



Emerging trends in the Industrial Manufacturing sector

September 2022



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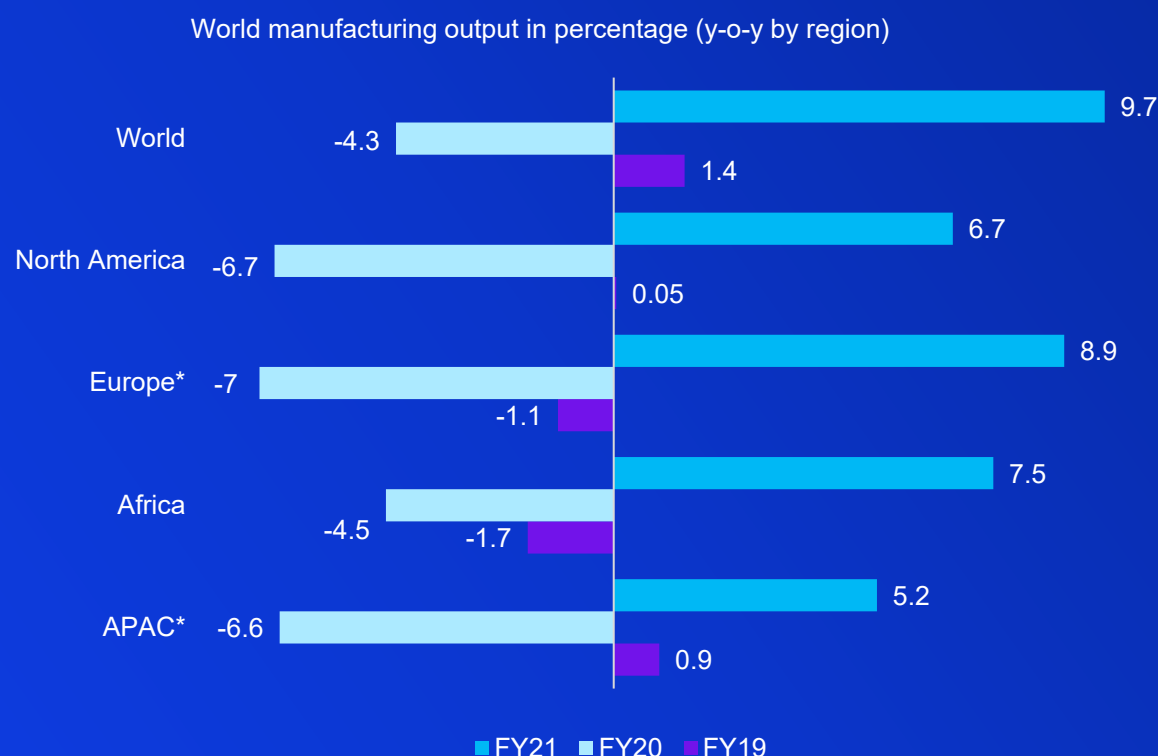
A close-up photograph of an orange industrial robotic arm in a factory setting. The arm is positioned diagonally across the frame, with its end effector (a blue tool) resting on a metal workpiece. The background is blurred, showing other industrial equipment and a worker in a blue uniform. A semi-transparent blue rectangular overlay covers the middle portion of the image, containing the title and page number.

01

Global manufacturing sector – A snapshot

1 Global manufacturing sector – A snapshot

In the last two years, the pandemic has adversely impacted economies, societies and people globally. The virus has also triggered the worst recession since the end of World War II, affecting the livelihoods, employment and household incomes. For the global manufacturing sector, which was already struggling owing to protectionism and trade tensions amongst large economies, the pandemic had a severe impact leading to the first global decline in world manufacturing production since the sub-prime crisis of 2008–09. According to the United Nations Industrial Development Organization (UNIDO), the second quarter of 2020 saw a considerable fall in worldwide manufacturing output of 11.2 percent compared to the same period in 2019¹.



Note: * in the above chart refers to the industrialised economies
 FY21 refers to the period from January 2021–December 2021
 Source: World Manufacturing Production, Quarter 4 - 2021, UNIDO, accessed on 28 April 2022

Nevertheless, over the last few quarters, manufacturing situation has improved owing to gradual phasing out of economic and social restrictions across many countries. World manufacturing output rose by 9.7 percent in FY21 while European region grew by 8.9 percent, exhibiting better growth compared to the last two years, on a y-o-y basis. The industrial production for manufacturing in the European Union neutralised the impact of the pandemic (98.5) and attained pre-pandemic levels in 2021 (107.2) similar to 2019 (107)². Countries and territories with stronger manufacturing capabilities and more diversified industrial sectors have sustained the impact of the pandemic better than other countries, depicting the importance of having agile and resilient manufacturing systems.

As industrial production and capacity utilisation surpassed pre-pandemic levels in the middle of the year 2021, strong increase in new orders for all key sub-sectors indicates that the growth will continue in 2022. A combination of high firm valuations, robust profitability, and low-cost loans may drive companies to use M&A to enhance their technological capabilities, increase market share, and enter

¹ World Manufacturing Production, Quarter 4 - 2021, UNIDO, accessed on 28 April 2022

² Production in industry - annual data, Eurostat, accessed on 07 May 2022

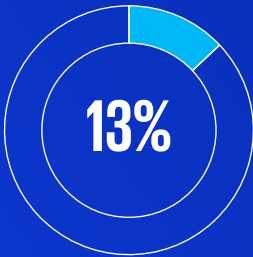
new markets as capital expenditures rise. Moreover, investments in infrastructure and policy changes could aid in the resurgence of the manufacturing sector.

The ongoing conflict between Russia and Ukraine has triggered uncertainty for the global industrial landscape. The war has caused major supply disruptions, which in turn led to a surge in raw material prices, especially for energy and metals. The average price of Brent crude oil increased by 55 percent in March 2022 to reach US\$116/bbl (Barrel of crude oil), compared with December 2021, while World Bank's metals and minerals index rose by 13 percent in 1Q22, vis-à-vis the last quarter³. Manufacturers, notably those in Europe, have seen substantial disruptions because of the rise in costs and raw material constraints brought on by freight delays and diversions as well as additional COVID-19 lockdowns in China. In March 2022, the manufacturing Purchasing Managers' Index (PMI) for the Euro zone was 56.5, lowest in the last 14 months⁴.

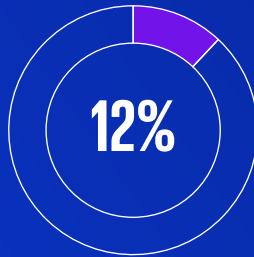
Major risks identified for organisations



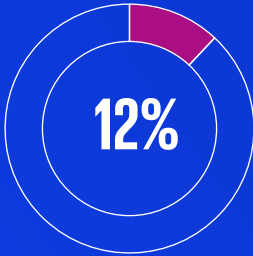
Supply chain risk



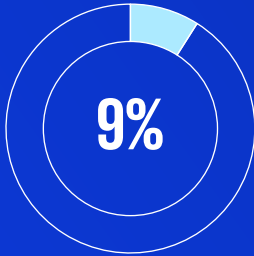
Operational risk



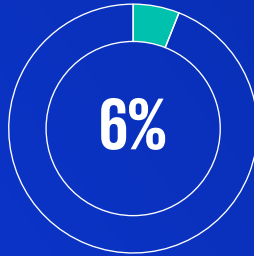
Emerging/disruptive technology risk



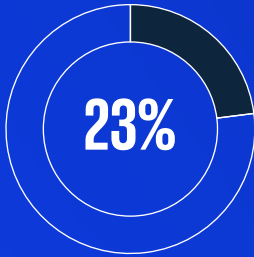
Regulatory risk



Environmental/climate change risk



Cyber security risk



Other risks such as talent risk, tax risk, reputational risk etc.

Source: Global manufacturing prospects 2022, KPMG

³ Commodity Markets Outlook, World Bank, April 2022

⁴ Global factory activity slows as Ukraine crisis, inflation bite, The Economic Times, 1 April 2022

Given the current challenges of supply chain disruptions and its impact on the trade flow process, supply chain risks have emerged as the biggest threat to organizations, as per KPMG 2021 CEO Outlook⁵ report, showcasing the need for companies to build a resilient supply chain and stay prepared for future challenges.

Driven by the evolving geo-political dynamics, the outlook for the manufacturing sector seems to be perilous, taking into consideration the uncertain financial developments in many countries, the pandemic's unpredictable future trends, the supply chain bottlenecks and the ongoing Russia-Ukraine conflict with marked regional disparities. Recent economic analyses suggest strong but dissimilar developments of different economies, with headwinds arising from variable sources.

Businesses that want to participate in the upcoming growth period as well as function through the volatility of an exceptionally quick economic recovery may find that business agility is essential. Manufacturers who were more digitally advanced before COVID-19 had an advantage in terms of resilience, as did those who accelerated their digitalization during the crisis. A more competitive and sustainable future in manufacturing may depend on digitisation, which now includes everything from e-commerce and enterprise transformation to smart factory initiatives.



As per the KPMG 2021 CEO Outlook^{*} report, manufacturers may focus on the below mentioned parameters as their operational priorities to align well with their growth objectives over the next few years.

- Advancing the digitization and connectivity across all functions
- Integrating ESG goals and consumer preferences into the company's future strategic initiatives
- Sustained employee value proposition to attract and retain talent
- Inflation-proofing capex, procurement and opex
- Reconfiguring the supply chain
- Driving cybersecurity and data resiliency

KPMG 2021 CEO Outlook, KPMG International, accessed on 28 April 2022

In the following sections, we will be covering major trends shaping the manufacturing industry in the coming years, with a focus on building a resilient supply chain, sustainable manufacturing and increasing use of advanced technologies/Industry 4.0.

⁵ KPMG 2021 CEO Outlook, KPMG International, accessed on 28 April 2022



02

Building a resilient supply chain

2 Building a resilient supply chain

2.1 Supply chain disruptions

Supply chain disruptions are among the major hurdles facing manufacturers for the time being. The pandemic along with other geo-political issues have added more complexity and disruptions to the industrial manufacturing sector globally.

The manufacturing units and shipping companies are shifting gears, re-evaluating their strategies and risk profiles, and struggling to keep up their production. Ripple effects could be felt with manufacturers as raw materials and other intermediate goods could not be sourced from other countries. The sourcing managers on the manufacturing side are not able to secure supply at a reasonable cost. Prices of raw materials, commodities, which had already been rising due to the global pandemic outbreak, have shot up further due to the Russia-Ukraine war.

Supply chains are already disrupted by the pandemic-driven recession and struggling with backlogs are now facing renewed pressures. Rising prices and compounded supply-side disruptions are likely to further exacerbate inflation, hampering global economic growth.

Below are some of the major reasons which led to disruptions in the global supply chain over the last couple of years along with key actions taken by manufacturers to minimise the impact:



Implications

Corrective measures taken

Russia-Ukraine war

- Russia is a noteworthy nation in terms of providing 35 critical minerals that the US Department of the Interior (DOI) considers important for economic growth and national security, including:
 - 30 percent of the global supply of platinum-group elements (including palladium)⁶
 - 13 percent of titanium⁷
 - 11 percent of nickel⁸
 - The conflict has also disturbed the supply of Neon (used for etching circuits on silicon wafers) and Palladium (used in catalytic converters for cars) etc.
- Absorbing volatility in commodity prices
 - Updating inventory policy and data-based planning for critical resources
 - Moving to alternate sources of supply by carefully diversifying suppliers
 - Investing and partnering in new freight routes and sustainable modes of transport
 - Friend-shoring by moving critical supplies to close allies/ partners

⁶ Russian invasion of Ukraine to further strain U.S. chip supply for auto, tech industries, CNBC, 24 Feb 2022

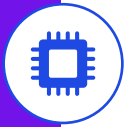
⁷ Explainer: Importance of Russian titanium to global industry, Reuters, 2 March 2022

⁸ Russia-Ukraine War Helps Drive Nickel Prices, EV Headaches, Forbes, 31 March 2022



Suez-Canal blockage

- The Ever Given ship caused blockage that disrupted around US\$9 billion worth of goods, including vehicle parts and accessories, garments, electrical and photosensitive materials, pharma goods etc.
 - With news that the blockage could last for weeks, oil prices jumped, and the supply deliveries were put on halt. Cargo schedules that were created for months were disturbed and there were traffic jams at the ports.
 - Ships could not be sent around the Cape of Good Hope, which could have added to the sailing time as well as raw material cost along with risk of pirates. Also, empty containers could not get back to Asia, which caused a shortage in container space.
- Rerouting through Africa's Cape of Good Hope, although it added to further delays
 - Exploring technologies like location tools to simulate 'what if' scenarios
 - Assessing different modes like planes, trains
 - Investing in AI/ML for faster decision making to handle such disruptions in future
 - Better insurance terms to cover similar disruptions



Semiconductor shortage

- The rising demand of laptops during the lockdown coupled with other factors such as surge for 5G networks, cloud computing and AI services led to chip shortage globally.
 - The water shortage in Taiwan due to drought and US sanctions due to the trade war further squeezed the chip market, which in turn led to increase in prices.
 - For instance, in August 2021, a chipmaking giant in Taiwan announced a price increase for all their chips by about 20 percent, and other chip manufacturers started following⁹.
- Collaborating with chip fabricators with large production capacity
 - Redesigning product features to reduce chip usage
 - Using compatible old technologies
 - Leveraging software-based solutions to optimize hardware capabilities
 - In 2022, the EU launched an initiative "European Chips Act" to strengthen technological leadership, mobilise public and private investments to anticipate and swiftly respond to any future supply chain disruptions and increase production of cutting-edge semiconductors to at least 20 percent of the world production by the year 2030¹⁰



Brexit

- Both the EU and UK rely heavily on each other for their product requirements and UK's exit from the EU has had an overall impact on the economic growth and trade policies within the European region.
 - Custom checks and additional tariff for transportation and production of industrial products led to higher cost and rising inflation.
 - Additional administrative checks and paperwork resulted in fluctuations and delay
- Reviewing the existing contracts and profitability
 - Companies in pharma and technology have considered stock piling of their key products
 - Exploring onshoring opportunities by companies and developing regional suppliers or local footprints of international suppliers

⁹ TSMC hikes chip prices up to 20 percent amid supply shortage, Nikkei Asia, 26 August 2021

¹⁰ European Chips act, European commission, as accessed on 19 May 2022

Implications

in delivery time, which has been a major setback for the organisations having a “just in time” approach

Corrective measures taken

- Short-term adjustments for inventory tactics for ensuring business continuity and maintaining service levels
- Predicting the impact of changes using forecasting and managing the changes in demand



Raw material shortage and factory closures

- Multiple shutdowns since the beginning of the pandemic have exhausted the buffer stocks and negatively impacted the production globally. Although manufacturers have resumed production, they are still unable to meet the demand.
- Freight issues such as shortage of dock workers and truck drivers have also led to the demand-supply gap.
- The raw materials market is still under a strain and the reduced supply has led to increased material prices globally.
- Maintaining better supplier relationships
- Finding alternate suppliers
- Using alternative raw materials
- Updating commodity strategies, supplier base and risk management including what to insource and what to outsource
- Simplifying and standardising products to make them easy to source at lower costs
- Fixed price agreements and secured volumes in contracts



Labour shortages

- Workforce shortages in the manufacturing units prevailed prior to the pandemic, which has now deepened.
- A large number of people are exiting the workforce, especially the baby boomers who are retiring or quitting their job voluntarily.
- Workers are seeking opportunities for switching sectors and take up jobs in certain sectors due to concerns over wages and working conditions.
- The limitations on immigration and border controls have fueled labour shortages. Although automation and AI were expected to fill the gaps, human intervention is still required to manage production lines and apply problem solving.
- Partnering with local schools and colleges
- Offering internships leading to full-time employment
- Training students on industry requirements
- Conducting social media hiring programs

Major economies have started to realise the importance and impacts of supply chain disruptions on their growth potential and as a result, various institutions and countries have introduced initiatives to curb the effect of supply chain disruptions and establish a resilient supply chain. For instance, in March 2020, the EU launched a strategy to diversify supply chains and build a “strategy autonomy” in areas such as raw materials, batteries, active pharmaceutical ingredients, hydrogen, semiconductors, and cloud and edge technologies. Key highlights of the program include:



2.2 Managing supply chain risks

The ongoing crisis has demonstrated that manufacturing remains to be the backbone of all economies, but it also exhibits the susceptibility of the global production systems to sudden shocks. When asked about the importance of having a resilient supply chain, more than two-thirds (68 percent) of CEOs in KPMG 2022 “Global manufacturing prospects survey”¹¹ admitted that the key objective is to build supply chain resilience in the event of a global lockdown.

