

## IMPACT COVID-19 PANDEMIC ON IMPLEMENTATION INDUSTRY 4.0 IN ENTERPRISES AND SUPPLY CHAINS

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**Purpose:** The aim of this study is to discuss the impact COVID-19 pandemic on implementation 4.0 technologies in enterprises and supply chains.

**Design/methodology/approach:** The study performs review of literature to identify key aspects of Industry 4.0, the COVID-19 pandemic in the economy.

**Findings:** The paper explained the changes in the functioning of enterprises and supply chains and their transformation towards Industry 4.0. The authors defined the impact of the COVID-19 pandemic in the context of applying technology trends of the Industry 4.0 by enterprises and supply chains. We claim that in the enterprises and supply chains will be the need to invest in new technologies for the long term and implement new infrastructures. The COVID-19 pandemic is likely to help us push the accelerator pedal on Industry 4.0 in the industries, especially manufacturing industry.

**Originality/value:** The study is one of the analysis of the relationships between enterprises and supply chains in the framework of Industry 4.0 and the aspects the COVID-19 pandemic in creating value chain. The study can be addressed to project managers and supply chains managers responded for implementation technologies of Industry 4.0.

**Keywords:** Industry 4.0, COVID-19 pandemic, digitalization, enterprise, industry, management, supply chain.

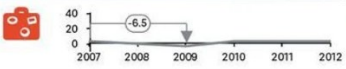
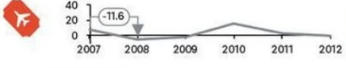
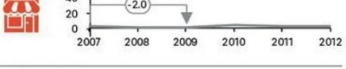
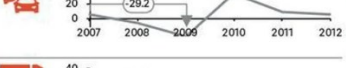
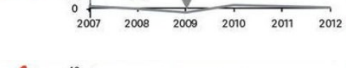
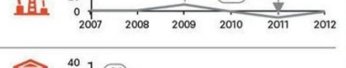
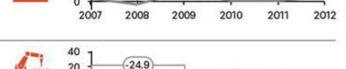
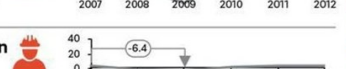
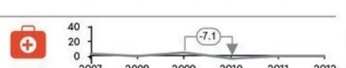

**Category of the paper:** research paper.

### 1. Introduction

As we can see, nowadays changes in the global world are becoming faster and more unpredictable. Enterprises, especially small and medium sized enterprises have to react very quickly to challenges and opportunities of the business world. The industries, including the automotive industry, manufacturing industry, are being pummeled by the COVID-19 pandemic at a time when it already has enough challenges to deal with in the form of digital transformation as a consequent of the Industry 4.0 concept.

On the one hand the world is gripped by the Covid-19 pandemic since December 2019 in China and since February in Europe and the rest of the world. The global economy will take a massive hit from the impact of the COVID-19 pandemic this year and the next years. The COVID-19 pandemic is hitting many enterprises and supply chains, harder than the 2008 financial crisis. We can suppose that it will take longer to recover from the losses they sustain. The economic slump will affect all regions and countries. Every manufacturer is impacted by this crisis in some way and for many this poses an existential threat. The industries in Europe and in the United States will be hit even harder than in China. In those countries we expect the weeks of lockdown and the further measures to protect the health of the population to cause GDP to plummet by 5.2% (Europe) and 5.4% (USA) in 2020. Although we do expect the global economy to grow again in 2021, even in China, Europe and the United States, this growth will not be sufficient to offset the losses of 2020 (Roland Berger, 2020).

