Flexible pricing





# COMPANY RESILIENCE

- The company's response to survive by paying attention to its internal conditions.
- Measured by the speed at which the company recovers to initial conditions, quickly recovers the relations with partners, maintains control of the business, and obtains new solutions during the disruption period.



# INNOVATION SYSTEM

“Innovation is a creative and interactive process to produce an added value for the new product to meet the customer demand and benefit the company.” (Xu et al., 2016)

- Finding ideas
- Adopting new technology, new skills, new techniques, and new management best practices
- Culture changes for better performance



PRODUCTS



CULTURE

Operational excellence

- Reduce operating costs
- Increase customer
- Demand sustainably

SYSTEMS & STRUCTURES

Innovation

- Process
- Product
- System/People

OPERATIONAL EXCELLENCE



LEADERSHIP



PEOPLE

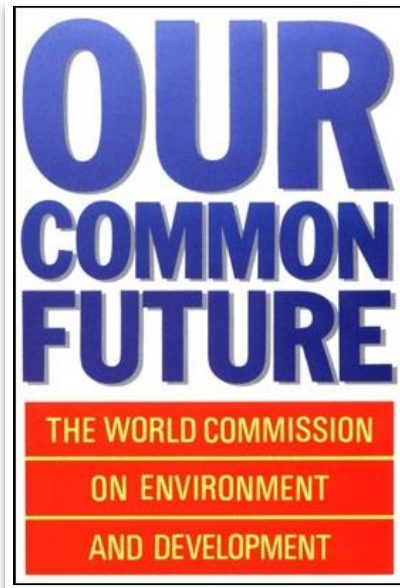
PROCESSES



# SUSTAINABILITY ISSUES



**Sustainable Development:**  
“Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.”

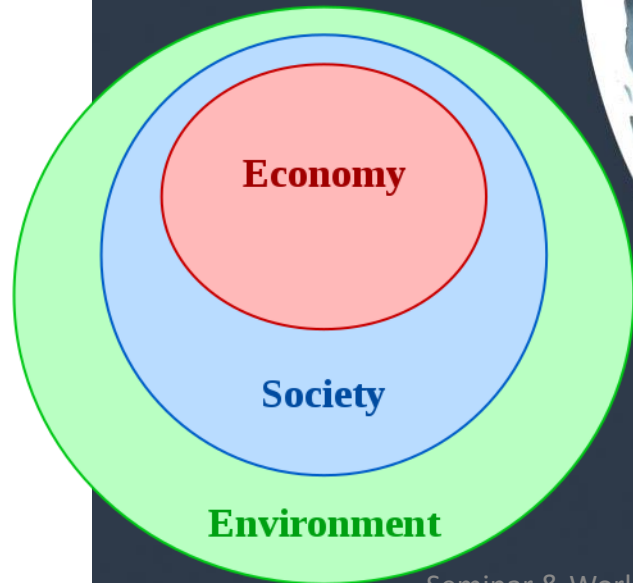
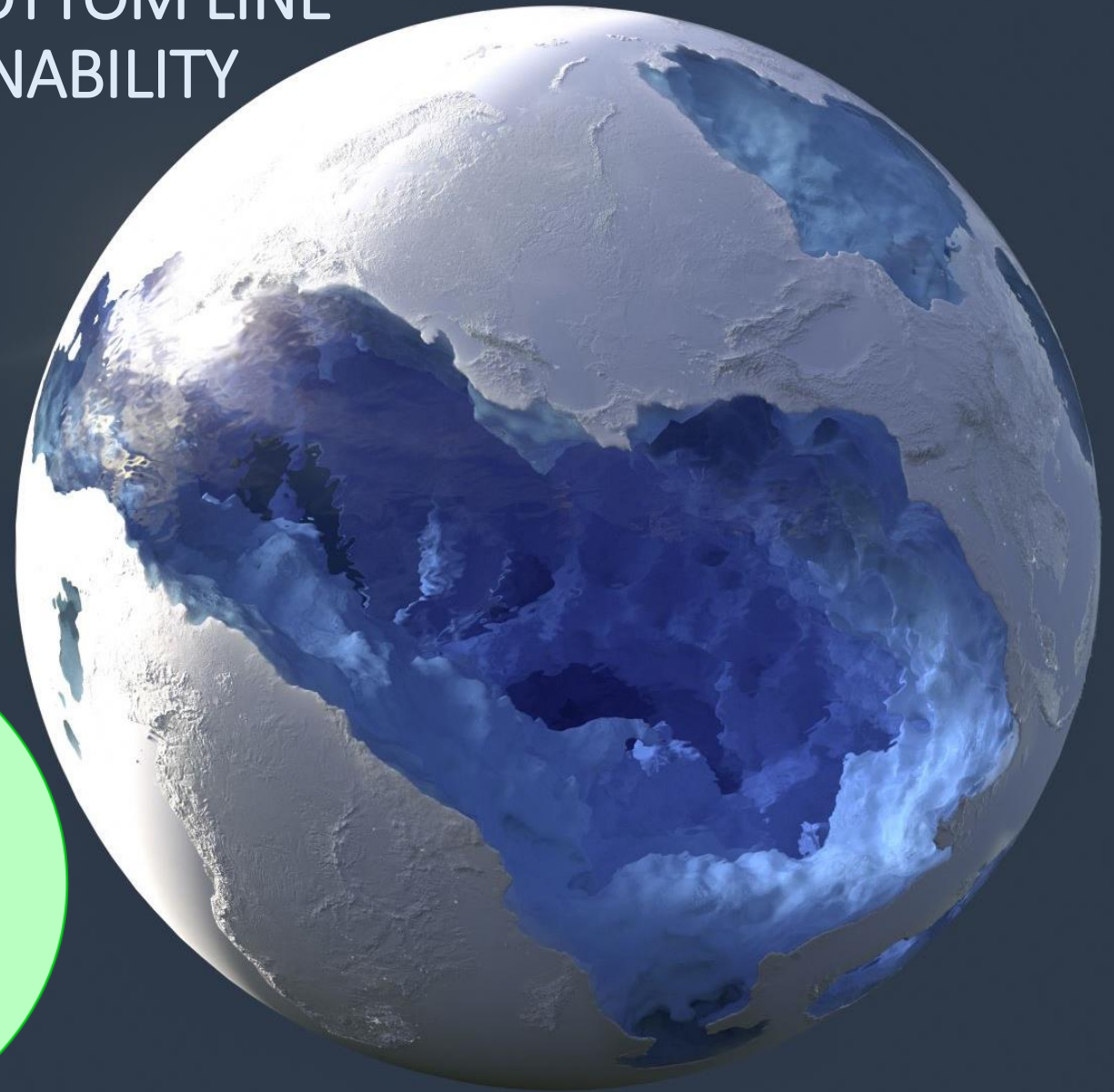
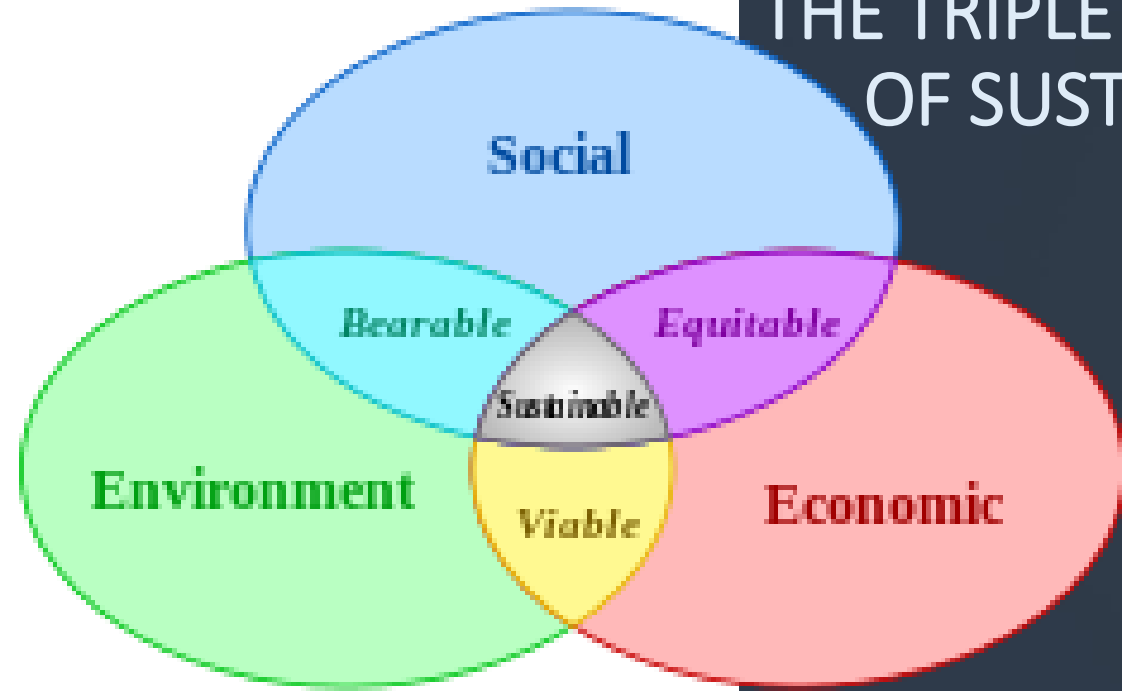


*Sustainability can be referred to as a system that is economically effective, environmentally sustainable and socially fair.*

Dr. Gro Harlem Brundtland



# THE TRIPLE BOTTOM LINE OF SUSTAINABILITY



# SUSTAINABILITY CHALLENGES

## Increases in waste generation

Single-use and other disposable products (gloves, robes, masks, face shields, and other equipment –plastic waste)

Products destined for markets that have been shut down (e.g. food products for restaurants)