To overcome/minimize the effect of disruptions on their supply chains, companies are adopting various strategies to ensure smooth flow of services starting from the production phase to the end delivery. Manufacturers need to learn from the past scenarios and work on adopting an approach towards continuous changes and innovation. It is important for the organisations to strengthen their strategic approach and implement strategies to minimize the risk of supply chain disruptions and building up the operational efficiency.

Manufacturers are adopting various technologies and are also looking at transferring various business operations, specifically in terms of selecting locations for moving their own manufacturing capability or a key supplier, which will be more viable to the demand location. Additional support to supply chain can be provided by diversifying resources which can eventually reduce the impact of events with shocks and shortages. The US and many other countries face limitations in the existing global supply chain due to dependence on China. European, Middle Eastern and African companies have been



Some of the top strategies to mitigate strain on the supply chain in the coming years include:

- Thorough monitoring of the company's supply chain (tiers 3 and 4) to foresee any potential issues more accurately
- Increasing the variety of input sources by including new locations to strengthen the supply chain
- Improving the production and operational resilience, the supply chain should onshore additional inputs
- Increasing the use of strategic planning techniques, such as long-term contracts and hedging programmes, to stabilise the company's input costs

¹¹ Global manufacturing prospects survey 2022, KPMG

exploring neighbouring countries in Central and Eastern Europe and North Africa for probable solutions.

Procurement heads play a pivotal role in mitigating supply chain risks, enhancing operations and productivity and making strategic moves that help manufacturing companies bounce back with more resilience and competitive cost base. Manufacturers must relook into how the work gets done, stimulate legacy styles of working, and bring in further transparency and intelligence across central workforce dimensions (partners in the ecosystem and the physical production network).

Changes in strategic models to help with supply chain resilience

01

Automation and digitalisation

- Helps to operate in a streamlined manner for efficient working of the supply chain mechanism
- Enables demand forecasting, scenario planning, positioning of the inventory and maintaining greater transparency within the system
- Latest purpose-built tools and technologies, such as Digital Supply Chain Twin solution, are useful in accessing future risks, forecasting demand, and maintaining adequate inventory to avoid any disruptions

02

Offshoring to Nearshoring/Reshoring

- Reduces transportation costs and narrows down delivery time
- Lowers the chances of disruptions in end-to-end delivery, maximising the supply chain efficiency
- Helps in minimising total cost and increasing profits, for instance, many manufacturers in western Europe have built factories in nations such as Turkey, Hungary, Poland, and Romania, where costs are competitive with the costs in China and help in financial success

03

From “just-in-time supply chains” to “just-in-case supply chains”

- Helps in accurate forecasting of demand and minimising risks arising due to the unsurety around the existence of related risks
- Provides flexibility of manufacturing products and stocking inventory as per the market requirement, avoiding huge losses
- Smoothens the process of inventory management and compresses the need for having large spaces/warehouses

04

Integrating supply chain management into structural decision making

- Builds a formal way of addressing supply chain issues with the management
- Provides equal importance and covers all dimensions of company governance
- Amplifies involvement of other decision makers, enhancing co-ordination for a smooth supply chain

05

Diversifying sourcing and procurement

- Ceases the over dependence on a single supplier for fulfilling the requirement
- Boosts the power to negotiate for better price competitiveness
- More reliable in case of a sudden surge in product demand

06

Reconfiguration of manufacturing plants

- Enhances capability to help adapt to the production capacities and functionalities of the manufacturing systems according to the transforming product families
- Optimises efficiency in case of a surge in demand with minimal efforts
- Maintains high level of performance by altering plant configuration to serve multiple functional requirements or changes in operational conditions

07

Building agile and future ready systems

- Helps in identification of volatility in the supply chains impacting medium to long-term goals of the organisation
- Scales the supply chain network and organisational development across product groups based on asset and capacity
- Shortens lead times and supply chain cycle times with frequent production runs

08

Reinventing processes and operating models





- Mitigates the risk of supply chain disruptions, enhances operations and productivity
- Helps in better adoption of strategic moves to attain a competitive cost base
- Identifies priority segments to manage supply chains
- Better assessment of the supplier network for financial stress and enabling safe and efficient selection process for onboarding new suppliers

Case Studies

	Challenges faced	Approach	Impact
Bosch	The company witnessed a shortage in component and supply disruptions in 2021, hence, decided to reshore its activities from Southeast Asia to Europe	Announced a five-year agreement with Astrata for reshoring the production from Malaysia to France. Under this agreement, Astrata's advanced fleet management system for heavy goods vehicles (HGVs) and light commercial vehicle hardware will be manufactured and Bosch will be responsible to handle Astrata's European production at its Mondeville facility in Normandy	Bosch expects that the reshoring of manufacturing activities will bolster the company's European delivery performance while lowering environmental and logistical concerns
Mercedes Benz Group (formerly Daimler)	<ul style="list-style-type: none"> • Need for building a secured platform to establish a transparent and secure enterprise B2B data marketplace • Developing a secure pathway for monetisation of data across supply chains 	Mercedes Benz Group collaborated with Ocean protocol and signed a proof-of-concept (PoC) to explore decentralised distribution of internal sales and financial data within the production hubs and few of its external supply chain procurement partners	<ul style="list-style-type: none"> • The application will help the company in monetising data across its supply chains • It helped build transparency in ease of sharing data and extracting insights with other enterprises
Volkswagen	<ul style="list-style-type: none"> • Need for connecting data chains from the supplier to the manufacturer for enhancing efficiency • Early-stage identification of supply bottlenecks 	Volkswagen is part of the industry-wide initiative "Catena-X automotive network" in 2021 that intends on promoting industry-wide data exchange and establishing data standards for the whole automotive value chain	<ul style="list-style-type: none"> • It will help Volkswagen in forming valuable synergies for expanding the Industrial Cloud, which can be used by the company to form a connection between its factories, suppliers, and industrial partners. • This will help generate new opportunities for improved efficiency and transparency in production and supply chains

Potential impacts of the supply chain rebuild

It is very important for the organisations to maintain a healthy balance between being resilient and cost effective along with having an agile system to ensure efficient supply chain mechanism. The existing trends can help the organisations in building a resilient supply chain, which is indeed an important factor in determining their financial success. Implementation of these trends can have a significant impact on the top and bottom line of the organisations. Below is the list of few trends and their potential impacts.

Area of focus	How will it impact?	Area of impact
Demand forecasting		
	<ul style="list-style-type: none"> Offering a proactive approach for supply chain management Help in predicting long-term product planning, procurement and shortages Linking raw material requirements to sales and operations to help drive a robust forecasting process Evaluates capacity utilisation targets and identifies triggers based on utilisation trends 	<p>Accurate forecasting can have an impact on bottom line of the company as the production quantity is determined basis the demand, hence chances of additional costs associated with the production gets diminished</p>
Inventory / Asset management		
	<ul style="list-style-type: none"> Proper management avoids leasing of unnecessary spaces Maintaining a safety stock to prevent production constraints Supply assurance for all the critical parts to avoid shortages and obsolescence Efficient inventory strategies for order flexibility and service level performance Focuses on cost-efficient sites to make up lost global efficiencies 	<p>Impact is observed on the bottom line as timely execution of inventory/asset management can lead to reduced production and storage cost</p>
Market awareness		
	<ul style="list-style-type: none"> Awareness about products and suppliers Mapping market-specific needs and trends Monitoring the technology curve for materials and design 	<p>Impacts the top line as it ensures development of sourcing and procurement strategies as per the current market and consumer sentiments resulting in increased market share and additional competitive advantage</p>
Diversity in suppliers		
	<ul style="list-style-type: none"> Reprioritizing geographies to reduce supply risks Expanding/ diversifying supplier network Developing strong supplier-buyer relationships Linking supply chain risks to sourcing strategy 	<p>Impact is observed on the bottom line as it increases the bargaining power of the organisations for the raw materials/finished goods sourced and minimizes the risk of inadequate supply in case of a complete network shutdown</p>

Another important factor in supply chain management is sustainability. Sustainable supply chain management is established when organisations are aware of the environmental, social and economic impact and are willingly making changes to lessen these impacts. For instance, if a company is involved in manufacturing products, its sustainability strategy can include reviewing the entire

manufacturing process, which would further include the sustainability practices of all vendors, product assembly in the plant, and waste disposal and recycling. The following chapter will elaborate more on the importance of sustainability in industrial manufacturing.

03

Sustainable manufacturing

3 Sustainable manufacturing

3.1 Increasing focus on ESG

In the global economy today, adopting sustainable and ethical business practices is an imperative for the manufacturing sector to remain profitable. The relevance of ESG and sustainability programmes has grown to the point that they might have larger and more significant consequences, especially for industrial companies. The preference for companies that embrace ESG is rising among investors, regulators, employees as well as consumers. Consumers are more aware of sustainable products, and supply chain partners are under more pressure to adopt ESG standards in B2B transactions. Even C-suites and boardrooms are paying close attention to the ESG goals and initiatives.

Key concerns that make it an imperative for embracing ESG initiatives are high carbon emissions, water shortage, fossil fuel consumption, disruptions due to weather and waste management. The manufacturing sector alone is the largest contributor to producing greenhouse gases. For instance, in Europe, the manufacturing industry emits about 880 million tons of carbon dioxide annually¹². This coupled with other considerations, is driving the increased focus on ESG.

Top four factors that make ESG initiatives a major concern for the manufacturing sector include:

- 1 Increasing customer demand**
 - Compared with 2019, the number of large-scale purchasers asking their suppliers to provide environmental data increased by 24 percent in 2020.
- 2 Monitoring internal governance**
 - Companies that do not comply with ESG goals are expected to face significant regulatory penalties. More than 70 countries, for example, have enacted legislation to restrict plastic usage and about 170 countries have vowed to "substantially cut" plastic consumption by 2030.
 - In addition, SEC established a Climate and ESG Task Force in the Division of Enforcement last year, which will create strategies to proactively identify ESG-related misbehaviour. The task force will also investigate disclosure and compliance problems associated with investment advisers and funds.
- 3 Participation of leadership**
 - With global sustainable investment already exceeding US\$29 trillion, up by 68 percent since 2014 and 10 times since 2004, boardroom directors and C-suite executives are under increasing pressure to make sustainable investments. Since the beginning of 2020, almost 57 percent of CFOs have made it a priority to invest in ESG activities, with 23 percent acknowledging that ESG investments are more important for their organisations now than before 2020.
 - Companies are also beginning to link executive compensation to environmental, social, and governance (ESG) goals and KPIs. This emphasises the importance of developing and implementing relevant ESG strategies.
- 4 The changing labour forces**
 - The labour force is shifting, owing to a labour shortage triggered by the "great resignation" and "grey tsunami."
 - In fact, ESG commitments are considered by 76 percent of millennials when picking where to work. It will become increasingly important for companies to commit to ESG initiatives to fill the talent pipeline, especially with younger generations.

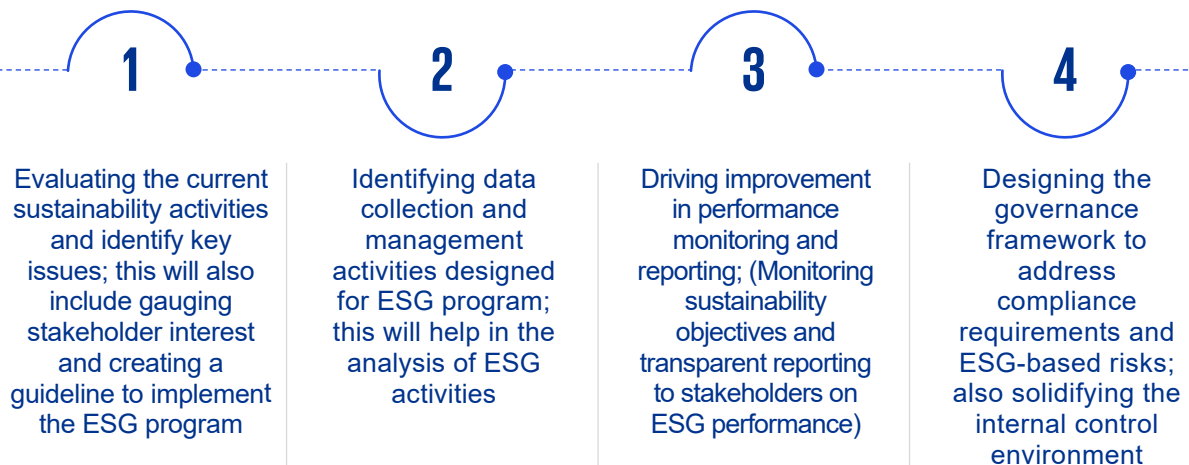
¹² From remanufacturing to recycling how manufacturing can raise the bar on global climate goals, Weforum, 14 June 2021

3.2 Incorporating ESG agenda

3.2.1 Introduction

Manufacturing technologies and solutions are enabling the measurement and reporting of precise and consistent ESG metrics across industries, as well as the enablement of both profitability and sustainability. Companies can set the agenda and show a stronger commitment to ESG.

The ESG journey of a company may include the following steps:



Some of the ways in which manufacturing companies globally are revamping their business operations to suit local/global level ESG targets include:

- 1** Engaging with partners to reduce the environmental impact of sales and distribution processes
- 2** Expanding the product life cycle by making it reusable and recyclable
- 3** Reducing the product size and weight to optimise packaging requirements
- 4** Tracking ESG metrics around downtime, manufacturing cycle time etc.
- 5** Using efficient and sustainable logistics and transportation
- 6** Use of renewable and non-hazardous materials
- 7** Supporting biodegradable, recyclable and reusable products
- 8** Redesigning and adapting to the production processes that reduce the overall carbon footprint

For measuring sustainability, frameworks including ESG goals are becoming an imperative, with a major focus on the environment to determine how that company performs in its natural or physical ecosystem. Environmental considerations were expected to have a marginal effect on the economic growth, however, climate risk, water scarcity, extreme temperatures and carbon emissions are observed to be the key pillars in economic growth today.

- Companies may experience greater financial risks for neglecting the effects of policies and practices on the environment
- Companies may also harm the shareholder value if faced with government sanctions, criminal actions and any damage to the reputation

The threat of environmental risks has led to fragmented global regulatory response. In Europe, regulators are progressively pushing towards a carbon neutral economy and mandating standards for environmental reporting. EU has been redirecting investments towards sustainable manufacturing along with pushing ESG factors into the capital markets over the last few years.

The industrial manufacturing sector has been at the forefront in terms of environmental performance over the last few decades. While certain highly polluting manufacturing units have come to a halt, certain other companies are getting more involved in voluntary schemes to compensate for their impact on the environment. The industrial manufacturing sector alone is responsible for a huge impact on the environment in terms of pollution and waste generation.

Possible impacts of sustainability on a company's performance



Impact on financial performance

- Increase in sales by earning a competitive advantage by meeting social and environmental expectations
- Improvement in productivity and efficiency by reducing resource waste and regulatory load
- Reduction in dependence on hazardous materials by leveraging greener and innovative alternatives



Impact on business excellence

- Staying ahead of regulations rather than reacting after implementation of changes
- Winning better access to capital due to reduction in operational, strategic and supply chain risks and offering sustainable products in the market
- Gaining foresight on the strategic front by anticipating solution innovation and value addition



Impact on stakeholder relationships

- Enhancement in reputation due to green initiatives
- Improvement in employee retention and morale by contributing to the environment
- Building better relations with the community by demonstrating a responsible approach towards local people and environment

3.2.2 Government initiatives around sustainability

Europe



- The EU is extending support to the climate in many ways. For instance, the EU increased its contribution on the European Green Deal. The InvestEU Programme is anticipated to bring more than US\$685 billion of added investment by 2027, through the usage of an EU guarantee¹³.
- Mitigation and adaptation of climate change has been integrated and mainstreamed into the EU's key spending areas. In its proposal budget of over US\$1 trillion for the duration of 2021–27, the European Commission increased its aim to spend a minimum of 25 percent of expenditure on activities related to climate; representing about US\$338 billion¹⁴.
- According to European Environmental Agency (EEA), the EU has already cut down its net greenhouse gas (GHG) emissions by about 31 percent since 1990. However, further progress is required to meet the new reduction targets of 55 percent for 2030¹⁵. The National Energy and Climate Plans (NECPs) have undertaken various pathways and planned measures to meet the 2030 ambition. Implementation of the measures planned under the NECPs of the Member States is expected to reduce the EU emission levels by 41 percent by 2030¹⁶ (without considering emission removals) and would be a significant step towards achieving the new climate target.
- The European Commission in March 2020, outlined an industrial strategy that aimed at supporting the twin transition to a green and digital economy, improve the open strategic autonomy of Europe, and make the European Union more competitive globally. The Industrial Strategy of 2020 enlisted actions to support the transition to green and digital economy, most of which have already been launched or adopted by the EU.