**Table 1.**  
*COVID-19: some industries impacted similarly to the global financial crisis*

Industries	Financial crisis 2008	COVID-19 pandemic
<b>Tourism &amp; Travel</b>		<ul style="list-style-type: none"> <li>Due to curfews and travel restrictions, companies in the tourism industry are unable to generate revenues at present</li> <li>The industry could suffer from the pandemic in the long term if consumers' travel behavior changes for fear of disease</li> </ul>
<b>Airlines</b>		<ul style="list-style-type: none"> <li>Airlines, too, are expected to suffer from curfews and travel bans</li> <li>As in the tourism &amp; travel sector, there is a great danger that changes in the behavior of private as well as business customers will have a long-term negative impact on business</li> </ul>
<b>Retail<sup>1)</sup></b>		<ul style="list-style-type: none"> <li>In contrast to the last crisis, the brick-and-mortar retail trade was severely affected by the closure of shops, while online retailers were able to benefit</li> <li>There is a significant danger that consumer behavior will change in the long term to the detriment of brick-and-mortar retail</li> </ul>
<b>Automotive</b>		<ul style="list-style-type: none"> <li>Already burdened by high regulatory interventions and its transformation efforts, the automotive industry will suffer severe damage from the coronavirus crisis</li> <li>Reflecting the uncertainty of auto buyers about their own economic situation, the time to recovery could be significant longer than in the financial crisis</li> </ul>
<b>Logistics</b>		<ul style="list-style-type: none"> <li>The logistics sector suffers strongly from closed borders. Also, closed factories and shops mean that orders are absent or cancelled</li> <li>The strongly booming online retail business can only partially offset the deficits</li> </ul>
<b>Oil &amp; Gas</b>		<ul style="list-style-type: none"> <li>In addition to the COVID-19 pandemic, the market for oil was also severely affected by the oil price war between Saudi Arabia and Russia</li> <li>After an agreement was reached among the countries, the industry now fears a sharp decline in demand, which has pushed the oil price to a 21-year low</li> </ul>
<b>Financial Services</b>		<ul style="list-style-type: none"> <li>Unlike the financial crisis, the current crisis did not originate in the financial system</li> <li>But due to the high dependency on economic cycles and the already weak profit situation (low interest rates, digital transformation needs), especially in Europe, COVID-19 has the potential to affect the financial sector severely and for a longer time than after 2008</li> </ul>
<b>Mechanical Engineering</b>		<ul style="list-style-type: none"> <li>The industry is highly dependent on demand from other industries. Much therefore depends on how quickly other sectors can be ramped up</li> <li>However, service business continues to support the bottom line</li> </ul>
<b>Construction</b>		<ul style="list-style-type: none"> <li>As in 2008, it seems probable that public demand for infrastructure projects will increase in order to support the economy</li> <li>Nevertheless, it is worth noting that smaller construction companies in particular may run into difficulties due to increasing liquidity shortages</li> </ul>
<b>Pharma &amp; Medtech</b>		<ul style="list-style-type: none"> <li>The pharmaceutical sector is traditionally not very sensitive to economic cycles</li> <li>In the current crisis, there will be some winners (e.g. suppliers of ventilators, masks, Covid-19 treatments) and some losers (e.g. hospitals, physicians)</li> </ul>

1) Excl. vehicles — Growth rate of Gross Value Added (ppt.) Max. dip

Severity of impact: COVID-19 vs. financial crisis  
Time to recovery: COVID-19 vs. financial crisis  
— Significantly higher impact/ much longer time to recovery  
— Higher impact/ longer time to recovery  
0 Similar impact/ time to recovery

Source: IHS, Roland Berger

Adapted from: "Latest update of our corona economic impact series" by Roland Berger, 2020.

On the other hand the 4.0 concept is becoming more and more popular nowadays (Kumar et al., 2019) in manufacturing practice. The appearance of the Fourth Industry Revolution is a consequence of the dynamically changing business environment and constantly growing customer requirements. Currently, flexibility and response to changing market needs in real time are becoming increasingly important. This is why enterprises strive to adapt production processes in such a way that it is possible to produce individualized products at a time when there is a real demand for them. Industry 4.0 opens up new opportunities for creating added value for the customer and stimulating technological and process innovation, which allows for increased competitiveness.

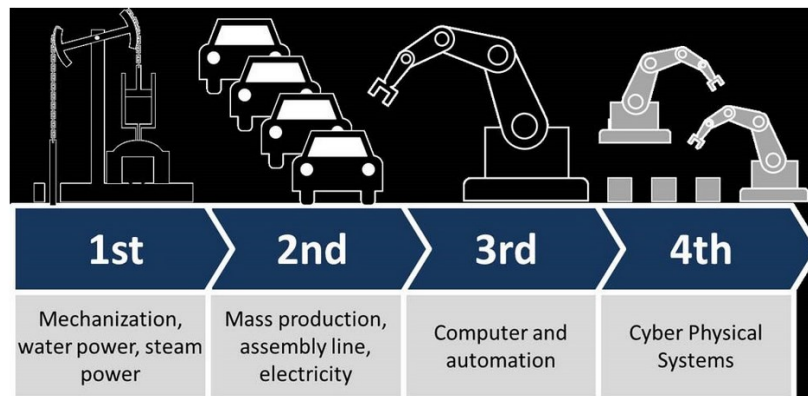
Prior to the crisis generated by COVID-19 pandemic, Industry 4.0 was an area of great interest to many manufacturers in the world, especially in Europe. It was an exciting topic with huge potential benefits and was widely regarded as a 'positive' and future thinking topic. Today, many of enterprises, especially manufacturing enterprises are focused on the here and now because of the COVID-19 pandemic. Some manufacturers have ceased production completely, some have seen greatly reduced demand and others have seen a huge increase in demand. Additionally, we can observe that the global supply chains are experiencing a level of disruption that has never been seen before. The focus for many manufacturers now is survival first and foremost and beyond that, damage limitation.