## Life cycle impacts of new and fluctuating product streams

Material inputs

Manufacturing processes

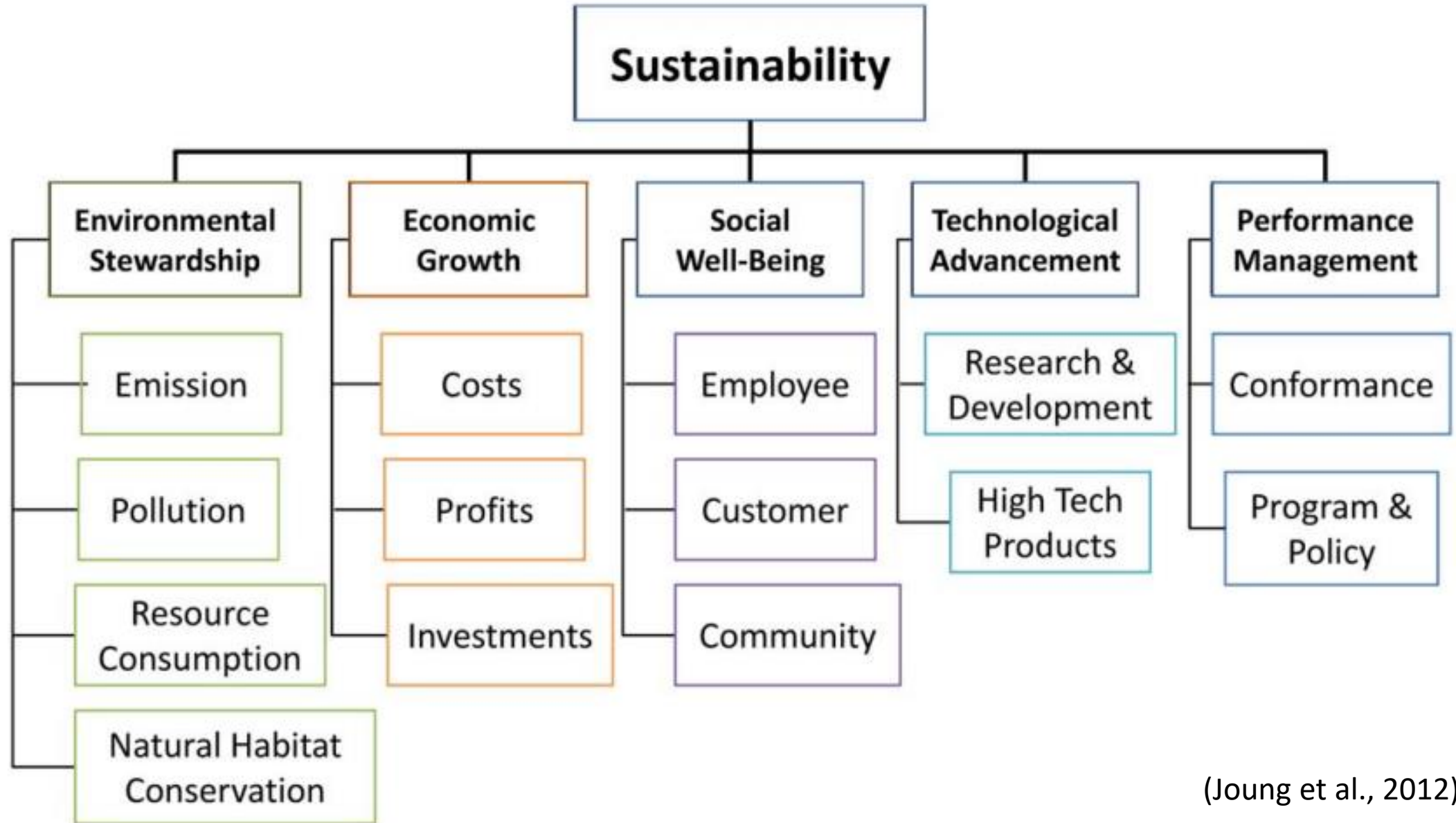
## New modes of operation for manufacturing