To accelerate the green and digital economy twin transitions, the Commission has proposed the following:

EU Industrial Strategy



Transition pathways

Co-create jointly with stakeholders and industry, transition pathways to identify the actions needed to accomplish the twin transitions, providing an improved understanding of the scale, conditions and benefits required.



Multi-country projects

To assist the recovery efforts and design digital and green capacities, the European Commission to support Member States in joint projects to maximise investments under Recovery and Resilience Facility.



Horizon Europe partnerships

Bringing together public and private funding to support research and development on low-carbon technology and processes.



Abundant, available, and affordable decarbonised energy

The European Commission will jointly collaborate with member states to facilitate investments into grids, renewables and address barriers.

¹³ European Commission Press Corner, as assessed on 19 May 2022

¹⁴ EU budget 2021-2027, European Commission, as assessed on 19 May 2022

¹⁵ 2020 Highlights - European Environmental Agency, as assessed on 19 May 2022

¹⁶ Data and maps - European Environmental Agency, as assessed on 19 May 2022

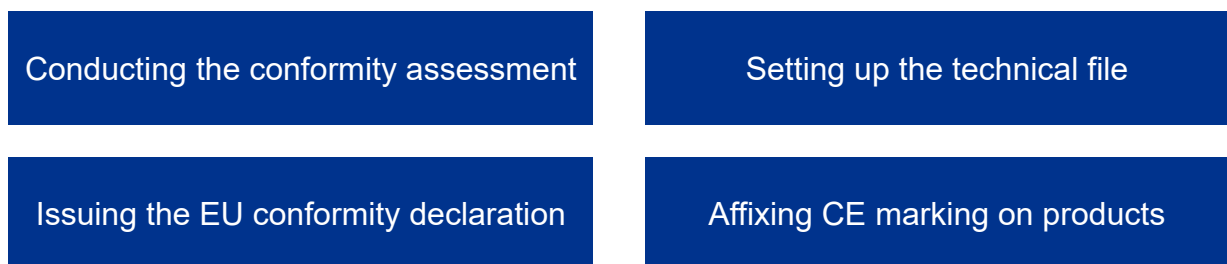
Middle East and Africa



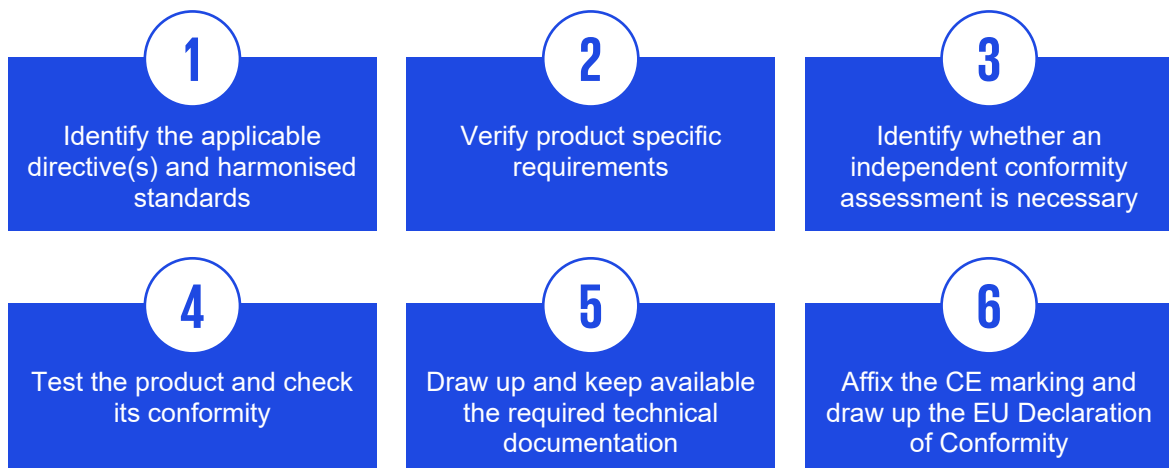
- Saudi Arabia as part of its Vision 2030 strategy,¹⁷ has planned to invest US\$6.4 billion towards recycling waste by 2035. The circular economy model has opened up enormous opportunities across the region, in terms of energy creation, products, or services, and can contribute substantially to economic diversification.
- The Arab Chambers of Commerce, Arab League, the Government of the United Arab Emirates (UAE), and Bahrain Chamber of Commerce & Industry, have stressed on their responsibility to accomplish the 17 global goals mentioned in the 2030 Agenda for Sustainable Development.
- Building on the Climate Change Action Plan by World Bank, the Middle East & North Africa (MENA) Climate Roadmap is anticipated to guide the support of the World Bank to the MENA region for the upcoming five years and drive their involvement to help countries cut down emissions and adapt to climate change. The roadmap consists of World Bank Group's funding investments of up to US\$10 billion, to be utilised for climate smart projects and policy reforms, and leverage added US\$2 billion in financing of the private sector¹⁸. In keeping with country and region-specific demands that manage climate adaptation and mitigation measures, about 50 percent of this climate funding will be invested in interventions that help in building resilience.

Regulatory framework for industrial manufacturing:

Manufacturers in Europe need to ensure that the products placed in the market are safe. They need to ensure that the products meet safety, environment and health protection requirements. To trade products in the EU market, manufacturers need to ensure the below points:



As per the **European commission**, below are the six steps required for affixing a CE marking on a product.



¹⁷ Saudi Vision 2030 – Arab News, as assessed on 19 May 2022

¹⁸ Feature Story - Driving Transformation: A Climate Roadmap for the Middle East & North Africa, World Bank, as assessed on 19 May 2022

For products that pose a high safety risk like gas boilers, the safety checks are performed by an external organisation that has been appointed by the national authorities. The CE marking on the products can be fixed only after clearing the safety check. The industrial policy of the European Union aims at making the European industry more competitive so that it can sustain its role as a driver of employment and sustainable growth. The transition toward a digital and carbon-neutral economy has led to the adoption of various strategies to ensure better framework conditions for the industry.

Framework for regulatory requirements at each phase of the PLC



Sustainability in Industrial manufacturing – European region



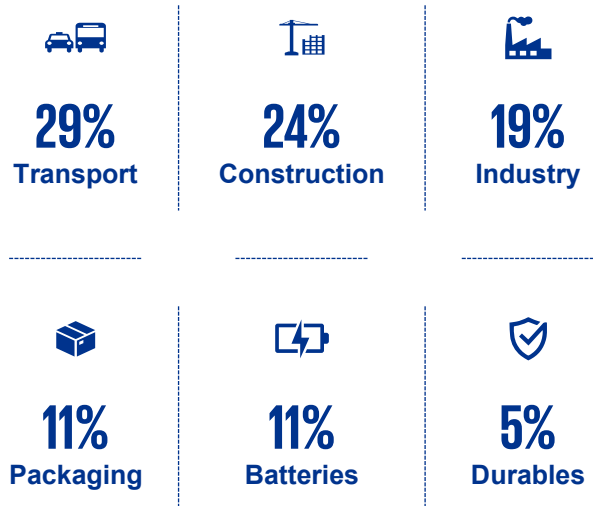
Metal

Annual production of **47 million** tonnes, representing over one-fifth of the global production

52 percent of pure base metals and alloys come from recycled sources

13 percent of the Earth's crust is made up of non-ferrous metals

Distribution of metal usage by sector (in %)



Source: *Our Metals Future*, Eurometaux, accessed on 17 May 2022

Industries in Europe are using metals to produce and generate more sustainable products, services, and infrastructures. Following are some notable examples:



Renewable energy sources

Renewable energy technologies including solar thermal systems, photovoltaic cells, and hydroelectricity need metals such as zinc, copper, nickel, and potassium to operate. **Metal components contribute to nearly 90 percent of the weight of a modern wind turbine.**



Efficient communication

Recent innovations with metals such as cobalt, lithium, nickel, or copper have substantially improved the battery life of devices such as laptops and cellular phones. Technologies are utilizing metals to create smaller and resource efficient devices.



Other applications

Non-ferrous metals have been an integral part for resource **efficient packaging**, as trace **elements in modern medicine** and for improving human health through medical equipment.



Sustainable buildings

The durability, recyclability, and strength of metals contribute to construction of **sustainable and safe buildings**. Copper, nickel, lead, aluminium, and zinc are corrosion resistant and can last more than 100 years without maintenance. Metals with conductive and semi-conductive properties are also essential for efficient use of **electronics and electricity in modern buildings**.



Low-carbon transport

Metals such as magnesium and aluminium can help in construction of **light weighted vehicles**, lowering their fuel consumption, without compromising on their safety. Precious metals such as platinum are critical to catalytical converters, whereas batteries using lead, nickel, lithium, cobalt and copper are used for **improving fuel efficiency** in electric and hybrid vehicles.

Source: *Our Metals Future*, Eurometaux, accessed on 17 May 2022



Eurometaux is an association of the non-ferrous metals industry in Europe. It includes an extensive network of companies engaged in the production, transformation and recycling of non-ferrous metals in Europe. Eurometaux is involved in executing short-term projects with the target to support the transition towards a sustainable economy. Noteworthy examples of the actions, research and projects in which Eurometaux and the industry are engaged in are as follows:

Europe

Product Environmental Footprint

- The pilot project for three years known as the Product Environmental Footprint, is coordinated by Eurometaux and involves distinct metal commodity companies and associations that strive to achieve a robust methodology to evaluate the impact of metals through the lifespan of several products.

Benchmarking and defining certification schemes

- Eurometaux is managing a project to define the conditions required for certification schemes for processing of waste at the pre and end stage, covering environmental, quality, efficiency and health criteria.
- The project will also establish a benchmark for quantifying and measuring the impact of these certification schemes, along with improvements in recycling and collection.

Water regulation knowledge-sharing

- Eurometaux will introduce a project to notify member states about the impacts of new water regulations on permits.
- It will utilise training tools and materials and scientific knowledge to highlight the toxicity and presence of metals in water, and guidance on executing bioavailability models to harmonise national approaches to metals.

Source: *Our Metals Future*, Eurometaux, accessed on 17 May 2022

US\$ 241 billion
of annual turnover



884,600
direct employees



88 million
indirect jobs along the EU
value chain



Aerospace & Defense

Since 2000, the retrofitting of winglet devices on aircraft has meant

80 million tonnes of CO₂ have been avoided

CO₂ emissions from aviation dropped by

64 percent in the EU in 2020

92 percent of the total weight of an aircraft is recycled.

Today's modern aircraft producing

80 percent less CO₂ per seat than the first jets in the 1950s.

EU Emissions Trading System has so far contributed to reducing the carbon footprint of the aviation sector by more than

17 million tonnes per year, with compliance covering more than

99.5 percent of emissions.

TARMAC AEROSAVE, a jointly owned organisation of Airbus, Suez, and Safran recycled more than 135 aircrafts since its establishment in 2007.

Sustainability goals:

- To have a carbon neutral growth from 2020
- To reduce absolute emissions by **50 percent** by 2050, compared to 2008 levels.
- Net zero CO₂ emissions by 2050 via a combination of four elements: enhanced aircraft and engine technologies, Sustainable Aviation Fuels (SAFs), Air Traffic Management and economic measures.

EU Investments:

Approximately **US\$5 billion** over the last 10 years through various programmes (e.g., Clean Sky, SESAR, Life, Horizon 2020, Connecting Europe Facility) and an array of measures (e.g., EU ETS, CORSIA, aeroplane CO₂ certification standard)

Source:
Reducing emissions from aviation, European commission
EUROCONTROL Data Snapshot #2 on CO₂ emissions from flights in 2020, Eurocontrol
European Aviation Environmental Report 2019, EASA
European aviation sector proposes EU Pact for Sustainable Aviation to realise EU's 2030 and 2050 decarbonisation ambitions, ASD Europe



Machinery

Europe non-road mobile machinery contributes to about

30 percent of the traffic pollution,

16 percent of nitrogen oxides and about

7 percent of particulate matter

CO₂ emissions from machinery industry can be reduced by

50 percent if partial electrification is used.

The emissions are further reduced by additional

7 percent in case of advanced electrification

83 percent of the machines are made of recyclable metallic materials

Sustainability goals:

- The European Green Deal aims at achieving environmental sustainability for industrial sectors by 2050
- The European Green Deal has laid down compliance implications for 2030 targets that include subsequent goals –
32 percent of energy sourced from renewables, **40 percent** cut in GHG emissions, and a **32.5 percent** increase in energy efficiency

EU Investments:

Approximately **US\$7 billion** of investment funds have been allocated by EU under the French Support measure to provide investment support towards sustainable recovery for industrial sectors including machinery and equipment manufacturing



US\$2 trillion
of annual turnover



18 million
direct employees



4 percent
construction output
of Eurozone in 2021



Source:
2021 European Construction Outlook ING
Construction Sector: European Union
European Aviation Environmental Report 2019, EASA
European Commission - Energy Efficient Buildings - Renovation Wave
European Commission - Sustainability - Building & Construction

Building & Construction

Use of sustainable concrete for construction can alone reduce carbon dioxide production by almost

50 percent

CO₂ emissions from building operations dropped

6 percent in 2020

GHG emissions from material extraction, construction and renovation of buildings contribute to

5-12 percent of emissions.

Greater material efficiency could save

80 percent of those emissions

Investments in energy efficiency and green building certifications resulted in reducing carbon output from buildings and the investment in energy efficiency increased to more than

39 percent in 2020 from 2015.

Sustainability goals:

- Renovating public and private buildings under the European Green Deal Initiative to tackle energy poverty and worst performing buildings
- Double annual energy renovation rates of buildings in next 10 years
- Requirement to renovate **3 percent** of the existing building block stock each year to increase energy efficiency

EU Investments:

- Approximately **US\$79 billion** of investment funds have been allocated to the buildings sector under the Recovery and Resilience Facility (RRF) under NextGenerationEU
- The Cohesion Policy Funds and InvestEU also contributed to efficient building construction

Case examples of initiatives undertaken by industrial manufacturers towards sustainability

Siemens (Germany) - Siemens launched the Sustainability Vision towards 2040¹⁹ to ensure its contribution has a significant impact in the future.

- The Vision outlines a path to reach the net-zero emissions goal by 2040, including emissions generated by the entire value chain of the company. Previously, the net-zero targets to achieve a decarbonised economy was year 2050
- The company **will seek opportunities to accomplish a carbon intensity rate of zero-emissions** per MW installed without any measures to offset compensation. Few key actions will be replacing all existing and new cooling and heating systems with zero carbon alternatives, and self-generation in the factories and wind farms.
- Siemens Gamesa accomplished carbon neutrality and became the first renewable energy manufacturer by confirming to its climate-related targets by the Science Based Target initiative (SBTi). In addition, it switched to being powered 100 percent by electricity generated from renewable energy sources.

Airbus (France) - In 2005, Airbus undertook a voluntary approach to **aircraft decommissioning and recycling**. Presently, Airbus and Tarmac Aerosave have identified a proven method for dismantling, decommissioning and recycling the entire product range of the Airbus aircraft in an environmentally efficient way, with about 90 percent of aircraft eligible for recycling or reuse. For non-recyclable parts, the organisation emphasizes on safe disposal²⁰.

The project has been successful in achieving the following results since 2007:

517

Aircrafts stored

117

Aircrafts recycled

92%

Reuse of left-over parts

100

Engines recycled



¹⁹ Sustainability Vision towards 2040 – Siemens, as assessed on 17 May 2022

²⁰ Sustainability Overview - Airbus, as assessed on 17 May 2022



CO₂

Airbus has committed to contribute to the Paris Agreement targets and leading the decarbonisation of the aviation sector in full collaboration with all stakeholders. The company is committed to reduce its industrial emissions by up to 63 percent by 2030 in line with a 1.5°C scenario.



Energy

The company is working to increase the share of renewable and low-carbon energy at its sites. Improved monitoring, increased efficiency for lighting, heat and steam, and new constructions in line with certified building standards are additional initiatives that are currently underway.



Water

To limit water consumption, the company focuses on increasing water recycling and reuse in industrial practices. Increased measuring and monitoring are also the key.