We consider following problem: given is a manufacturing enterprise and its supply chain, which is focused on implementation the concept of Industry 4.0 prior to the crisis generate by the COVID-19 pandemic. The key business drivers of Industry 4.0 prior to the crisis were focused on competitive advantage, cost reduction, productivity, sustainability and innovation. We are looking an answer for the following question: does the enterprise engagement in implementation the concept of Industry 4.0 change because of the COVID-19 pandemic? Can the Covid-19 pandemic accelerate implementation the concept Industry 4.0?

## 2. Literature review

Industry 4.0 describes the increasing digitization of the entire value chain and the resulting interconnection of people, objects and systems through real time data exchange. The 4.0 concept is a result of some processes, for example: internationalization, information technology development and also hyper competition. Dynamic development of manufacturing Industry 4.0 is observed since 2011, when the main idea of Industry 4.0 was published for the first time (Kagermann et al., 2011). In the same year it became a strategic initiative of the German government and was included in the "High-Tech Strategy 2020 Action Plan". In the literature, the term Industry 4.0 is often referred to as the Fourth Industrial Revolution (Kagermann et al., 2013) (Figure 1). Additionally, in the literature we can find such terms:

“factories of the future”, “smart factory”, “intelligent manufacturing” (in Europe), “Industrial Internet” (in USA) and “Internet+” (in China) (Mrugalska, and Wyrwicka, 2017).