Needed skills not being available and/or inadequate

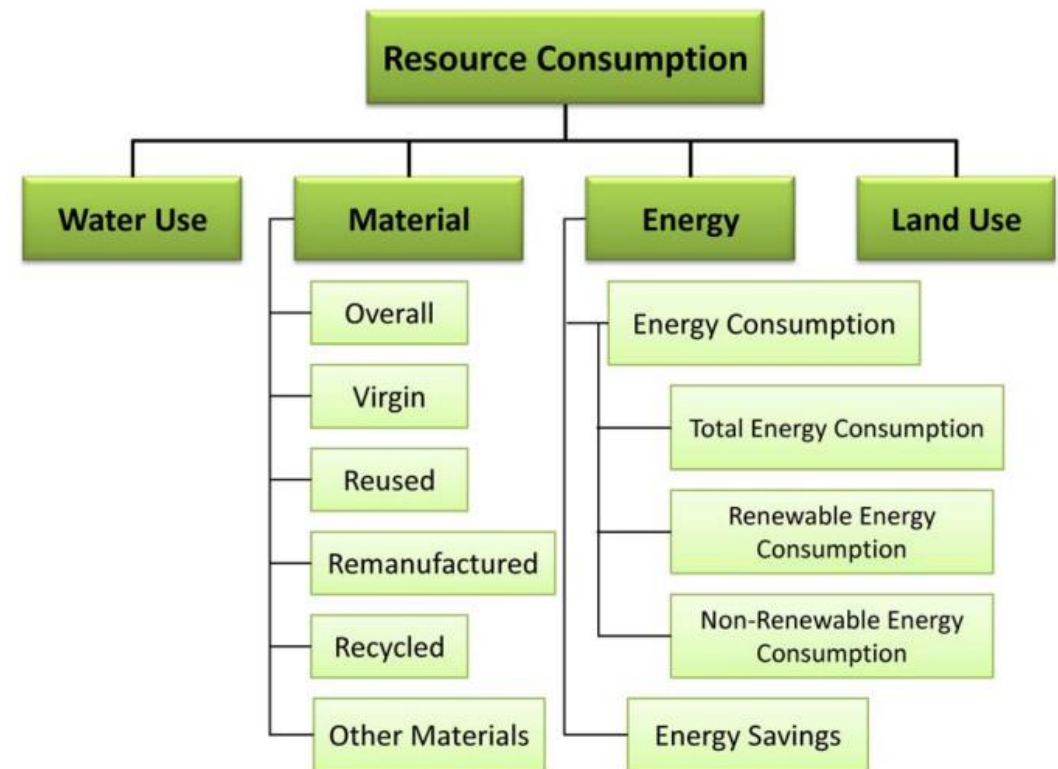
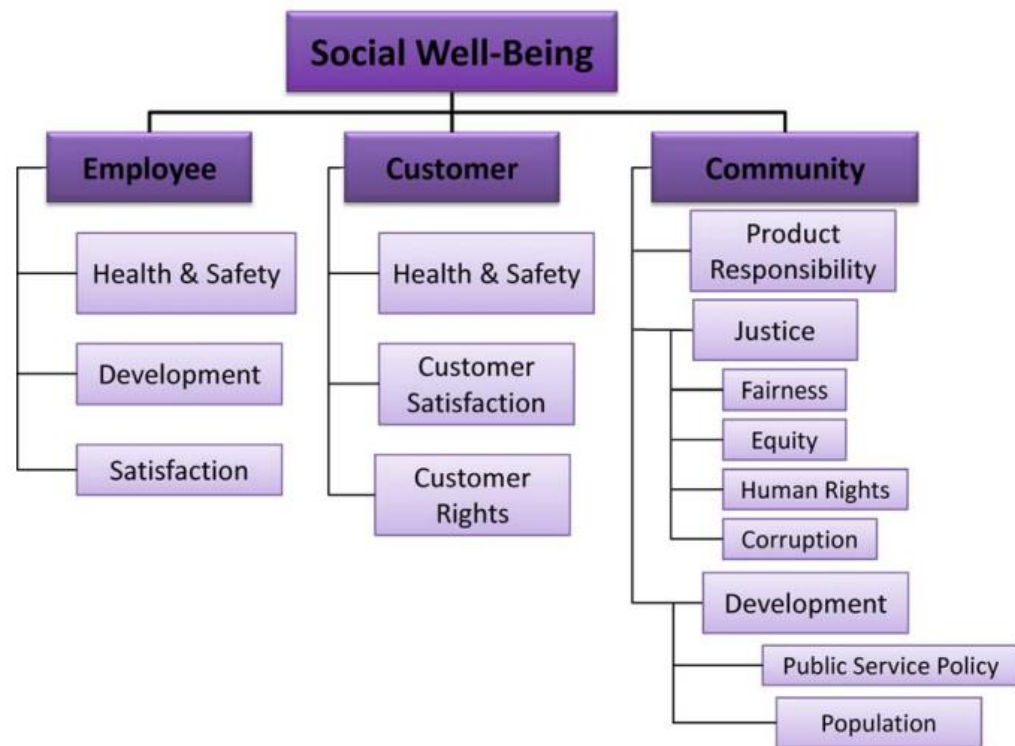
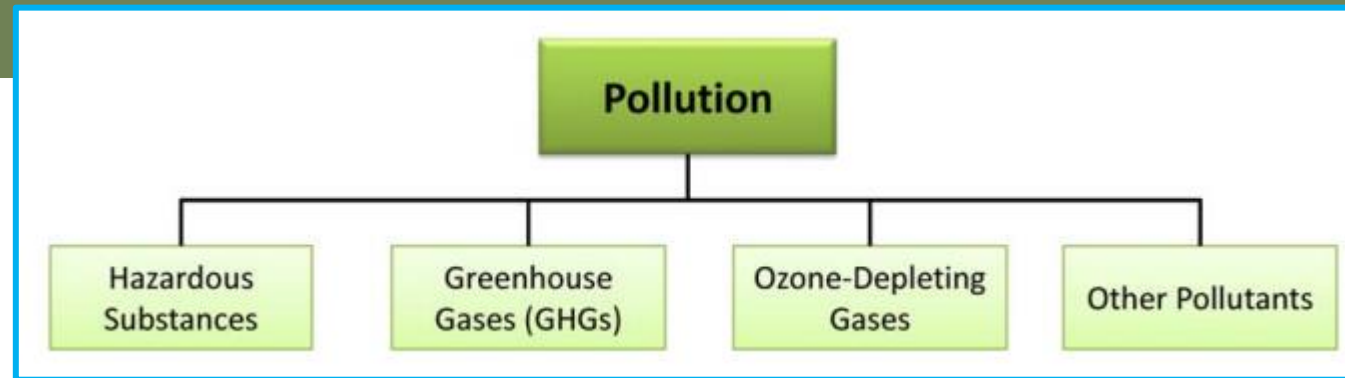
Supervision of the work, creating more waste or other environmental impacts.

Increased interest in greater automation





(Joung et al., 2012)



(Joung et al., 2012)

# WASTE MANAGEMENT

## Circular Economy

Integration of the 6Rs  
(Reduce, Reuse, Recycle,  
Recover, Remanufacture,  
and Redesign)

Managing waste streams  
more efficiently and  
agilely

## Data Availability & Transparency

Life-cycle engineering  
Metrics based on the 6Rs  
to mitigate environmental  
impacts.

## Responsive Capacity

Greater local and regional  
capabilities for recovery,  
recycling, and reuse of  
materials and  
components

# LIFE CYCLE IMPACTS

## Improved Demand Visibility

- Greater visibility into true demand can reduce unnecessary stockpiling and the associated consumption of energy and resources.