Air emissions

Air emissions, such as volatile organic compounds (VOCs), are mainly related to surface cleaning, treatment and paint. Even with delivery rates increasing, the company aims to maintain 2015 levels.



Waste

New ambitions as part of the high5+ programme have been set for waste management for 2030.

These include reducing the amount of produced waste by 20 percent, diverting waste from landfilling and avoiding incineration without energy recovery.

Another sustainable concept is Circular Economy (CE) that contributes to a more sustainable world but doesn't necessarily translate to sustainability. Circular economy concentrates on resource cycles, whereas sustainability is widely related to the planet, people, and economy. Sustainability and circularity stand in a long tradition of related theories, visions, and models. By promoting system innovation that boosts resource efficiency, keeps materials in use, and decouples growth from the consumption of finite resources, CE is thought to have the potential to disrupt the current linear economy of unsustainable production, consumption, and waste generation, thereby achieving a healthier balance between the economy, environment, and society. The long-term goal is to switch to a circular, regenerative economy where resources are used in ways that maximise their long-term worth to society. CE increases resistance to upcoming setbacks like pandemics, intense and frequent weather catastrophes or the effects of a changing environment.

3.3 Focus on circular economy

3.3.1 Introduction:

When implementing CE in industrial manufacturing, four cornerstones must be considered: **Reduce, Refurbish/Reuse, Recycle, and Recover**. Each of the four foundations contributes to long-term manufacturing sustainability. Their importance for CE, impact on present manufacturing strategy, and simplicity of implementation, vary on the other hand. Furthermore, the level of influence and applicability varies per industry.



3.3.2 Significance of circular economy in industrial manufacturing

Manufacturing firms should analyse the five circular economy-based business models and their sub-models to address the inefficiencies in the linear value chain:

Circular business approach	Usage	Impacts
Rethinking the usage of resources	Use of bio-based products, renewable energy, or potentially completely recyclable materials	<ul style="list-style-type: none"> • Reduce production cost • Increase market share • Reduce utility costs • Access to funds
Recovering value of waste	Recovery of energy or usable resources from by-products or waste	<ul style="list-style-type: none"> • Supply risks are diversified since materials can be recycled repeatedly and provide a more predictable supply of resources
Optimising capacity use	Improved rate of usage through collaborative models for access, usage, or ownership	<ul style="list-style-type: none"> • Reduce cost like sharing warehouse
Implementing outcome-oriented solutions	Offering products for usage with retention of product ownership that incentivizes increase in resource productivity through the entire life cycle	<ul style="list-style-type: none"> • Increase revenue • Replace product ownership with PaaS (Product as a Service) model, for example, Uber and Airbnb
Extending repurposed product life cycle	Extension of the life cycle through repair, maintenance, remanufacture, upgrade, and resale	<ul style="list-style-type: none"> • Reduce operating expenses • Increased sales (from reselling) • Increase gross profits

While manufacturing companies can reap huge benefits using CE, there are several challenges that these companies need to overcome to transform themselves. These challenges may be intrinsic as well as extrinsic and can be related to the organisational culture, ecosystem and finances.

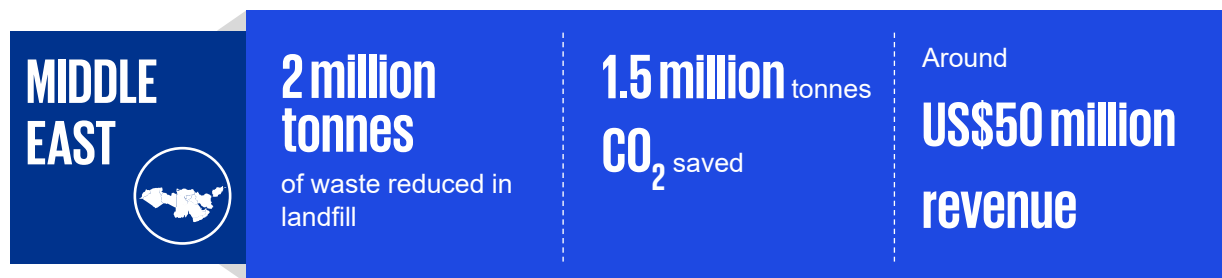
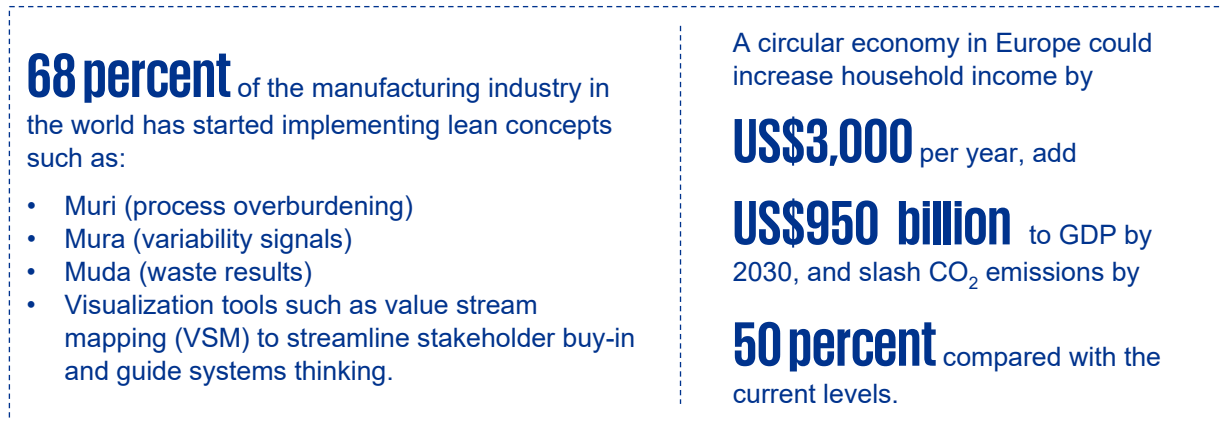
Some key challenges

- 1 Need for introducing policies that define correlation between monetary benefits through circularity as well as the impact on environment
- 2 Linking of various production chains can make the company vulnerable to disruptions
- 3 Limited benefits from economies of scale in repurposing waste
- 4 Requires legal guidance for new business models
- 5 Managing the entire life cycle of the product and building a reverse value chain is expensive for companies
- 6 Requires new risk assessment and mitigation strategies
- 7 Requires experience in circular economy principles

Manufacturers can take steps to overcome these challenges, some of which may include:

- 1 Run dedicated programs to induce cultural changes
- 2 Develop ecosystem by including new and relevant partners
- 3 Assess all benefits of CE holistically
- 4 Assess funding requirements for the specific business model
- 5 Develop risk mitigation strategies
- 6 Identify funding partners with experience in CE

3.3.3 Focus on circular economy in Europe and Middle East



Source:
 Multi-Stakeholder Platform Input to Reflection Paper Sustainable Europe 2030 - Eurostat, accessed on 17 May 2022
 Circular economy action plan – European Commission, accessed on 17 May 2022
 Analysing the Implementation of Lean Methodologies and Practices in the Portuguese Industry: A Survey– MDPI, accessed on 17 May 2022
 Material flows in the circular economy - Eurostat, accessed on 17 May 2022
 Growth within a circular economy vision for a competitive Europe – Ellen Macarthur Foundation, accessed on 17 May 2022
 Middle East’s Circular Economy Expectations for the Next Ten Years – Open Science Journal, accessed on 17 May 2022

3.3.4 Initiatives undertaken by the government towards circular economy

- The Circular Economy Action Plan (CEAP)²¹, which the European Commission unveiled in March 2020, aims to empower consumers by establishing a right to repair while also promoting waste reduction and sustainable product design. The emphasis is on industries that use a lot of resources like plastics, textiles, electronics and ICT and construction.
- In a resolution on the new CEAP adopted in February 2021, the Parliament called for additional steps, such as stricter recycling regulations and binding targets for material use and consumption by 2030, to achieve an environmentally sustainable, carbon-neutral, toxin-free, and fully circular economy by the year 2050.
- To hasten the transition to a circular economy, the Commission published the first set of CEAP measures in March 2022. The plan called for educating customers about the green transition, promoting sustainable products, revisiting legislation governing building supplies, and developing a plan for sustainable textiles.

3.3.5 Industrial manufacturers' initiatives towards circular economy

Current inefficiencies	Addressing these inefficiencies using circular principals
Materials are unsustainable	<ul style="list-style-type: none"> • Volvo utilises around a third of recycled materials for construction of new trucks, and about 90 percent is recyclable towards the end of the truck's lifespan • Wärtsilä designs its engine by applying modular architecture to allow backward compatibility of parts and increased commonality
Capacities are underutilised	<ul style="list-style-type: none"> • Caterpillar acquired Yardclub, a management tech start-up, with a platform facilitating equipment renting, selling, and sharing. This acquisition will help Caterpillar in gaining technical expertise for offering better digital experiences to its customers
Product life is premature	<ul style="list-style-type: none"> • The Circuit Breaker Retrofit program by Schneider Electric, updates and modernizes electrical distribution centres • Bosch makes use of remanufacturing chains for components, to confirm the material stays in the loop at its highest possible value and for as long as possible
End-of-life value is wasted	<ul style="list-style-type: none"> • Maersk introduced a database called the Cradle-to-Cradle Passport for vessels, for registering the material composition of the main ship components, thereby facilitating fine recycling of parts and materials • GM owns 111 landfill free facilities and recycles 84 percent of its manufacturing waste worldwide
Customer engagements are unexploited	<ul style="list-style-type: none"> • Philips has various contracts in place for offering light-as-a-service on a monthly subscription or pay-per-lux basis • Michelin provides sensor-based data analytics for predictive maintenance and tire-as-a-service i.e., pay per mile

Sources:

Volvo Trucks: First in the world to use fossil-free steel in its trucks, 24 May 2022
 Increased Commonality of Components
 Caterpillar buys into construction rental start-up Yard Club, CNBC, 27 May 2015
 Retrofit solutions for electrical distribution, Schneider electric
 How GM Makes \$1 Billion A Year By Recycling Waste, Forbes, 21 Feb 2013
 Preventive maintenance API, Michelin

²¹ Circular economy action plan, European Commission

The application of digital and technological systems has helped in the uptake of CE. While there needs to be more efforts to increase reuse and recycling of materials, technology can help establish CE across all sectors. As we move towards the Fourth Industrial Revolution, innovative technologies provide massive opportunities to revolutionize the way we do businesses today. These technologies are driving innovative ways of creating value in a circular economy, for both established and emerging businesses.

A close-up photograph of a robotic arm in a factory setting. The arm is metallic and has various sensors and cables attached. It is positioned over a workbench. The background is slightly blurred, showing other industrial equipment. A semi-transparent blue and purple gradient box is overlaid on the left side of the image, containing the text.

04

Increasing use of advanced technologies / Industry 4.0

4 Increasing use of advanced technologies / Industry 4.0

4.1 Technology in manufacturing

4.1.1 Introduction

The Fourth Industrial Revolution or Industry 4.0 is the creation of a digital manufacturing firm that is not only connected but also communicates, analyses and uses data to motivate more intelligent action in the real world. It powers the physical act of designing, production, distribution and performance in a continuous cycle.

The significant advancements in cyber-computing capabilities over the previous few decades are the reasons why Industry 4.0 is gaining popularity. Artificial intelligence (AI), the Internet of Things (IoT), and other cutting-edge technologies have helped to close the gap between the virtual and physical worlds to build an interoperable platform between information technology (IT) and actual physical activities. The technologies listed below had a favourable impact on industrial manufacturing.

Technology Use cases in manufacturing

Autonomous Robots



Robots are used for collaborative assembly, painting and sealing, inspection, welding, drilling, and fastening. Robots are replacing many dangerous human occupations, such as those in the chemical and metal industries.

Nano technology



Widely used in automotive and aerospace industries, it is used in coatings, nanoengineered polymers, lubricant coatings, DNA-based structures and nanomachines.

Big Data Analytics



It examines large data sets to unleash market trends, hidden patterns, unknown correlations and provides insights to enable real-time decision-making.

Industrial IoT



IoT-enabled and sensor-embedded equipment can send data that assists the supply chain team in tracking assets (using RFID and GPS sensors), forecasting, gauging vendor relationships, and scheduling predictive maintenance programmes.

3D Printing / Additive manufacturing



It supports manufacturing-as-a-service (MaaS), which allows businesses to maintain an up-to-date infrastructure that can serve several clients without having to buy new equipment.

Technology Use cases in manufacturing

Smart Factories



Smart factories are advantageous for operations such as planning, supply chain logistics, and product development since they can help produce at a large scale.

Artificial intelligence and machine learning



Even in production facilities, AI-enabled systems identify objects on conveyor belts and can sort products automatically based on their predefined shapes, colours and sizes. Such intelligent systems use image analysis and image recognition to identify product flaws in manufacturing.

Digital Twin



Using digital twin, companies can get a complete digital prototype of products that they can use to detect physical issues sooner, build better products and predict outcomes more accurately. Not just that, the combination of Industry 4.0 and digital twin will enable various industries to market a new product quickly, improve operations and bring up new business models to drive revenue.

Cloud Computing



To better schedule resources and direct workforce, as well as track inventories, an aerospace company, for instance, established a cloud AI platform. The solution tracked "machine available to perform work," tracking and tracing where parts were in the facility for staging and integrating localised data with ERP and 3PL systems.

Augmented Reality










Designers and engineers are utilising VR to generate realistic product models, allowing them to visualise their concepts in 3D and troubleshooting difficulties before going into production. They can even contact an expert to receive real-time assistance using AR technology. Another big advantage of AR is that it enhances industrial training and learning by reducing risks and costs.

For instance, fuel consumption has decreased, scheduling has improved, and flight delays are reduced by using real-time flight data gathered from sensors in an aircraft. By using data to track asset status and foresee component and system breakdowns, Aerospace & Defense 4.0 technologies are also enhancing the aftermarket experience.

The effects of these technologies are already becoming apparent to some businesses. They are investigating considerable potential benefits in several areas, including cost-cutting, supply chain reorganisation, accelerated delivery and widespread product and device connectivity. The leading objective of Industry 4.0 is to excel in manufacturing operations: to become faster, more efficient and customer centric. For instance, the usage of Mixed Reality devices can help the repair personnel to see through the machine and easily detect the faults. The identification of drilling point becomes easier. Also, with Industry 4.0, manufacturing companies can not only automate and optimise their processes but also discover new business opportunities as well as different models.

This transformation can provide information around the entire value chain which can help manufacturers in multiple ways:

-  • **Design strategies to manage the supply chain** – Introducing smart logistics can be transformative such as automated warehousing, cargo tracking and remote fleet management
-  • **Prevent wastage of resources** – A combination of technologies could also be easily used to automate recycling tasks — an area that is more popularly known as 'robotic recycling'.
-  • **Improve the production rate and manage risk of surplus production** – Deploy a smart asset monitoring solution on a robust IoT platform. It gives information on the entire manufacturing process in real time. The organisation's value chain is visible to the user — resources employed in production, their distribution throughout several phases, provenance and the various production-related activities.
-  • **Enhance communication between employees** – Sensors, actuators, embedded computers, cell phones, and other cyber-physical systems are all connected to one another and share data among themselves.
-  • **Controlled distribution of goods** – Technology can improve the distribution of goods by increasing the shipping speed. We can use latest technologies such as logistics management, port clearance on site etc. to deliver the goods to customers within the shortest possible time.
-  • **Develop smart products for different market segments** – Manufacturers can create self-aware, connected items that can exchange data about their location, usage pattern, storage conditions and more. Everything can be enhanced — from product quality and customer service to logistics and R&D with the help of the data these smart gadgets provide. They may also foresee service requirements, get upgrades remotely, and pave the way for fresh, service-based business models.
-  • **Deliver excellent customer experience** – To provide an outstanding customer experience, manufacturers must make sure they are collecting, monitoring and analysing data about product requests and customer service from all relevant touchpoints or input channels.

Technology today plays a vital role in managing industrial manufacturing, particularly in areas such as inventory, supply chain and operations management. Unlike before, customers are at the centre of every industry, and they dominate the product strategy. Owing to the pandemic, buyer demands have changed, and manufacturers are implementing technology to design better products and services to meet the market demand. Technologies such as IoT, robotics, quantum computing and 6G will also find their way in product development and go-to-market strategies through trends such as mass customisation and mass production.