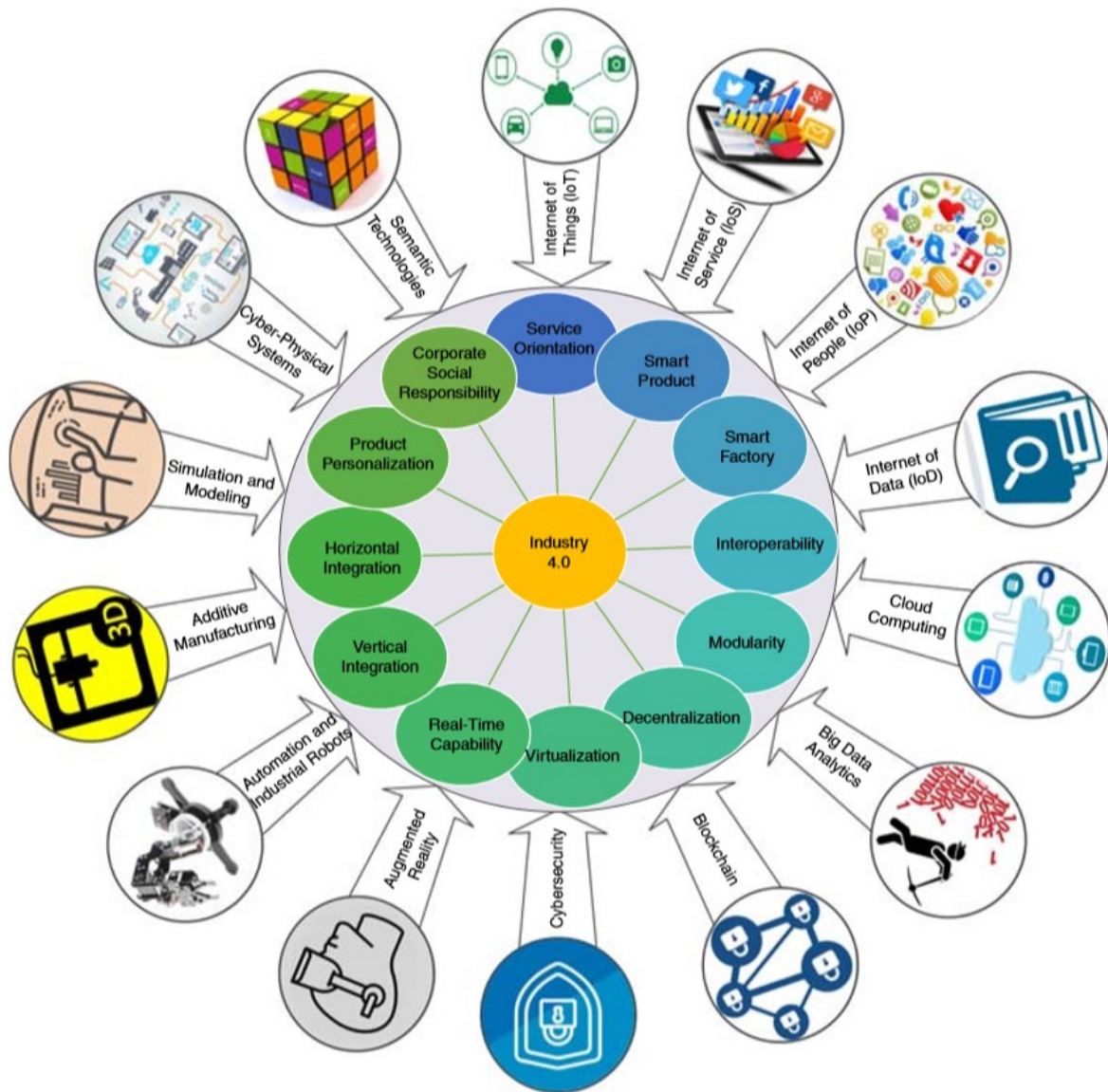


**Figure 1.** The four major industrial stages. Adapted from: “Examining COVID-19’s Impact on Industry 4.0. Is Coronavirus Triggering Industry 5.0?” by C. McMahon. Copyright 2020 by KEYPOINT INTELLIGENCE.

The growing interest in the concept of Industry 4.0 has resulted in the growing number of papers and reports dedicated to this concept. Industry 4.0 was a top priority for many organizations, research centers and universities before the financial crisis. The majority of experts in the academia believe that the Industry 4.0 term itself is unclear, and manufacturing firms are facing difficulties when it comes to understanding this phenomenon, and identifying the steps required for the transition toward Industry 4.0. Based on the systematic review of Industry 4.0 literature we can state that a number of definitions are being created, but none has yet been established as the generally accepted one. Some scholars such as Gilchrist (2016), Liao et al. (2017), Santos et al. (2017), Ustundag and Cevikcan (2017) and Vogel-Heuser and Hess (2016) believe that Industry 4.0 can be defined based on its design principles and technology trends. One of the definition presented in the literature based on design principles and technology trends of Industry 4.0 is proposed by Ghobakhloo (2018). He defines Industry4.0 as an integrative system of value creation that is comprised of 12 design principles and 14 technology trends (Figure 2).

The concept of Industry 4.0 (or Smart Industry) has become its element. This revolution is connected with the following three phenomena (Paprocki, 2016):

- universal digitization and ensuring constant communication between people, people with devices, and devices among themselves,
- increasing the implemented innovations of subversive character (disruptive innovations), allowing for a stepwise increase in the efficiency of the socioeconomic system,
- the development of machines capable of autonomous functioning through the use of artificial intelligence.



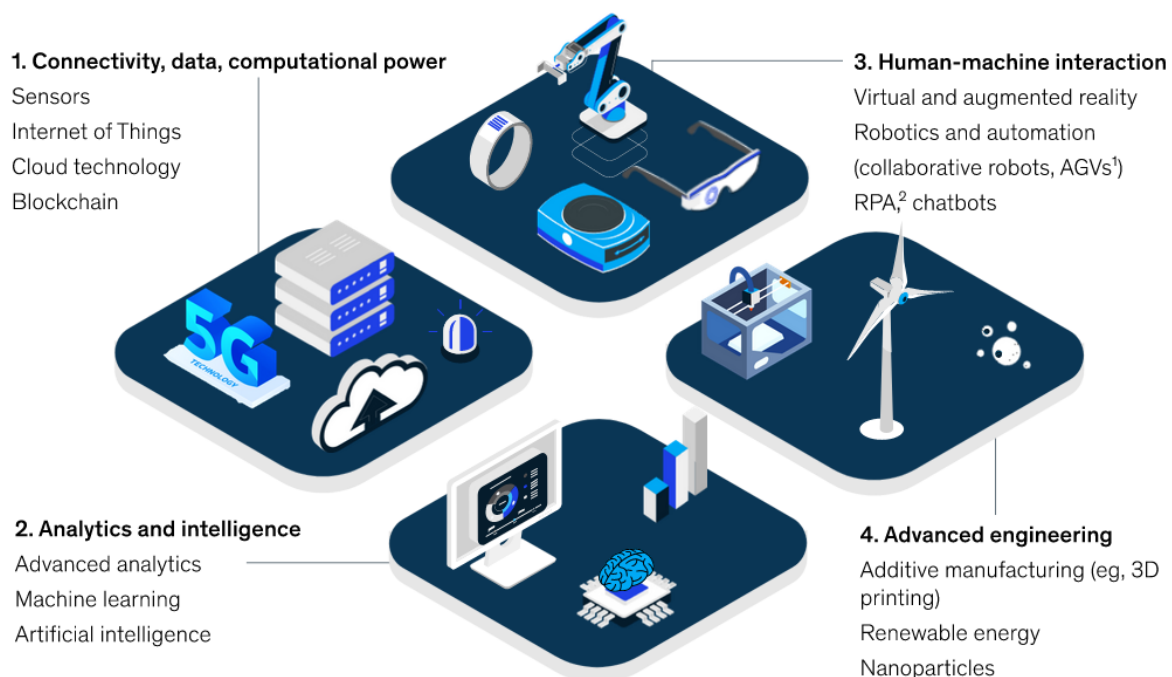
**Figure 2.** Key design principles and technology trends of Industry 4.0. Adapted from: “The future of manufacturing industry: a strategic roadmap toward Industry 4.0” by M. Ghobakhloo. Copyright 2018 by Emerald.