## Digital Technologies

- Underlying principle for digital technologies to align human, capital, and environmental resources
- Better predictions of life cycle impacts for new products

## Local Production

- High-quality jobs and flexible production sites
- Sustainably produced products to global markets, reducing the impact of environmentally harmful outsourcing to less stringent regulatory jurisdictions.
- Increased resiliency for both workers and the environment



# PRODUCTS WITH INCREASED DEMAND DURING THE COVID-19 PANDEMIC



## Health and PCPs

- Personal protective equipment (PPE)
- Ventilators
- Hand sanitizer and hand soap
- Surface disinfectants



## Telework & E-Learning

- Electronic devices (computers, laptops, tablets, phones)
- Accessories (webcams, headsets, headphones, )
- Improved internet connectivity (bandwidth)
- Office furniture (desks)



## Home Comfort

- Indoor air quality (HVAC system upgrades or replacements, air filters)
- Upgraded furnishings
- Home renovation projects



## Outdoor Recreation

- Bicycles and bicycle parts
- Backyard recreation (swimming pools, playgrounds, trampolines)
- Recreational vehicles
- Kayaks

(Diaz-Elsayed et al., 2020)

# NEW MODES OF MANUFACTURING OPERATIONS

## Continuity of Operations

- Operating within a sustainability-focused
- Critical skills and equipment are in place within their supply chains
- Promoting resilient local and regional 'clusters' of sustainability-focused companies.

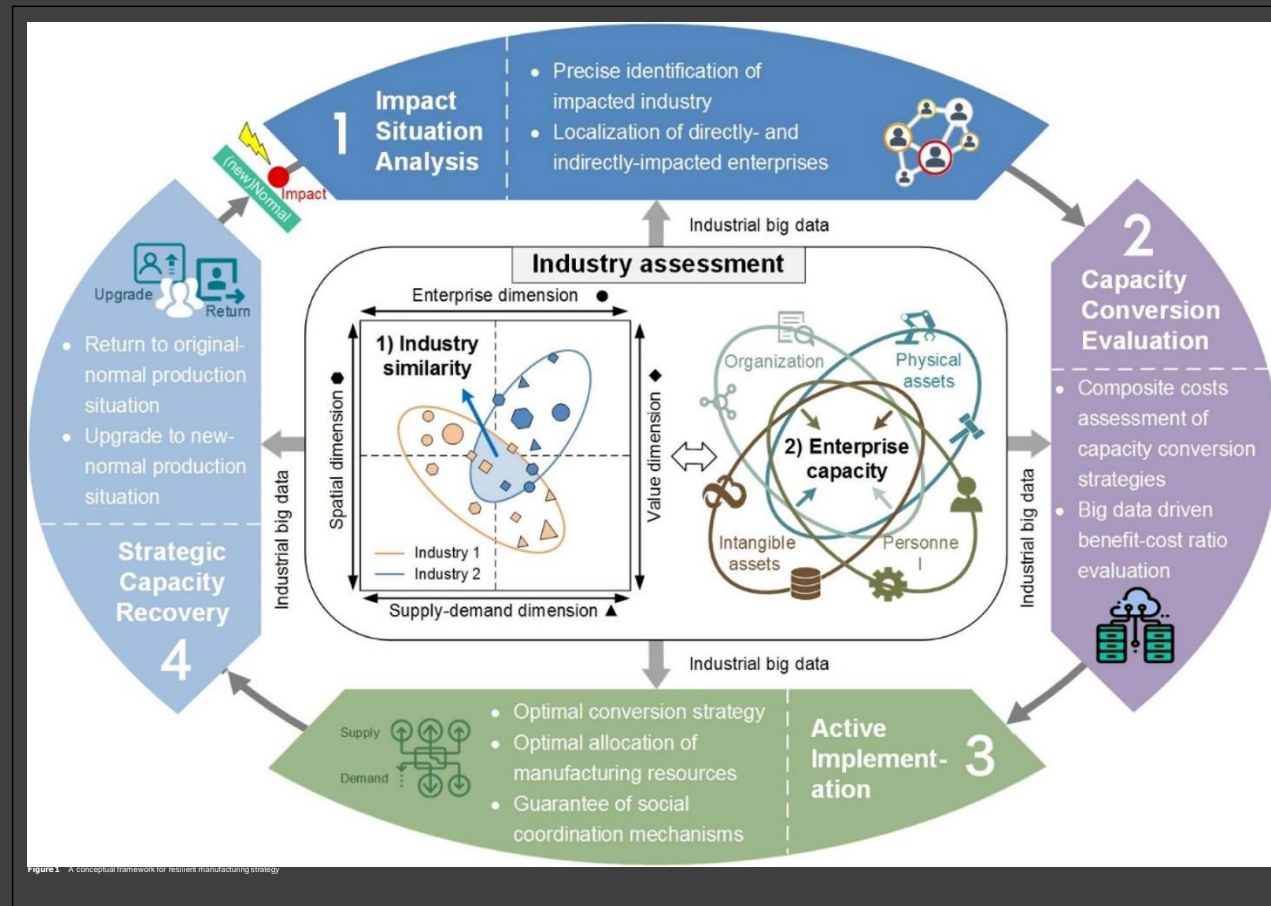
## Re-skilling and Upskilling the Workforce

- Rapidly re-skill workers (cybersecurity awareness)
- Ability to quickly retrain the incumbent workforce for an increasingly competitive global climate.
- Digital tools (virtual or augmented reality)
- Digital thread deployment