Mass customisation:

Mass customisation allows customers to receive products at a lower cost. Customers' unique requirements are fulfilled by the company as a part of its business strategy. This approach is used not only by the manufacturing sector but also by service providers such as retail, financial services, software and technology, home construction and interiors, among others. Some of the factors which manufacturers must consider are product features preferred by customers, making goods or services suitable for customisation through reusing or restructuring and providing unique proposition to the customer. For instance, Dell maintains close relationships with its suppliers and customers and allows its customers to select preferred configurations online. Dell provides made-to-order products and assembles parts promptly.

Many industries such as food, automotive, consumer electronics, healthcare have adopted customisation and personalisation in shapes, features, colours, graphics etc. Some of the technologies that are being used are around digital models, product visualisation, product recommendations on ecommerce platforms and dynamic pricing. The top ways in which mass customisation can help organisations is by reviving the stagnant markets and providing opportunities for higher growth and profits.

Challenges



Potential Benefits

Balancing the right amount of differentiation and costs	Gives a competitive edge
Creating online platforms for customisation	Attracts more customers and improves brand image
High production time for custom made products	Simplified production and inventory management
Need for excess inventory due to variations in demand	Less waste
Increased information management	Unit cost of product is decreased as production scale increases
Due to the abundance of possibilities, predicting trends and spikes in sales is increasingly challenging	Allows introducing premium pricing
Buying flexible machinery and hiring highly skilled personnel could be significant investments.	Less expenses on product research
	Lowers fashion risk and product model obsolescence

Mass production is viewed as the most effective production approach where costs are driven down while production capacity is sustained at a higher level. Mass production can be demarcated as the production of large quantities of standardized products quickly.

Comparison between mass production and mass customisation

Parameter	Mass production	Mass customization
Production	Large scale	Large scale
Products	Standardized	Custom-made
Demand	Stable	Fragmented
Economies of scale	Possible	Not possible
Technologies	Less investments	Heavy investments
Customer involvement	Passive	Active and integrated
Machines / processes	Specific machines and less skilled operators	Process oriented factories, highly skilled supervisors

Case examples of mass customisation:

Audi

Customisation efforts

- Mass customisation techniques were applied, including flexible production and logistics systems, modular product architecture, and integrated IT systems, to enable the provision of highly personalised products at a reasonable cost.
- Implementing product variant management was one recent attempt to improve the firm's operational effectiveness. It helps in balancing the requirements from the customer and production costs by finding the best combination of standard and custom components.
- This program's major goal is to preserve a wide range of products that consumers demand while reducing internal complexity and related expenses along the whole value chain.

Impact

- Helped the company to establish a luxury brand image

Nike

Customisation efforts

- Nike adopted mass customisation with different colour combinations, various materials and option to engrave name on shoes.
- The idea of the brand was to gain a competitive edge and grow its margins.
- The brand also launched an app for mobile phones targeting its D2C approach to cut middle-men costs.

Impact

- Generated over US\$100 million after launching NikeiD
- 10 to 20 percent price hike for premium customised sneakers
- Custom-made NikeiD sport shoe costs only 20 percent more than a mass-produced one.
- NikeiD dominates the customisation market worldwide
- Increased brand loyalty

4.2 Penetration of advanced technologies in manufacturing



The penetration of advanced technologies in the manufacturing sector helps enhance the economic prosperity with increase in technology exports, higher productivity and compensation of employees. Competitive nations focus more on building their R&D capabilities in the technology space to nurture the innovation ecosystem. The digital and physical worlds have completely converged in the 21st century manufacturing competitiveness, resulting in smarter products, processes and more intimate connections between consumers, suppliers, and manufacturers, attributed to advanced hardware, advanced software, sensors, big data and analytics.






Impact of technology on manufacturing

- **Production:** The immediate bottom-line impacts include reduction in scrap and downtime issues, lesser machine failures and improved output
- **Innovation:** Allows manufacturers to introduce new products to the market by reducing production lead times
- **Operations:** Industrial IoT improves the operational effectiveness and helps in cost reduction
- **CX:** Customer experience can be enhanced through digitisation
- **Enterprise Risks:** Systematic reduction in risks and likelihood of occurrence
- **Other benefits:** These include enhanced agility, high business continuity through advanced maintenance and monitoring, better product quality and real-time data

4.2.1 Penetration of industry 4.0 across Aerospace & Defense

The A&D sub-sector has a history of being one of the first to adopt disruptive technologies to improve product development and production processes. Several major technologies are now being used by the sub-sector to address new manufacturing issues and deal with the pre-pandemic order backlog of aircrafts.

Technology	Current applications	Emerging application
Additive manufacturing	 <ul style="list-style-type: none"> • Prototyping, tooling, and functioning • End-use parts manufacturing 	<ul style="list-style-type: none"> • Improving aerospace parts and accessories by combining innovative materials • Developing large-scale digitisation of plane maintenance data and schedules • Enabling the “connected plane”
Advanced analytics	 <ul style="list-style-type: none"> • Tracking the condition of aircraft in real time • Intelligent scheduling determining system/ component failures • Intelligent scheduling 	<ul style="list-style-type: none"> • Developing large-scale digitisation of plane maintenance data and schedules • Enabling the “connected plane”
Advanced robotics and cognitive automation	 <ul style="list-style-type: none"> • Efficient aircraft manufacturing systems 	<ul style="list-style-type: none"> • Time-saving simulations of the performance of satellites, missiles and aircrafts

Technology	Current applications	Emerging application
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Blockchain	 <ul style="list-style-type: none"> • Improvement in just-in-time logistics • Improvement of inventory turnover 	<ul style="list-style-type: none"> • Improving tracking in supply chains • Improving validation of supplier performance and reputation • Time-stamping records to reduce fraud
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- Improvement in just-in-time logistics
- Improvement of inventory turnover

- Improving tracking in supply chains
- Improving validation of supplier performance and reputation
- Time-stamping records to reduce fraud

Digital Reality (AR/VR/mixed)	 <ul style="list-style-type: none"> • Replacing assembly manuals • Smart glasses display 	<ul style="list-style-type: none"> • Simulate factory or warehouse • Train workers to safely use equipment and machinery
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- Replacing assembly manuals
- Smart glasses display

- Simulate factory or warehouse
- Train workers to safely use equipment and machinery

IoT	 <ul style="list-style-type: none"> • Monitoring health of aircraft engine • Optimising performance of engine basis data collected from sensors 	<ul style="list-style-type: none"> • Manage demand fluctuations by considering weather conditions, seasonal demand and past trends • Integrated smart connected assets • Autonomous production environment
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- Monitoring health of aircraft engine
- Optimising performance of engine basis data collected from sensors

- Manage demand fluctuations by considering weather conditions, seasonal demand and past trends
- Integrated smart connected assets
- Autonomous production environment

AI	 <ul style="list-style-type: none"> • Automatic programming of tasks and processes • Predictive maintenance 	<ul style="list-style-type: none"> • Advanced safety features in aircrafts such as CT scanners, biometrics that use data for analysis • Replacing human co-pilots with robots • Autonomous aircrafts
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- Automatic programming of tasks and processes
- Predictive maintenance

- Advanced safety features in aircrafts such as CT scanners, biometrics that use data for analysis
- Replacing human co-pilots with robots
- Autonomous aircrafts

4.2.2 Penetration of Industry 4.0 across metal manufacturing



The metals sub-sector approaches digitalisation and Industry 4.0 in a variety of ways. Metal production is a highly complex process, and the use of modern technology can greatly aid in the optimisation of the entire process. Steel manufacturing can be digitalised due to an intelligent combination of process automation, information technology, and networking that goes far beyond traditional industrial automation.

Legacy equipment, uncertainty about the impact on jobs and data protection/security issues are the key challenges facing the European iron and steel industry on the road to Industry 4.0.

The most significant initiative for creating innovations in the European steel industry is the RFCS (Research Fund for Coal and Steel). As a result, this programme addresses innovation in the steel industry's digitisation. 145 RFCS projects have been found in a recent assessment by the Erasmus+ Program of the European Union.

Following are a few examples:

Robot-assisted production



Use of humanoid robots for assembly and packaging.

Project	Description
ROBOHARSH (2016–19)	<ul style="list-style-type: none">Human robot is used in the steel industry for the development of a complex maintenance procedure.In this project, the operator role changes to that of a supervisor. Hence, there is no replacement of the human workforce.
DESDEDMONA (2018–21)	<ul style="list-style-type: none">Use of robotic and automatic systems such as UAVs and ground mobile robots for steel defect detection.

Production line simulation



Combination of Industry 4.0 technologies such as IoT, smart sensors and big data analytics among others are used to achieve assembling line simulation and optimisation.

Project	Description
Burner 4.0 (2019–22)	<ul style="list-style-type: none">Combined Industry 4.0 technologies are applied in different areas, such as process optimisation, predictive maintenance and improving the combustion system leading to a breakthrough burner concept in the steel industry.IoT, smart sensors, big data analytics are among the technologies used and integrated in the existing burners.
BLEMAB (2020–23)	<ul style="list-style-type: none">This ongoing project aims at developing a new measurement device for the Blast Furnace (BF) process stability and management, leading to the optimisation of resources and energy consumption.

Self-organising production



Real-time control of production networks is enabled by self-organising production which improves automation.

Project	Description
DESDEMONA (2018–21)	<ul style="list-style-type: none">Advanced tools are used to develop novel design methods, procedures and technical solutions for self-inspection and self-monitoring of metal structures.

Cyber Security



New cyber risks for manufacturers that are smart and connected, require managing and mitigating these risks

Project	Description
Auto Surveillance (2019–22)	<ul style="list-style-type: none">Solutions for detecting anomalies along the process route reheating furnace, rolling mill and cooling in the metal manufacturing unit are expected to be developed.The system will be able to announce threats and distinguish between faults and intentional attacks.






4.2.3 Penetration of Industry 4.0 across Machinery

Technological transformation and digitalisation have provided growth opportunities to the machinery sub-sector. The sub-sector in Europe is under a lot of pressure to innovate. The adoption of connected and digital assembly processes will benefit the manufacturers by reducing the costs. One of the biggest challenges in adopting automation is the complexity of assembly processes due to which many companies still follow traditional manual assembly.

Some of the key benefits of smart manufacturing include:

- Replacing tools before they break down will be the main cost-reducing factor
- Minimising human errors will increase efficiency
- Reducing downtime by using data analysis will help reduce costs

Applications of advanced technologies in the machinery sub-sector:

Technology	Penetration
Robotics 	<ul style="list-style-type: none"> • The machinery accounted for roughly 11 percent of global demand in 2020, was one of the biggest users of robots, according to the International Federation of Robotics' (IFR) annual World Robotics report*. • The use of robots in the machinery sub-sector is most prevalent in nations such as Finland, Sweden, Switzerland, Belgium, Austria, Italy and Denmark.
IoT 	<ul style="list-style-type: none"> • IoT is becoming more prevalent in agricultural machinery • For instance, manufacturers of agricultural machinery can offer intelligent field management and the utilisation of field data to over-the-air updates of software and firmware. These services enable better use of the technology, boost farming productivity, and decrease the need for manual labour.
AI 	<ul style="list-style-type: none"> • One of the prime uses of AI in machinery is maintenance • AI plays a vital role in intelligent quality inspection and helps in automating visual inspection and fault identification of small components using machine learning and cutting-edge image recognition systems • End users will be able to efficiently plan their machine use, dynamically plan material flow and supply and foresee potential shock events due to dynamic simulation and optimisation of processes.
AR/VR 	<ul style="list-style-type: none"> • The pandemic is anticipated to increase demand for virtually focused production methods, particularly in equipment manufacturing. • Virtual tools are used to design new vehicles from a distance while assisting with the manufacturing of trucks and loaders.
Blockchain 	<ul style="list-style-type: none"> • The machinery sub-sector has not yet embraced blockchain. • This technology's capabilities might make it possible to track and trace components and goods in a safe manner throughout their full lifecycles and provide more transparency for transactions on cloud platforms.

*Annual World Robotics report, International Federation of Robotics (IFR), as assessed on 17 May 2022

4.2.4 Penetration of Industry 4.0 across building and construction

The construction sub-sector is undergoing significant transformations by the fervour of industry 4.0 to improve its overall effectiveness for the successful completion of projects. Integrating manufacturing processes with information technologies such as the Internet of Things (IoT), the Internet of Services, cloud computing, and cognitive computing is the fundamental goal of Industry 4.0. The construction sub-sector has been rather slow to implement these innovations, in contrast to other sub-sectors that have made progress. However, it is starting to understand the importance of industry 4.0 in terms of the technology and architectural requirements.

Building and construction is currently making progress as new technologies push for industry penetration. Cyber-physical systems (networked control systems) and digital ecosystems serve as the two key building blocks of Industry 4.0, which integrates physical and digital technologies in building and construction. The advancing technologies and systems, including industrialised buildings, robots, AI, drones, and digital twins, among others, further assist these components.



The use of digital technologies in building and construction

While some of the technologies are observed to have moderate penetration in this sub-sector, other technologies such as robotics, 3D printing, digital twins, AR/VR, AI/ML are observed to have high penetration. Examples of pilot projects utilising 3D printing for a complete building include ETH in Zurich, Switzerland. Testing of AI in structural analysis, design and optimisation is still quite limited and mostly restricted to pilot projects.

An AI-powered platform for construction simulation created by the American business ALICE Technologies can analyse a project's requirements and produce effective building schedules. They claim that incorporating AI into the design process can reduce construction costs by 32 percent and speed up schedules by 10.2 percent.

Technologies	Design & engineering	Construction	Operation & maintenance	Renovation & demolition
Sensors	Y	Y	Y	Y
IoT		Y	Y	Y
3D Scanning	Y	Y		Y
Robotics		Y	Y	Y
3D Printing		Y		
Drones		Y	Y	Y
BIM	Y	Y	Y	Y
VR/AR	Y	Y	Y	Y
AI	Y	Y	Y	Y
Digital Twins		Y	Y	Y

Y indicates Yes, technology is used

Source: Digitalisation in the construction sector – Analytical Report 2021, European Construction Sector Observatory, as assessed on 17 May 2022

Technology

Examples of usage

Building Information Modelling (BIM)



- It has effective infrastructure and building planning, design, construction and management.
- The sub-sector with the most advanced and widely applied digital technologies. Its market penetration, though, is currently quite minimal in the EMA region.
- The market structure and company sizes are to be blamed for its uneven adoption. Large corporations are mostly in charge of implementing BIM, with SMEs adopting it to a lesser extent.

Sensors



- The building and construction sub-sector has seen a considerable rise in the use of sensors.
- In the EMA region, Spain, Romania, Sweden, the Netherlands, and Belgium seem to have the highest adoption rates.
- Globally, sensors are considered among the top data acquisition technologies.
- It can determine how to best utilise the equipment and machinery to maximise Return on Investment (RoI) by reducing costs associated with fuel and energy.
- It may lower the risk and expense of repairs and breakdowns through predictive maintenance, which can result in cost reduction of up to 20 percent* over the course of a project's entire lifecycle.

3D Scanning



- 3D scanning is still only being employed in a limited number of experimental projects and by start-ups and government agencies for the preservation of cultural assets.
- If 3D laser scanning is used consistently, it is predicted to reduce project costs by 5-7 percent, improve project timeliness by 10–12 percent and reduce site time by up to 80 percent*. This would be a considerable improvement over time.

*Digitalisation in the construction sector – Analytical Report 2021, European Construction Sector Observatory, as assessed on 17 May 2022

4.3 Technology in delivery and customer acquisition

Leveraging technologies to improve customer experience

Emerging technologies such as Artificial Intelligence (AI) and Machine Learning (ML) have been the major catalysts in transforming the 'Digital Customer Experience' and enabling the emergence of new business innovations by transiting from products to services. Together, they accelerate growth opportunities for customer-centric businesses aiming to harness the potential of digitalisation.