The concept of Industry 4.0 means the connection of production machines in the real world with the virtual world of the Internet and information technology. People, machines, and IT systems automatically exchange information during the course of production – within the factory and within various IT systems operating in an enterprise. Industry 4.0 covers the entire value chain: from ordering and delivering components for on-going production to shipping goods to customers and after-sales services (Figure 3).

The concept of Industry 4.0 is presented as an emerging structure in which manufacturing and logistics systems in the form of a Cyber-Physical Production System (CPPS) intensively use the globally available information and communications network for an extensively automated exchange of information and in which the production and business processes are matched (Bahrin et al., 2016; Lars, 2016). In production management, Industry 4.0 is very responsive and adaptive to customer demands. Fulfilling individual customer needs is the main

objective of Industry 4.0 (Neugebauer et al., 2016). The need for Industry 4.0 in production management is to convert regular machines to self-aware and self-learning machines to improve their overall performance and maintenance management with the surrounding interaction (Lee et al., 2014). The significant efficiency of Industry 4.0 can be obtained mainly through the consequent digital integration and intelligentization of manufacturing processes (Zhou, 2013). As we know, integration needs to take place on the horizontal axis (across all participants in the entire value-chain) and on the vertical axis (across all organizational levels). Fully integrated and networked factories, machines, and products then need to act in intelligent and partly autonomous ways that require minimal manual interventions. By converting the analog data in Industry 4.0 into digital data, the information available in this productivity chain can be used by all players from any location and at any time. On this basis, production and sales processes can be optimized.

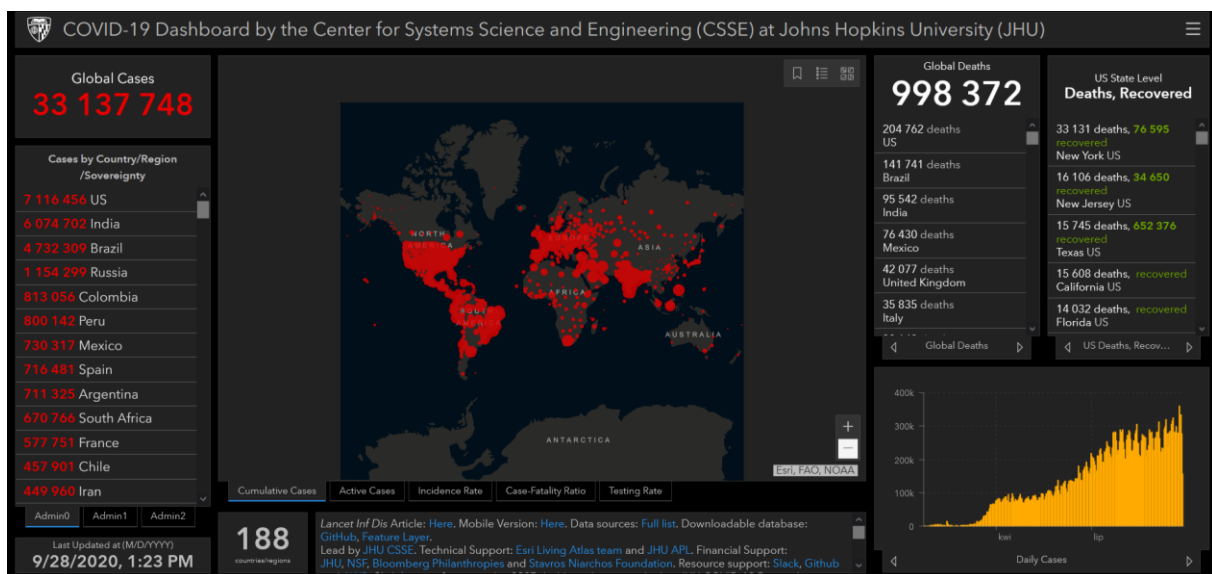
Enterprises have two pathways ahead of Industry 4.0 in the area of production management (i.e., users of Industry 4.0 or providers of Industry 4.0). Users are those who primitively try to implement CPS-based solutions in various departments, whereas providers are the ones who provide these solutions to other companies (Kagermann, 2013).