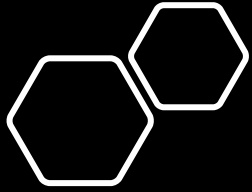


# ENABLING TECHNOLOGIES FOR MANUFACTURING STRATEGY



A conceptual framework for resilient manufacturing strategy

- (Peng et al., 2021)



# Technologies for Resilient Manufacturing Strategy

Data acquisition management

Big data analysis

Intelligent service

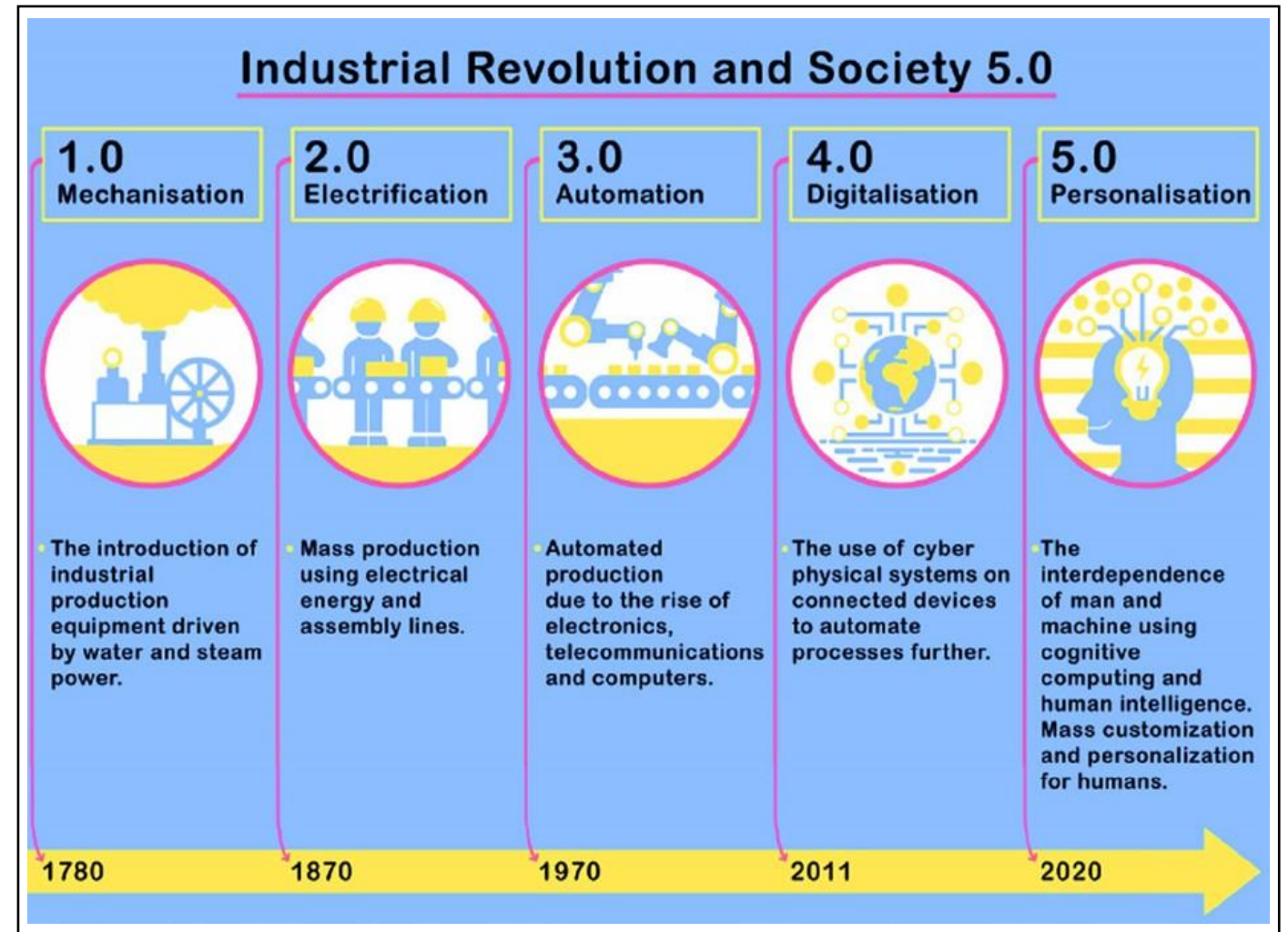
5G

3D printing

XR

The timeline of industrial revolutions and the emergence of society 5.0 amid the COVID-19 pandemic in 2020

(Sarfraz et al., 2021)



## Industry 4.0

- Artificial Intelligence (AI)
- Big Data (BD)
- Internet of Things (IoT)
- Digital platforms
- Augmented and virtual reality
- 3D printing

## Society 5.0 (The Super-Smart Society)

- Final bridge between machine and man.
- Artificial Intelligence (AI)
- Robotics
- 3D printing
- Digital platforms

# 3M CASES

Sales of approximately \$32 billion, employ over 96 000 people and have over 120000 patents

Four business groups working together: Safety and Industrial, Transportation and Electronics, Healthcare, and Consumer

Ramped up production of sanitizers and disinfectants.

Digital platforms: Computer vision, Data science, Electronic systems, Modeling & Simulation, Advanced robotics, Sensors, and Software solutions

Five strategic platforms: Internet of Things (IOT), Edge Computing, Artificial Intelligence (AI), Modeling & Simulation, Visualization & Perception, and Data.

Ramped up N95 respirator manufacturing at different locations and manufactured over 2 billion N95 respirators.