Technologies enable organisations to gain competitive advantage by:

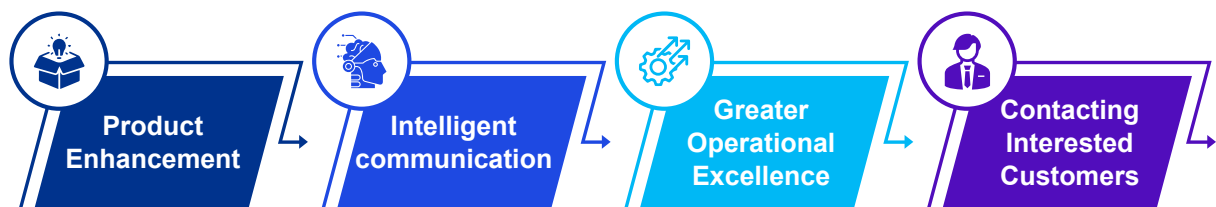
- Understanding customers' ever-changing desires and alleviating customer pain points
- Creating a great digital experience that a potential customer will value for lifetime
- Analysing customer behaviour to deal with rapid shift in preferences
- Driving loyalty among existing customers

Predicting customer behaviour and patterns correctly is a business imperative. Organisations across the world are combining AI and ML to examine historical and behavioural data. It also captures a precise understanding of clients' behaviour and employs real-time decisioning to achieve more effective marketing objectives. Every day, companies leverage this real-time customer intelligence to provide more hyper-personalised experiences to their customers by delivering highly relevant content and personalised recommendations that help them interact with customers on a more personal level. Some of the key merits of using AI to enhance customer experience include:

- Streamline the process of purchase
- Enhance simplicity and efficiency of the buying process
- Product recommendations
- Prevention of frauds
- Customer analytics

Firms that successfully deploy user experience strategy achieve reduced customer churn, enhanced revenues and higher customer satisfaction rates.

Following are the factors essential for predicting customer behaviour:



AI and ML play a vital role to predict customer behaviour. As a result, companies can understand their end-users needs, offer improved products and serve their potential customers better without them even asking for it. This way, they are taking a step towards an excellent customer experience.

The virtual customer assistant (VCA) or chatbot technology is the new normal for a better customer digital experience in the wake of the global COVID-19 crisis.

The customer service (via chatbots) –

- reduces human dependency by analysing what to say when interacting with people and when to route to humans.
- minimizes room for error and ensures increased digital (and self-service) effectiveness.

AI is the key enabler to greater digital operational excellence as it can quickly predict end-users' behaviour in real-time.

It allows businesses to become more innovative, improve risk prediction, raise top-line profits, generate better customer insights, and gain greater business agility by efficient scaling through intelligent automation.

Investing in a centralised CRM data centre can yield immediate results by documenting every interaction with a customer throughout the customer lifecycle.

This data can be leveraged to gain a deeper understanding of the customer's expectations at every touchpoint. This allows a company to reach out to potential customers at the right time with the right messaging, resulting in increased business prospects.

Leveraging tools that offer supportability and greater customer engagement:

Customers want B2C experiences in B2B environments. A manufacturer can leverage digital technologies and tools in combination with SAP ERP to provide these experiences and to drive unprecedented customer engagement.



For instance,

- A digital-enabled manufacturer can use SAP/ERP to get real-time access to customer data via its front-end applications. This ensures that both employees and customers can access the information they need when they need it and at a single location. The result is a **360-degree view of ERP data leading to improved customer engagement.**
- The use of digital technologies and tools with SAP/ERP also provides **customer self-service options** and enables manufacturers to provide customers with **fast, seamless experiences virtually anywhere.**
- It also allows the manufacturers to provide customers with a wide range of information directly from their SAP system. Thus, if a customer wants to access its order history, status, invoices, and other information, it can do so without delay.

Impact of technology in delivery and customer acquisition

Industry 4.0 technologies drive the way in which organisations interact with their customers and their changing preferences. It further allows manufacturers to change their value proposition from products to ongoing data driven services. Connected technologies help generate opportunities to enhance customer experiences by improving efficiency, enabling manufacturers to retain customers and additionally generating significant, service-driven value.

4.4 Cybersecurity

Like other sectors, the manufacturing sector is also majorly impacted by cyber-attacks. Some of the common attack methods could be malwares, denial of service (DoS) and hacking. The manufacturing sector is attractive for cyber attackers who can break into the manufacturing network, move to IT systems and lead to industrial cyberespionage, IP leakage and production crippling. Manufacturers today lack preparation around a huge array of vulnerabilities through multiple endpoints.

- In 2017 and 2018, the effects of industry 4.0 and the rise in cybercrime gradually came to light. However, many businesses in the sector were still unaware of the dangers.
- In 2019, the manufacturing sector ranked eighth among the industries that cyber attackers most frequently attacked.
- The issue escalated because of pandemic-based limitations, compelling many businesses to rely almost solely on remote labour. Cyber attackers were ready for the impact of COVID-19, whereas most people were generally unprepared.
- The manufacturing sector rose from the eighth to the second most targeted sector by cybercriminals, after only the finance and insurance sectors. This is a 300 percent increase in threats in single year, according to the 2021 Global Threat Intelligence Report (GTIR).

Lack of information and training is the largest cyber concern for many manufacturing organisations. Most employees receive little to no training in identifying and avoiding possible threats, and management is all too frequently unaware of the risks. The first step in developing a cybersecurity solution to safeguard an organisation is learning about the top cyber dangers for industrial companies.

Following are the most common cybersecurity threats that affect industrial manufacturers

Cybersecurity threat



Phishing attacks

One of the oldest and most popular methods employed by cybercriminals is phishing. It has a long range of detrimental repercussions for a company, including financial loss, loss of intellectual property, reputational harm, and interruption of daily operations. These consequences combine to reduce a company's value, sometimes with irreversible consequences.



Ransomware

Ransomware is becoming a common type of cyber threat. It affects most businesses, with manufacturers being most at risk. A simple email or an official document can easily be used to launch an attack. In the long run, organisations end up losing revenue due to downtime. Not to mention the recovery expenses that may never be reimbursed. Additionally, customer data is compromised. And with this comes the risk of irreparable reputational damage.



Intellectual property theft

Manufacturing firms depend on intellectual property (IP) to be competitive. It also determines how long they remain relevant in the industry. This is why intellectual property theft is a frightening concern. Businesses that commit intellectual property theft suffer from lost competitive advantage, damaged reputations, slowed corporate growth and diminished customer trust. IP theft may cost businesses a lot of money and pile up to huge amounts on a national scale.



Supply chain attacks

From extraction to supply chain warehousing, manufacturers are now moving most of their operations online due to increase in digitisation. Because of the strong internet presence, manufacturers need to be aware of the threat of supply chain attacks. System outages, financial losses and reputational harm are the growing effects of these attacks.

One of the recent reasons for the rise in threat of cyber-attacks is the Russia-Ukraine War:

- A series of distributed denial of service (DDoS) attacks have already commenced since the onset of war, impacting both the Ukrainian government and banking institutions.
- Some of the cyber-attacks on Ukraine could be launched on other countries, including governments and companies working with Ukraine.
- On 23rd February 2022, a new variant of wiper malware named HermeticWiper was discovered in Ukraine. A new round of website defacement attacks was also observed impacting Ukrainian government organisations.
- Future attacks may target other countries in retaliation for increased sanctions or other political measures against the Russian government.
- All organisations, especially sensitive and critical sectors have higher exposure to these threats

It has become imperative for manufacturing firms to identify and manage cybersecurity risk mitigation pursuits. The following business objectives can help manufacturing firms to prioritise and manage cybersecurity risks:



Business objectives	Impact
• Maintain quality of product	• Managing cybersecurity risks can help protect against compromise of integrity of associated data and manufacturing process. Breach of cybersecurity could adversely affect the quality of products
• Maintain human safety	• Cybersecurity risk on the manufacturing system could adversely affect human safety. It is essential for personnel to understand safety interdependencies and cybersecurity
• Maintain production goals	• Risk against cybersecurity on the manufacturing system, including asset damage, could adversely affect production goals
• Maintain trade secrets	• It is essential to manage cybersecurity risks that could result in loss or compromise of sensitive business data and intellectual property of the organisation
• Maintain environmental safety	• Risk against cybersecurity on the manufacturing system could potentially affect environmental safety. It is thus essential to manage cybersecurity risks affecting the environment, including both deliberate and accidental damage.

Strong cybersecurity can generate tremendous revenue opportunity with the adequate use of technology, time and talent. **Some of the ground-breaking impacts of implementation of cybersecurity can be referred below:**

- Risk modelling to protect from costly cyber threats
- Increase employee productivity from removing malwares and viruses
- Save losses incurred due to customer data / personal information leakage
- Build trust and drives customer confidence
- Scale cybersecurity to adopt more technologies for business growth
- Drive competitive advantage

Case examples of implementing cybersecurity by manufacturing industry:

Volkswagen

- Volkswagen has implemented cybersecurity measures in the firm and has an independent cybersecurity network across its group brands and all operational regions to monitor potential cyber risks. This enables the company to respond swiftly in case of a potential threat

Bechtel

- Bechtel's asset performance management (APM) and operational technology (OT) cybersecurity solutions have safeguarded their critical infrastructure.
- To increase the availability of operational assets that are crucial for the operation of the organisation, APM blends cybersecurity, process optimisation, software tools, and applications.

The industrial manufacturing sector's competitive environment is still being shaped by these technical advancements. As a result, manufacturers must choose where and how to invest in new technologies as well as which ones would be most beneficial for their businesses. Successful manufacturers require a clear articulation of their corporate objectives, knowing where to play in rapidly emerging technology ecosystems, in addition to effectively appraising their current strategic positions.

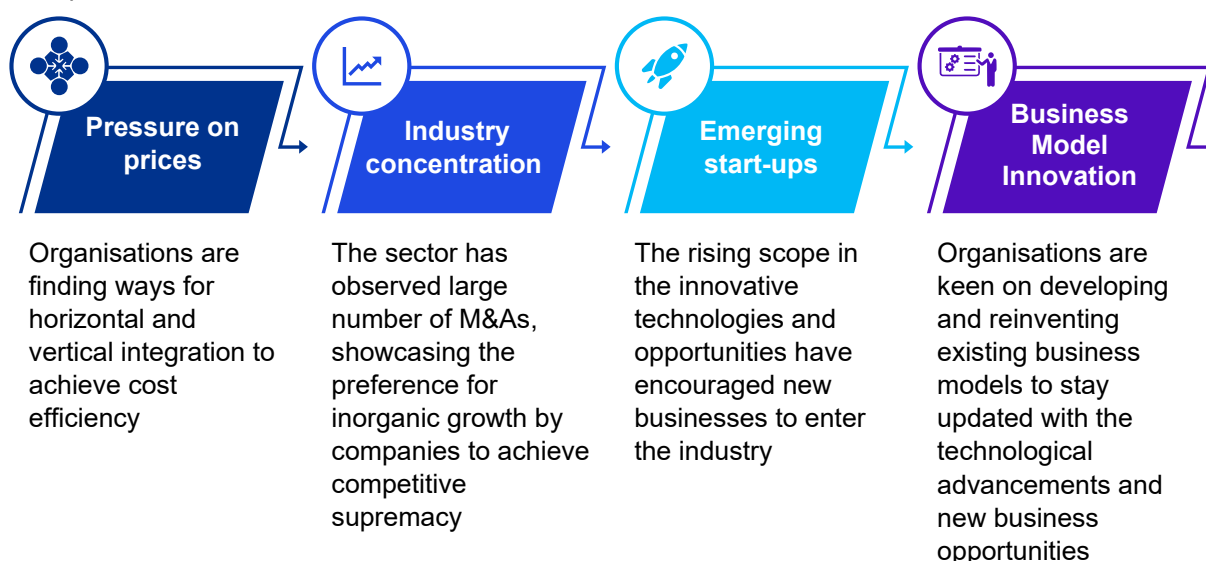
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Emerging competitive landscape

5 Emerging competitive landscape

The ongoing turbulence surrounding adverse global events has created immense pressure on industrial manufacturing players to evaluate new opportunities in the market for sustaining in a competitive environment. Manufacturing companies must start thinking beyond digitalising their operations and work upon leveraging their investments in advanced manufacturing, inorganic growth and partnerships/collaboration with emerging players to transform their existing operating model and generate opportunities for developing new revenue models for the business. New revenue models have the potential to provide manufacturers with recurring cash inflows, offering more agility and flexibility, affirming relationship with the supplier and ensuring success of the business.

Rising prices, shift of business models from existing traditional models to innovative models, emergence of new start-ups in the ecosystem and increasing consolidation in the industry via M&As are few salient themes leading to competition between the industrial manufacturing players to affirm their position.



5.1 Pressure on prices

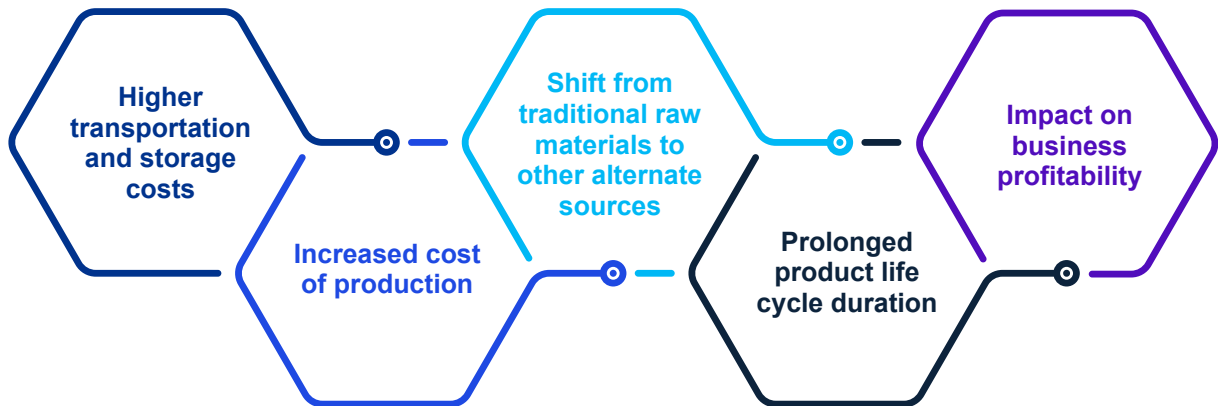
Demand for commodities rebounded to the pre-COVID levels owing to the recovery in global economy, wherein commodity production observed a gradual increase, burdened by several years of weak investment in new production capacities and continuous supply disruptions.

The war between Russia and Ukraine has not just prompted a surge in energy and commodity prices, but also highlighted the compounded existing stresses in commodity markets and dependence of EU nations on the two warring countries. The potential impact of the war on commodity markets can be noticed through two main channels — the physical impact of trade barriers and the levelling of production capacity, and the impact observed on trade and production due to the newly imposed sanctions. Policy responses have inclined to favour trade restrictions, price controls, and subsidies, which are likely to augment shortages in the near term. The Russo-Ukrainian crisis is amplifying supply and demand tensions, damaging consumer sentiment causing a major threat to the global economic growth. In March 2022, the Economic Sentiment Indicator (ESI) dropped substantially in both the EU (-5.3 points to 107.5) and the euro area (-5.4 points to 108.5), mainly due to plummeting consumer confidence²².

The pressure on prices remains a major challenge for businesses and it is essential for the organisations to develop frameworks restricting the impact of higher raw material prices, negligence of which can hamper business operations significantly.

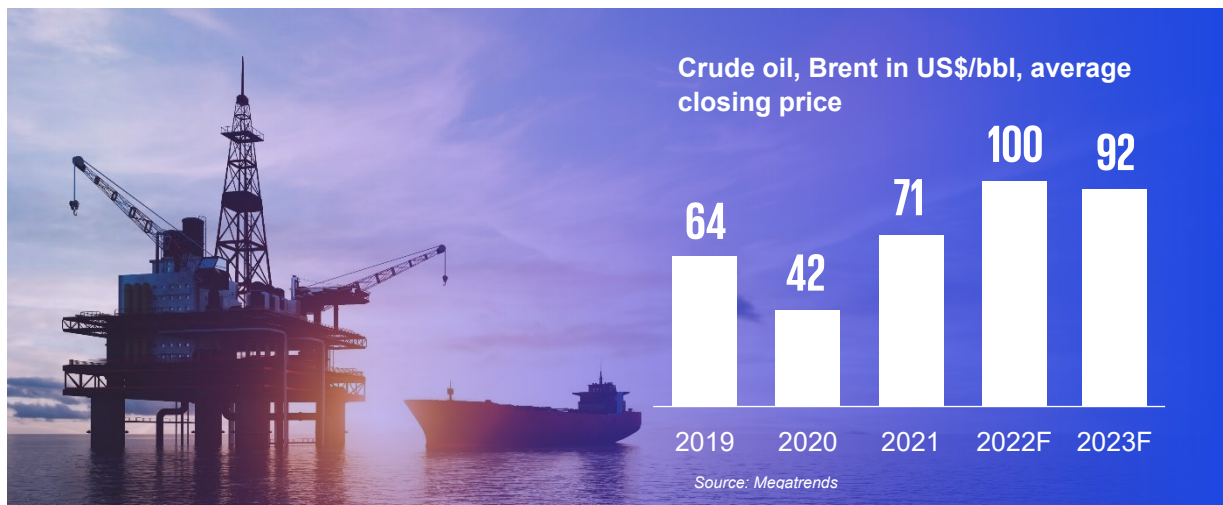
²² Economic sentiment indicator, Eurostats, accessed on 15 May 2022

Some of the impacts of increased pressure on prices are illustrated below:



Price volatility -

Russia is a major oil exporter to European countries and EU imports about 49 percent of oil from Russia for meeting its energy needs. The ongoing war has severely impacted the oil supply and triggered a surge in oil prices across the globe. As a result, energy prices recorded a growth of more than four times in March 2022 in comparison to the April 2020 lows depicting the largest 23-month increase in energy prices since oil price hike in 1973²³. In the past, oil price hikes have led organisations to look for new sources of supply and find ways to reduce demand through efficiency improvements and substitution of other commodities, A similar trend can be expected in the coming years, wherein organisations may tend to switch to alternate commodities in case of a resource scarcity.