**Figure 3.** The core technologies of the Industry 4.0. Adopted from: “Industry 4.0: Reimagining manufacturing operations after COVID-19” by Agrawal M., Eloit K., Mancini M., Patel A., Copyright 2020 by McKinsey.

### 3. The coronavirus COVID-19 versus The Industry 4.0

As it was mentioned, the initial outbreak of coronavirus COVID-19 appeared in China in the end of 2019 year. However, the outbreak has grown into a global pandemic and has cut global supply chains. On March 11, 2020, the World Health Organization formally declared COVID-19 a pandemic, underscoring the precipitous global uncertainty that had plunged lives and livelihoods into a still-unfolding crisis (McKinsey, 2020). Currently worldwide confirmed 33 137 748 cases and 998 372 deaths (Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)). The coronavirus COVID-19 is affecting 213 countries and territories around the world (Figure 4).



**Figure 4.** COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU), Adopted from: <https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>, 28.09.2020.

As we can imagine, for some manufacturers, the digital transformation (the concept of Industry 4.0) might have always been in the pipeline. Now, it seems that the implementation of this concept has been fast-tracked as a result of the restrictions the COVID-19 pandemic has brought. Manufacturers will have been forced to abandon their traditional processes and to transform the processes and applied new principles and technology trends according to Industry 4.0. As we can observe supply chains and manufacturing leaders before the pandemic were forced to implement new technologies. We can formulate a research question: How will manufacturing and its supply chains look after the COVID-19 pandemic?

Many meetings, congresses, and exhibitions had to be canceled as a result of restrictive measures. This pandemic poses several major threats to economy stability and enterprises. COVID-19 has affected production, inbound and outbound logistics – logistics systems in many enterprises, and additionally many supply chains, for example public food distribution systems

in many countries. For example, schools closing under India's national lockdown resulted in suspension of school feeding programs – one of the country's largest safety nets. School closures are also depriving many poor U.S. children of publicly provided meals. Farmers and other suppliers have found difficulty finding market outlets to replace institutional outlets such as restaurants and schools, resulting in substantial wastage of milk and other nutrient-rich foods. Other safety nets are also affected, including community nutrition programs for pregnant women and lactating mothers.

Restrictions on working work travel and the current lockdown of the COVID-19 pandemic have seen a transition for many workers in manufacturing enterprises to remote working, with this being made possible by video conferencing platforms. The remote working can be done by management staff, the top and middle staff. Since the beginning of the pandemic, company sources have reported a 70 per cent increase in the use of Facebook Messenger's video call function, and in just one record day, applications like Skype, Zoom, WhatsApp and Google Hangouts received approximately 600,000 downloads, according to the New York Times. We have also seen more online sharing and multiple editing of documents on services such as SharePoint and Google Docs. The future of work has changed. Work-from-home arrangements are a viable strategy for many businesses and that this is likely to be true even after the crisis is over. Remote working may well become more of the norm, and businesses could reduce the volume of office spaces needed and spend more money on new technology (Diver, 2020).

The enterprises and the global supply chains are experiencing a level of disruption that has never been seen before. Some manufacturers have ceased production completely, some have seen greatly reduced demand and others have seen a huge increase in demand. Every manufacturer is impacted by this crisis in some way and for many this poses an existential threat.

Based on the latest report done by McKinsey we can state that the auto industry is one of the world's largest and has been devastated by the pandemic: sales may drop by 20 to 30 percent in 2020. The profits of this industry will fall by \$100 billion. But automakers can respond. One example: software-subscription services, which enable people to pay for programs that unlock features from heated seating to full self-driving capabilities, allow dealerships to develop a better relationship with consumers while offering drivers additional flexibility and customization (Agrawal et al., 2020).