Used modeling and simulation to accelerate innovation and scale up

Collaborated with other companies; over 1100 external collaboration requests





# PPIC CHALLENGES

# INTERNAL INTEGRATION

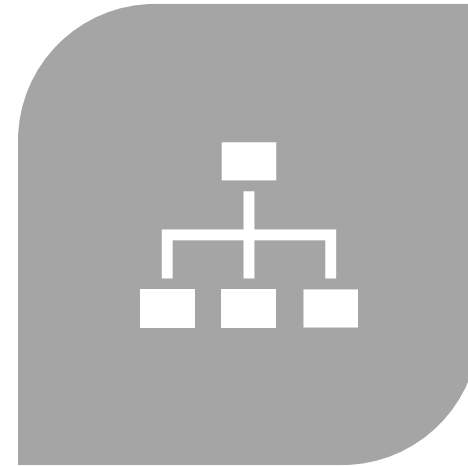
Coordination between purchasing, production, manufacturing, finance, marketing, and other functions

- Flexibility
- Visibility
- Traceability
- Reliability

# PRODUCTION PLANNING AND INVENTORY CONTROL



**HARDWARE - PRODUCTION**



**SOFTWARE - PLANNING &  
CONTROL**



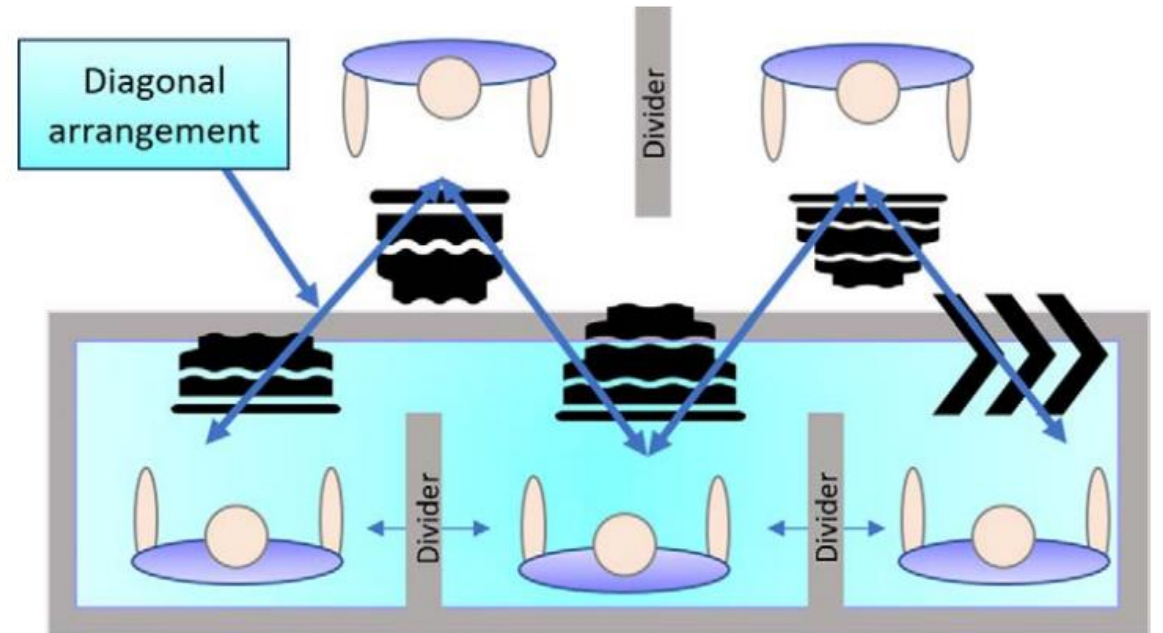
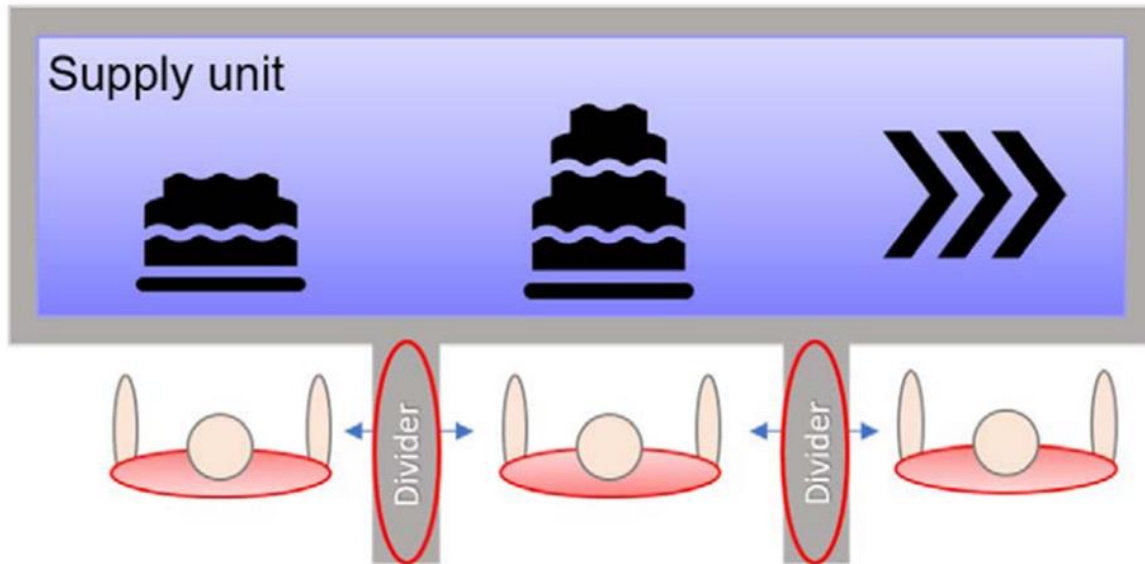
# Safe Workplace

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- Temperature checks & personal protective equipment (PPE);
- A workplace safety app to manage workspace distancing (e.g., workspace layout and design, employee shifts, and cleaning to maintain hygiene);
- A readiness app that gauge's employees' work-related well-being;
- A workplace PPE inventory app that allows companies to manage and monitor that inventory in real time.