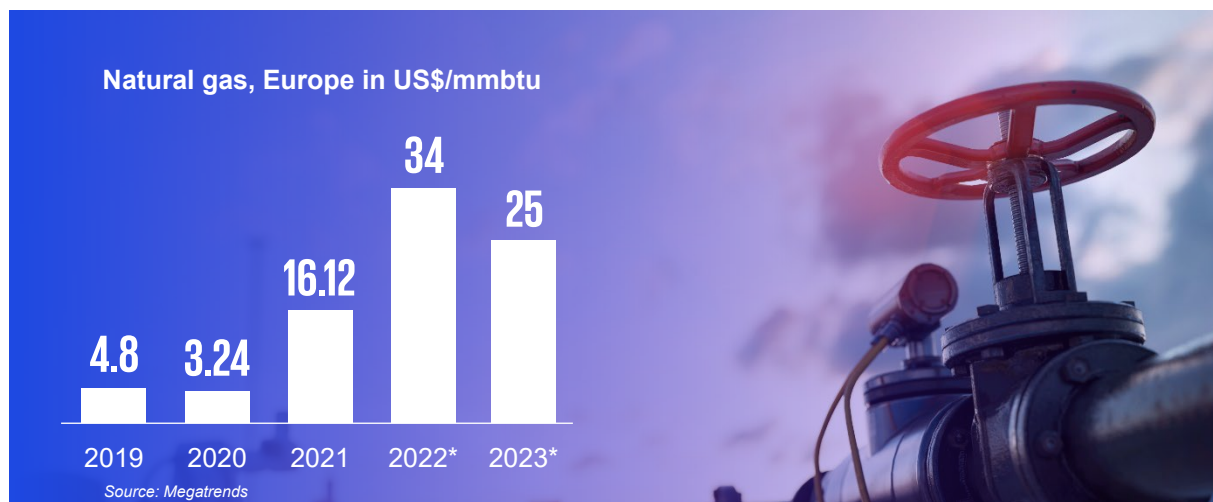


Price of natural gas in Europe has witnessed a massive growth in the last two years, showcasing a four-fold growth in 2021, compared with the 2020 price levels. Prices are further estimated to go up till US\$34/MMBtu in 2022, depicting a growth of about 100 percent from the current levels. High prices have in turn led some fertiliser, aluminium, and zinc operators to shut production in Europe. Increasing energy prices push the cost of extracting and refining metal ores, specifically for metals such as aluminium, iron ore, and steel. Further, higher metal prices drive up the cost of renewable energy technologies.

Manufacturing producer price index (PPI) inflation in the euro area averaged about 12.5 percent in the second half of 2021, substantially higher than an average of 1.5 percent during 2017–19²⁴. Price of nickel went up by 35 percent in the first quarter, primarily due to a short squeeze that halted the

²³ Commodity markets outlook, World Bank, April 2022, as accessed on 19 May 2022

²⁴ Supply disruptions added to inflation and undermined the recovery in 2021, VoxEU, 16 March 2022, as accessed on 5 May 2022



trading in the London Metal Exchange for several days in mid-March 2022. The prices of aluminium and iron ore also observed significant increases as Russia is a major supplier of these commodities. The World Bank's Precious Metals Index rose about 4 percent in 1Q22, vis-à-vis last quarter and inventories at metal exchanges have retracted to extremely lows, leading to price volatility. Key drivers for the price surge of these commodities include production curtailments due to high energy costs, supply concerns due to Russia's invasion of Ukraine, rising inflation, and pandemic-induced disruptions.

Price of metals (2019–23)

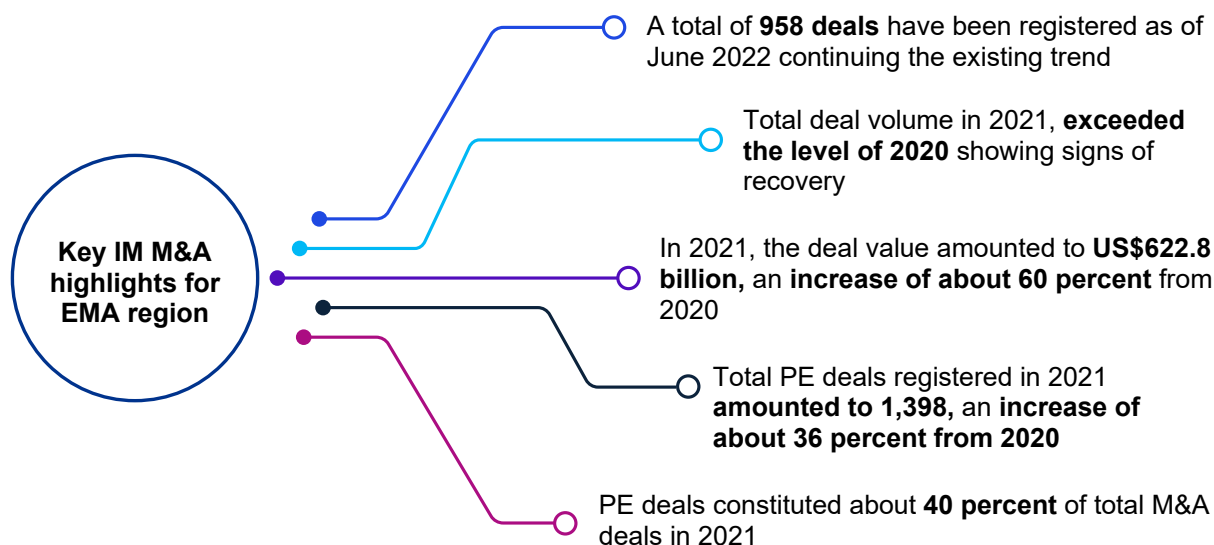
Metals	2019	2020	2021	2022F	2023F
Aluminium (US\$/mt)	1,794	1,704	2,473	3,400	3,100
Steel (US\$/t)	501.5	486.5	842.5	767.8	705
Iron ore (US\$/dmt ²⁵)	93.8	108.9	161.7	140	105
Copper (US\$/mt)	6,010	6,174	9,317	10,100	9,700
Nickel (US\$/mt)	13,914	13,787	18,465	28,000	22,000
Lead (US\$/mt)	1,997	1,825	2,200	2,300	2,100

5.2 Industry concentration

Companies who are looking to grow inorganically through M&As with a change in approach and transitioning from a defensive strategy to a more aggressive approach may view the disruption produced in the manufacturing sector as a business opportunity. It is crucial for the businesses to seize industry disruptions as well as other market possibilities that exist outside of their conventional market positioning. As a result, unconventional deal-making techniques can be seen as an additional means of seizing and investigating bigger chances. For example, joint ventures, alliances, partnerships, and Special Purpose Acquisition Companies (SPACs), collaborations and other tactics may be successful in reorganising companies for rapid expansion. The ability of M&A to boost inorganic development and profitability in a slowing economy, as well as its strategic fit for organisations, have forced to review and reconsider options. Current global cues have resulted in unanticipated limitations and business restraints.

²⁵ Dmt refers to dry metric tonne

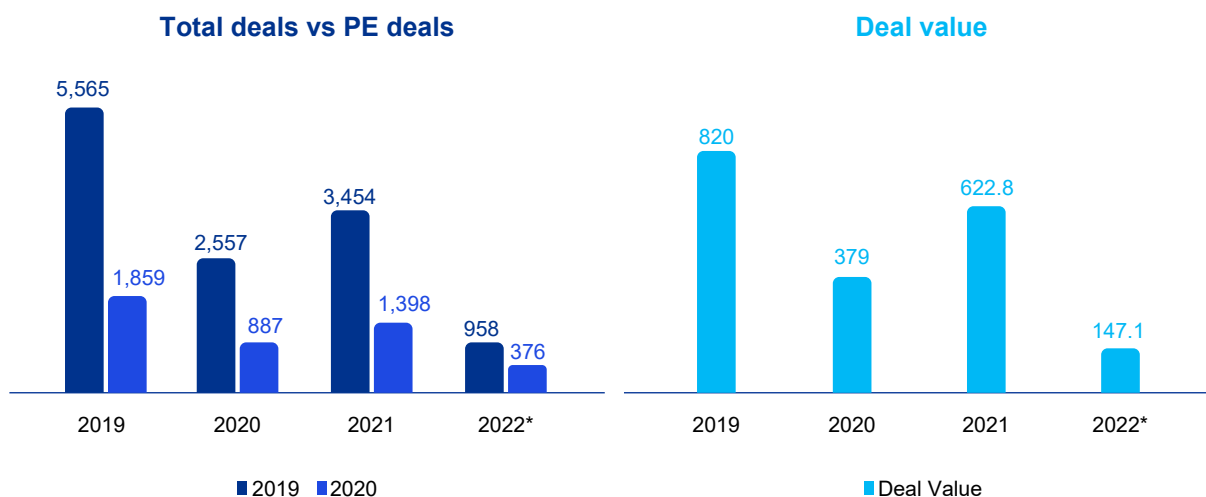
Key industrial manufacturing M&A highlights from EMA region during 2021–22



Source: Merger market

Emergence of the pandemic and other global events have changed the industry dynamic and deal rationale, where in companies have shifted their focus from just gaining access to new customers to determining fresh sources of growth in technologically disrupted spaces.

Historical M&A deals analysis (2019–21)



Source: Merger market

M&A deals in the EMA region constituted a major proportion of the total global deals and the outlook for M&A seems to be more volatile owing to the ongoing geopolitical tensions, fear of higher interest rates, inflationary pressure and regulatory changes. However, the key drivers deciding the upcoming trend will include the rising adoption and disruption into the technology areas, rising volatility in the prices leading to instability, Integration of ESG related practices into the production chain, active involvement of PEs and SPACs in M&As, portfolio optimisation and uncertainties in the global economies.

Key themes driving M&A –

Digitalisation

- Disruptive changes such as electrification, digitisation, and automation have led organisations to intensify M&A for gaining newly critical capabilities
- Tech-driven acquisitions have gained traction as companies are looking to accelerate integration of AI/ML, blockchains within the system and upgrade the existing resources and capabilities



High volatility in commodity prices

- Massive jump in the commodity prices has made organisations rethink their sourcing and pricing strategies
- Direct impact on availability of raw materials has impacted operational efficiency, which has pushed organisations to look for vertical or horizontal integration with other businesses



Integration of ESG goals

- In Europe, involvement of the governments in implementing ESG agendas and the race to a low-carbon economy are pressuring traditional business models, but also offer fantastic opportunities to test new industrial offerings
- The importance of building more resilient and sustainable supply chains will lead manufacturing players to adopt an 'environment friendly' approach and make strategic acquisitions



Volatility in market conditions

- Geopolitical instabilities, travel restrictions, additional transportation costs and tariffs have encouraged organisations to de-globalise their operations
- Vulnerabilities of interconnected economies and rising number of protectionist governments globally might impose greater regulatory scrutiny and deteriorate cross-border acquisitions



Capital availability

- Private equity and SPACs have largely contributed to industrial M&As and is assumed to continue a similar trend owing to the higher capital availability and M&A appetite
- Organisations tend to form partnerships/collaborations/JVs with the PEs and SPACs for capitalising on the potential in blooming industries such as technology, AI and EVs



Portfolio restructuring/divestitures

- Organisations are reassessing their portfolios to focus on new growth opportunities and divesting non-profitable assets to grow valuations
- Companies are re-evaluating ways of increasing flexibility and focusing specifically on their strong areas by dispensing non-core assets



5.3 Emergence of innovative start-ups

Manufacturing companies are looking at maintaining their productivity with reduced manpower also as an aftermath to the pandemic. Many start-ups are focused on building wearables, gadgets and smart sensors that eliminate the need for human presence. Simultaneously, companies are banking upon start-ups to help reduce the carbon footprint of manufacturing processes as well as the products and align with their sustainability goals. Start-ups are also helping companies in shifting the labour-intensive traditional style production methods to a new digitalised era using technologies such as AI/ML, robotics, AR/VR etc. For instance, 3D printing helps manufacturers in shortening their supply chains and reducing waste, which facilitates sustainability.

With the invention of disruptive technologies, predictive technologies, robotics and a huge shift towards industry 4.0, companies need to address these emerging opportunities and doing this in-house would not be possible, hence manufacturers are collaborating with cutting-edge start-ups. Start-ups have been able to establish and support manufacturing capabilities in multiple ways.

Start-ups have been on the forefront of creating value for manufacturers. Manufacturing companies need to employ various technologies to drive innovation and enhance productivity and start-ups globally are bringing the manufacturing sector forward.

Below are some of the key technologies provided by start-ups.

Disruptive technologies offered by start-ups	Potential benefits for manufacturers
Robotics	<ul style="list-style-type: none"> Assists the workforce in manual tasks such as picking, grinding, palletizing Advance robots can send process status Helping in cost reduction while increasing the productivity
AI	<ul style="list-style-type: none"> Provides diagnostics in manufacturing to prevent errors Helps in improving the product quality
Additive Manufacturing	<ul style="list-style-type: none"> Helps in speeding up the product development process and downsizes the production chain Helpful in mass manufacturing by eliminating convention machining process
Cloud computing	<ul style="list-style-type: none"> Remote monitoring, centralized control
Simulation	<ul style="list-style-type: none"> Helps in testing prototypes before manufacturing that prevents waste of resources Avoids errors that can be potentially expensive Helps in predicting the behaviour of a system
Industrial IoT	<ul style="list-style-type: none"> Helps in streamlining processes and production maximisation by transforming traditional factories Some advantages include integrating manufacturing systems, asset performance management, advanced sensors, automation of PLC etc.
Nano Engineering	<ul style="list-style-type: none"> Helps in reducing manufacturing costs and time by enhancing the materials with unique properties Helps in increasing the life cycle of mechanical parts as well as other components

In the last few years, EMA region has shown immense growth in adoption and implementation of digitalisation across industries/ sectors, which has led to rise of tech start-ups in the region providing automation and ML/blockchain related services to the manufacturing players for better optimisation and process efficiency.



Europe

- The total number of tech start-ups in Europe reached more than 43,000 by 2019.
- Cumulatively, the start-ups raised more than US\$40 billion in investment capital.
- In the last five years, purpose-driven tech companies raised about US\$20 billion across more than 3,000 funding rounds
- Of the total capital invested in European tech companies, 17 percent was invested in purpose-driven start-ups.
- European Smart Manufacturing Spending market size is expected to grow 2X during 2020–25.
- Germany (19 percent), France (16 percent), Spain (12 percent) and the Netherlands (11 percent) constitute about 60 percent of the total EU 27 start-up

Sources:
European start-ups report, Dealroom
2021: the year of deep tech, 8 January 2021
Supercharging the European tech ecosystem, Dealroom



Africa

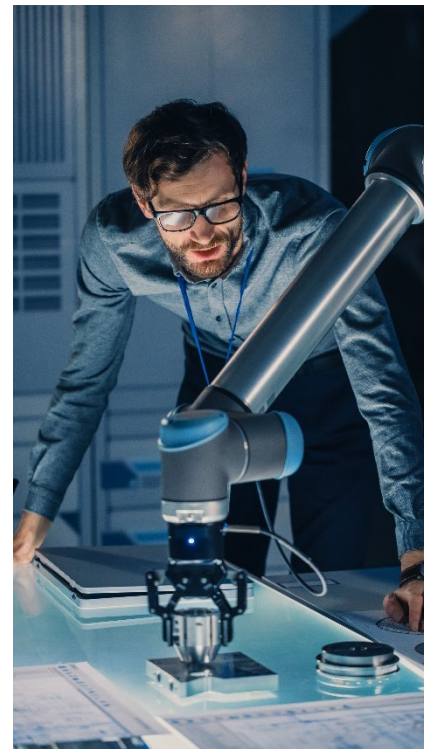
- Tech start-ups in Africa are growing six times faster than the global average.
- It is assumed that the digital economy will contribute an estimated US\$300 billion to Africa's GDP by 2025.
- African tech start-ups attracted US\$4.9 billion in funding in 2021, depicting a 243 percent increase from 2020.
- The “big four” markets of Africa namely Nigeria, South Africa, Kenya and Egypt, accounted for about 87 percent of tech start-up funding between 2010 and 2020.
- Four sectors constituting FinTech, AgriTech, HealthTech and EnergyTech secured about 60 percent of funding deals in 2020.