The business drivers of the Industry 4.0 pre-crisis were focused on: competitive advantage, cost reduction, time reduction, materials reduction, waste reduction, productivity creasing, sustainability and innovation. The goal was to make well run businesses run better. From one side the focus for many manufacturers now is survival first and foremost and then beyond that, damage limitation. We can observe many of companies are focused on the here and now. Many companies are moving to work remotely, the world industry is facing big problems due to delayed responses and unusable production capacities due to production stoppage and transport, especially in automotive enterprises.



#### **4. The role of The Industry 4.0 in the perspective of the pandemic**

The COVID-19 has the impact on implementation the concept of the Industry 4.0 in the area of production management in enterprises and global supply chains. The changes can be observed in research and development, designing, inventory management, service, and customer care. From the other side the pandemic transforms the design, manufacture, operation, and service of products and production systems. Manufacturing is transformed from single automated cells to fully integrated automated facilities that can communicate with one another and boost flexibility, speed, productivity, and quality.

This raises a few challenging problems dedicated to manufacturing and the concept of Industry 4.0. We believe that the Industry 4.0 is relevant topic for manufacturers. This concept is not only as relevant as it was before the pandemic. But how we can observe it is actually far more relevant for enterprises and supply chains.

In a production system, the nine pillars of Industry 4.0 will transform isolated and optimized cell production into a fully integrated, automated, and optimized production flow. This will lead to greater efficiency and changes in traditional production relationships among suppliers, producers, and customers as well as between human and machine. In Industry 4.0, these transformation, sensors, machines, work pieces, and IT systems will be connected along the value chain beyond a single enterprise. These connected systems (also referred to as Cyber-Physical Systems) can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes. Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This in turn will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce, ultimately changing the competitiveness of companies and regions (Rüßmann et al., 2015). Industry 4.0 aims at the construction of an open and smart manufacturing platform for industrial-networked information application (Bahrin et al., 2016). Real-time data monitoring (tracking the statuses and positions of products as well as holding the instructions to control production processes) are the main needs of Industry 4.0 (Almada-Lobo, 2015).

The COVID-19 pandemic has precipitated profound changes across the globe, accelerating the shift towards digital transformation and radically impacting workflow in global supply chains and in enterprises gathered in supply chains. The Industry 4.0 enable last-minute changes to production and deliver the ability to respond flexibly to disruptions in enterprises and supply chains. It is very important in the perspective the pandemic. The COVID-19 pandemic has already highlighted the possible uses and benefits of the components of Industry 4.0, especially virtual reality. It may be the dawn of a new digital reality.

The Industry 4.0 should have a different role in the time of the pandemic. It should help to make sure that more companies survive, shorten the recovery phase and help return businesses to normal operations as soon as possible, provide the platform to develop new, more resilient businesses in the medium to long term. These can be achieved because many of the capabilities it offers could have greatly reduced the impact of this crisis on citizens, enterprises, supply chains.

In this content we can observe: real-time visibility into the availability of raw materials, finished goods, WIP, people and assets, use of Artificial Intelligence and Machine Learning to constantly reassess and re-plan activities, Robotic Process Automation to support non-value add labor intensive activities, the use of mobile technology, Augmented Reality and Virtual Reality to enable workers to perform tasks they were not trained for more easily. This could have assisted with skills shortages due to self-isolation or repurposing of manufacturing. The same technologies together with digital twins and remote support from OEM's would improve availability of assets. The same technologies could also have enabled more remote working and virtual working to help with the issue of lockdown and social distancing. Additionally, 3D printing of spare parts that were stuck in the supply chains. Use of AGV's, autonomous electric vehicles and drones to again reduce the reliance on people and to further assist with social distancing. In the pandemic time which is full of the risk and uncertainty, the enterprises and supply chains have on open access to technologies that can help employees, companies, communities, and governments continue to move forward to better future.

As we can observe many manufacturing plants and premium logistics warehouses in China have already adopted Industry 4.0 and Logistics 4.0, respectively. Given the impact the COVID-19 outbreak has had on manufacturing and supply chains within the country, we do expect many more factories and logistics warehouses to follow and implement Industry 4.0 and Logistics 4.0 technology and systems, respectively in other countries. By doing this, manufacturing and supply chains will be able to better ensure that goods and products make their way from production facilities to customers in the most efficient manner under any situation and at any time.

We claim that in the manufacturing industry will be the need to invest in new technologies for the long term and implement new infrastructures. The COVID-19 pandemic is likely to help us push the accelerator pedal on Industry 4.0 in the industries, including manufacturing industry. In due to the pandemic the goal for all manufacturers will be to implement Industry 4.0 as soon as possible and at the lowest cost. In defining the operating model for this implementation the enterprises will factor in lessons learned from the global crisis of COVID-19 and try to build a more resilient and agile business. We believe that the key finding will be that the systems and processes in place were not fit for purpose. It is too early to say for certain, but it seems clear from events unfolding before us that one of the major weaknesses is a lack of real time visibility across the business. Visibility that is essential to support critical business decision.