# FUNCTIONAL ASSEMBLY LINE

- (Shahbaz et al., 2020)



# STANDARD OPERATING PROCEDURE: 5S



SEIRI (SORT):



SEITON  
(SET IN ORDER)



SEISO (SHINE)



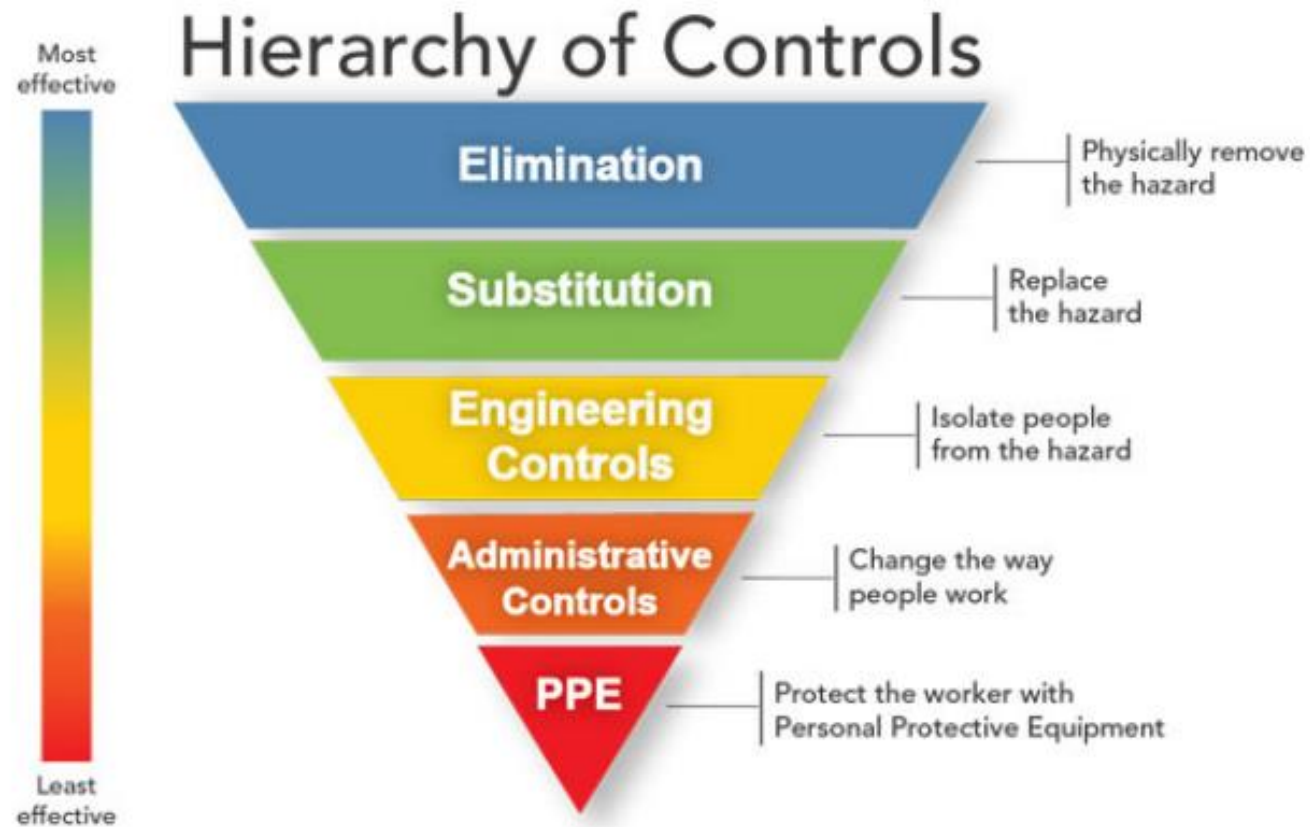
SEIKETSU  
(STANDARDIZE)



SHITSUKE  
(SUSTAIN).



# RISK ANALYSIS



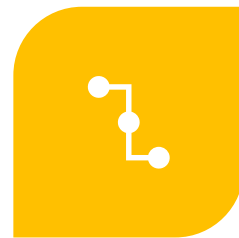
# EFFICIENT AND SECURE INTEGRATION



SECURITY AND  
PRIVACY ISSUES



DYNAMIC  
SCALABILITY



CONNECTION



SOCIETAL  
ISSUES



LEGAL ISSUES



# CONCLUSION



# CONCLUSION

## 1. The impacts of the COVID-19 pandemic

- Increasing the nature of uncertainty
- Increasing the opportunity to develop a circular economy
- Changing consumer preferences
- Changing global trade pattern
- Changing demographic and social lifestyle
- Rapid technological advances

2. Technological innovation is the key to success for survival, resilience, and sustainability for the manufacturing industry amidst the COVID-19 pandemic and the future





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