Sources:
Supercharging Africa's Startups: The Continent's Path to Tech Excellence, Tony Blair institute for global change

5.4 Business innovation models

The pandemic has underscored the importance of manufacturing and the role supply chain systems play in empowering the global economy. Hence, it is critical for manufacturing and supply chain leaders to enhance their efforts and adopt to the upcoming innovative business models if they want to remain competitive in the current environment. The new challenges posed by the recent geopolitical events have enforced organisations to think beyond operations, productivity and efficiency improvements and to be successful, companies will need to leverage their investments in advanced manufacturing not just to optimise operating models, but also to unearth the potential of new business models that can create and deliver maximum value to all stakeholders, including companies, society and the environment.

In case of a disruption, companies in the production ecosystem need to quickly pivot and accelerate the adoption of digital transformation for smooth operational process. Companies have started to leverage the advancements in technologies for optimising production and manufacturing processes and shifted their approach from traditional business models to innovative business models for driving efficiency across their operations and supply chains, bringing a more innovative, sustainable, and inclusive approach to enhance value creation. The table below depicts some of the recently developed innovative ideas used by the organisations to gain a competitive edge:



Product servitisation

- Description**
- Offering value added services to the customers rather than offering only the product
 - Integrates services with the products
 - Providing customers with successful case studies
 - Offering services that differentiate from other brands

- Potential Benefits**
- Generation of higher margins by adding services
 - Improvements in after-service along with overall equipment efficiency
 - Companies generate revenue primarily from a product's performance

Asset-light market entry

- Description**
- Easy penetration into new markets with minimal upfront investment
 - Provide distribution, logistics and marketing support which can help in optimising overall costs
 - Companies own few capital assets and focus on operations

- Potential Benefits**
- Lowers the cost for initial business set-up since most functions are outsourced
 - Keeps operations lean
 - Helps in ease of setting up business in foreign markets
 - Can easily respond to the changing marketplace trends

Mass production to rapid manufacturing

- Description**
- Companies have started manufacturing products as per the ongoing trends and changing consumer preferences
 - Accelerating the manufacturing process by using technologies like 3D printing
 - Consortium/collaboration of companies has enabled faster production, processing and delivering of goods to cater the growing demand of consumers
 - Establishing micro factories/smart factories and use of AR/VR technologies to support the supply and streamline end-to-end delivery

- Potential Benefits**
- Develops different products in a short span of time
 - Enables fulfilment of supply in case of a crunch situation
 - Has a positive impact on top line
 - Offers flexibility in changing specifications of a product

Multilocal manufacturing

- Description**
- Setting up production units in low-cost countries/ emerging economies
 - Moving from centralized to regional approach in design, supply and support

- Potential Benefits**
- Cost-effective since operations is located near to the end market
 - Economical in preparing small batches of customised products and their faster delivery to end markets
 - Allows identifying local market requirements and leveraging business opportunities
 - Allows mitigation disruptions including geopolitical push for local manufacturing

Impact of emerging competitive landscape on industrial manufacturing sector:

	Impact	Case example
Pressure on prices	<p>The pressure on prices is going to have the following implications:</p> <ul style="list-style-type: none"> • Increased cost of production • Supply chain issues • Extended lead time • Impact on business profitability • Higher transportation and labour cost 	<ul style="list-style-type: none"> • Bosch Group is witnessing a shrink in its profit margins due to rising cost of raw materials and energy. It witnessed a fall and squeezed by 4.65 percent against its forecasted margin of 8.45 percent for FY 2021 • To mitigate the burden of rising prices, the company plans to pass on the price increase to its customers
Inorganic Growth	<ul style="list-style-type: none"> • Improved economic scale • Increased market share • Competitive advantage • Portfolio strengthening • Enhanced distribution capacities • Access to more financial resources 	<ul style="list-style-type: none"> • In Aug 2021, Parker Hannifin Corporation, an aerospace & defense motion player announced all cash acquisition of Meggitt PLC • The acquisition aims at doubling the size of Parker's aerospace business by 2x and strengthening the prospects of the combined group within the A&D industry²⁶
Emerging start-up landscape	<p>Emerging start-ups in the manufacturing sector have started to bring a paradigm transformation to the manufacturing industry and have the following impacts:</p> <ul style="list-style-type: none"> • Result in newer offerings • Increased flexibility and customisation • Improved efficiencies • Cost savings • Speeds up transformation of industrial processes • Provides new manufacturing processes 	<ul style="list-style-type: none"> • Konux, a Germany based start-up, could succeed over more recognized automation players in equipping Deutsche Bahn with sensors that delivers online data to track status and efficiency on train. • It has been estimated that service and maintenance cost savings are in the range of 10 to 40 percent based on data through sensors
Evolving business models	<ul style="list-style-type: none"> • Enhances the business performance of a firm and brings sustainable competitive advantage • Enhances the customer experience • Helps in meeting customers new needs • Enables agile, co-created innovation for new processes, products, and services 	<ul style="list-style-type: none"> • Qingdao Doublestar Tire Industrial Co., a tire and automotive player, enabled an end-to-end production operating model, and achieved 1–3 percent reduction in users' fuel consumption, 10 percent extended service life and 10–20 percent reduction in cost of tire²⁷

²⁶ Press Release - Parker Hannifin Corp, as assessed on 25 May 2022

²⁷ Unlocking Business Model Innovation through advanced manufacturing WorldEcon, as assessed on 25 May 2022



06

Focus on key sub-sectors

6 Focus on key sub-sectors

Impact/importance of mega trends across key sub-sectors

A&D

Supply chain resilience

- Give A&D companies the ability to react to shifting demand and new technologies more effectively, allowing them to profit from the post-pandemic rebound.
- Manufacturers have better access to small and mid-sized suppliers (through database) who can provide low-volume materials for prototypes or new aircrafts/ drones
- By eliminating supplier margin, vertical integration can be used by A&D organisations to gain control over key supply chain operations and save operational expenses. Additionally, it gives them the flexibility to react quickly to changes in both market demand and product specifications, minimising the actual cost and time impact of the adjustments. They get access to authentic and locally available suppliers to speed up the aircraft / other equipment production

Sustainability

- Since its inception in 2007, TARMAC AEROSAVE, a business owned by Airbus, Safran and Suez, has recycled more than 135 aircrafts.
- To divide the passenger area from the gallery in an A320 aeroplane, Airbus developed a thinner, more durable "bionic" partition. As a result, the weight of the aircraft was reduced by up to 500 kg, cutting CO₂ emissions by up to 166 metric tonnes annually.
- In order to evaluate engine performance in real-time and ultimately save 22 million tonnes of carbon, manufacturers have developed digital twins of engines.

Digitalisation and automation

- Automation drilling and filling solutions save almost **10 percent - 20 percent** of the rig time.
- After implementing an automated drilling system, Boeing registered **93 percent improvement in hole quality**.
- **98 percent of flaws, tool marks, and misaligned holes have been eradicated** using the automated drilling method.
- Boeing's robotic painter **can complete a single coat in just 24 minutes**, compared to four hours for human painters.
- By building a predictive model, the automated technology utilised to improve assembly efficiency **saves about five hours of flow per assembly line**.
- According to Moog Aircraft Group, a lead time of four to six weeks occurred from outsourcing the production of CMM fixtures. However, the business can manufacture the identical fittings internally **using 3D printing in about 20 hours**.

Inorganic growth

- M&As in this sub-sector have seen a significant jump over the last one year, wherein a rise of about 60 percent (73 in 2021 and 45 in 2020) was observed in EMA deal volume from 2020 to 2021.
- Reduces operating costs significantly and eliminates supplier margin.



Metals

Supply chain resilience

- Metal producers can deal with price volatility across major mining geographies
- By creating alternate routes or means of transportation and maintaining buffer stocks at crucial points in the supply chain, the vulnerability to disruption at ports or during shipping of manufactured metals may be decreased
- Manufacturers also get access to diverse raw material suppliers for metal production

Sustainability

- Reduction in number of stages in metal manufacturing process
- Using AI to lessen the wasteful use of some materials, the generation of scrap garbage in excess and the uneven distribution of energy resources in order to increase sustainability.
- Energy utilisation in the manufacturing of steel **has decreased by 60 percent** over the past 50 years due to technological advancements and a switch from traditional blast furnaces (BFs) to electric arc furnaces (EAF).



Digitalisation and automation

- **10-12 percent** increase in production output
- The robotic automation of support removal might drastically cut the **cost per part by 25 percent**.
- Saves over **50 percent** of the working time
- Reduces unit **costs significantly below the level** of other processes or manual processing
- AI/ ML with RPA and enterprise analytics help underpin supply chain management and procurement and make the metal supply chain resilient and adaptive.

Inorganic growth

- M&As in the sub-sector have seen a steady jump over the last one year, wherein a rise of about 25 percent (77 in 2021 and 61 in 2020) has been observed in EMA deal volume from 2020 to 2021
- Cost efficiency has increased and there is adequate supply of raw materials.

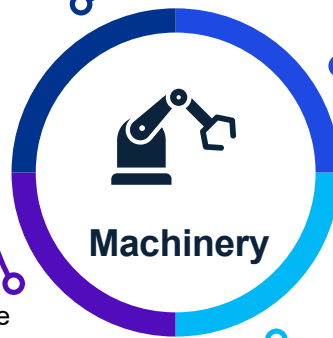
Machinery

Supply chain resilience

- Helps secured buy of industry-specific raw materials to support demand
- Maintained service levels and business continuity
- Enhanced cost optimisation and operational efficiency
- Helps in finding alternate materials to critical parts

Sustainability

- The sub-sector is aging and is not green enough to meet the EU's standards on sustainable production and environmental protection. The current proportion of "**green products**" in the machinery sub-sector is about **5–10 percent**.
- In another 10 years, it is anticipated that all items would adopt the green design family, which includes recyclable, easily reassemble-able, and recyclable parts and whole machines.



Digitalisation and automation

- The majority of CNC machines have **3 or 4 degrees** of freedom of motion. Industrial robots can move along more complex paths than most CNC machines. Articulated robot arms typically have **6 degrees** of freedom which means that machines of any shape can be produced without any limitations — even ones with complicated angles.
- Most collaborative robots can work on much larger pieces than CNC machines. A medium-sized industrial robot will have a work envelope of about **7 to 8 cubic meters**.

Inorganic growth

- Production capabilities have increased.
- M&As in the sub-sector have seen a massive jump over the last one year, wherein a rise of about 35 percent (470 in 2021 and 344 in 2020) has been observed in EMA deal volume from 2020 to 2021.
- Uncertainty over the supply of oil and natural gases, shut down of factories/plants, shortage of manpower and emergence of innovative business models have played a vital role in popularising M&As as an option for companies to enhance the operational efficiency and streamline the production process.

Building and construction

Supply chain resilience

For supply chains to be resilient in the building & construction sub-sector, procurement should focus on:

- **Supply chain vulnerability** – The subcontracting structure of construction projects drives risk further down the supply chain. Increased transparency and rebalance of risk are required with adequate mapping of the supply chains to fully understand vulnerability areas.
 - **Demand planning** – It is crucial for procurement teams to work in a non-competitive way to ensure supply remains as even as possible. Additionally, the subcontracting nature of construction products makes it unnecessarily complicated.
 - **Standardization of products** – Inefficiencies and risk in the supply chain are caused in case of customizations in a product. It is important for the construction sub-sector to focus on standard specifications across projects to achieve flexibility in sourcing from suppliers and in turn achieve increased productivity

Sustainability

- Reduction of environmental impact of resources such as water, materials, embodied energy throughout the lifecycle of buildings, from the extraction of building materials to demolition and the recycling of materials.
- Opportunities for better construction and demolition waste management
- Sustainable buildings combine improved energy performance and reduce environmental impact throughout their life cycle, providing users better health and well-being and productivity gains that translate into cost savings.



Building and Construction

Digitalisation and automation

- If construction companies invest in digitisation along with advanced automation, their overall productivity is expected to increase by 2x.
- The risk and cost of repairs and breakdowns can be decreased with sensors, which can result in a cost reduction of up to 20 percent over the course of a construction project.
- The effective cost saving estimate for IoT in building projects ranges from 22 to 29 percent of the entire project expenditure.
- IoT reduces energy usage by utilising coordinated digital building systems (up to 35 percent).
- The use of 3D laser scanning results in a 5–7 percent decrease in project expenses, a 10–12 percent improvement in project duration and a reduction of up to 80 percent in site time, making it a major benefit over the long term.

Inorganic growth

- The construction & real estate sub-sectors have bagged M&A deals worth US\$4.3 billion in March 2022, making Europe hold over 53 percent share of global deal value.
- The building and construction sub-sector in Europe have been witnessing substantial M&A deal activity with a count of 57 deals recorded during March 2022. However, there has been an average yearly drop of 3.4 percent from March 2021.
- The reasons attributed to the increase in M&A activity in the sub-sector include increase in demand for modern, sustainable buildings, the COVID-19 impact, asset clustering, building modular construction and ESG excellence.

6.1 The KPMG way:

Businesses today need to be resilient across their operations and product development for which they need a deeper understanding of the entire value chain as well as the regulatory landscape. There are additional risks for companies in today's volatile environment which may be around business agendas, automated production, ESG and customer centric offerings. KPMG firms can help companies in industrial manufacturing and bring future-forward thinking along with a value-driven approach. Across sectors, KPMG professionals can help clients embrace transformation that could range from evolving business models and ecosystems to advances in automation and analytics. Some of the key areas where KPMG professionals can offer clients a pragmatic and holistic approach include:



Supply chains are assumed to fall outside of a company's core operations hence there are uncontrollable risks that they are exposed to. The effects of these risks can fall under financial, operational, and reputational damage. KPMG firms can assist clients across various areas and provide insight and advise to enhance supply chains.

- Supply chain analytics
- Operations strategy
- Procurement transformation
- Measuring sustainability for suppliers
- Strategic global sourcing
- Spend reduction



Technology can provide solutions help automate and enhance decision making. There are unprecedented challenges for manufacturers globally. KPMG professionals encourage companies to think about the current and emerging technologies that can help in accelerating the digital transformation and build resiliency in future crises. Some of the technology-based solutions include:

- IT Sourcing
- ERP transformation
- Innovative business models leveraging technology
- Digital transformation
- Blockchain capabilities
- Automation, data analytics and connected systems
- Cyber / information security
 - Cloud security and resilience
 - Secured data management services
 - Understanding the regulatory landscape
- General Data Protection Regulation (GDPR)



Sustainability is at the core of every organisation that is focusing on making an impact on the environment as well as the society. The current linear economic model is low, and companies are getting aligned with the CE model which allows full extraction of product value before it is reused or recycled. This model is gaining momentum across all industries – from private to public and manufacturing to service. KPMG firms can help clients in the following ways:

- Sustainable strategies and business models
- Sustainable investments
- Reducing carbon emissions
- Circular Economy based opportunities
- Infusing CE principles into organizational plan
- Identifying CE opportunities beyond waste management
- Reporting frameworks
- Workplace health and safety



Strategy focus is paramount for companies today as they face shifts in structure due to new technologies, regulations, sector convergence and customer needs. There is a need for agile strategies in the rapidly changing world today. KPMG professionals can help companies in identifying and implementing a set of platforms that can accelerate growth. Some areas for fulfillment of goals and ambitions include:

- Pricing and market access
- New business models
- Portfolio transformation
- Market entry and expansion
- Operating strategy and cost
- Multi-year strategic planning
- Corporate center redesigns



Risk mitigation and compliance come in play when companies need to earn the trust of their stakeholders, marketplaces and customers whom they serve. Companies today are facing challenges due to increased regulatory requirements, financial assessments and operational instability. KPMG professionals can help companies in enhancing their performance and decision-making processes as well as aiming for highest levels of integrity through various offerings:

- Enterprise risk management
- Governance, risk and compliance
- Regulatory compliance
- Risk Analytics
- Fraud Management
- Crisis Management

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