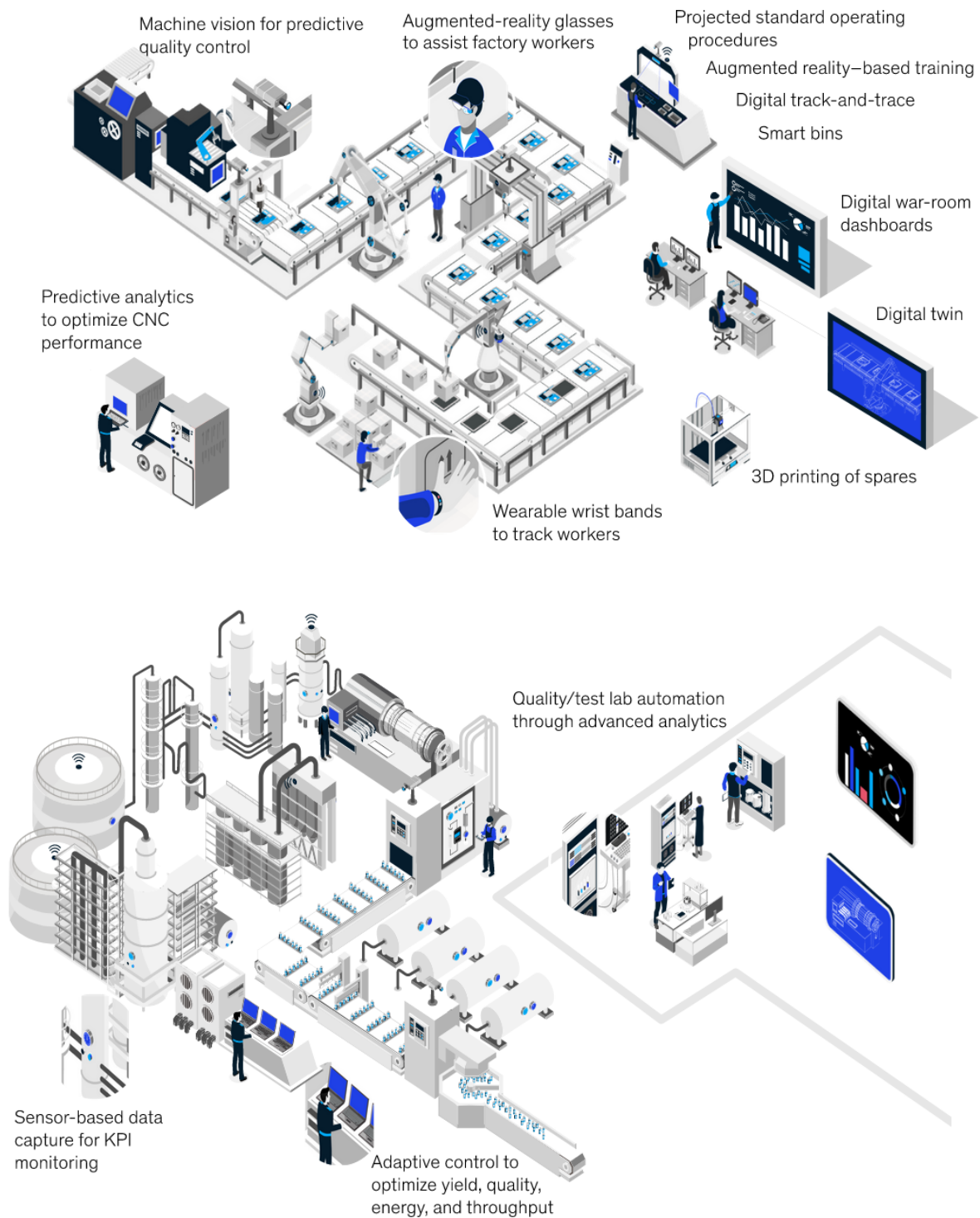
## 5. Results

Based on the results of research papers and surveys of manufacturers we can state that the enterprises and supply chains should be much more digital in the future, as is already evident in the immediate response to the crisis. We can observe that industry leaders are leveraging Industry 4.0 solutions. Fast 40 percent have implemented a nerve-center, or control-tower, approach to increase end-to-end supply-chain transparency, and around a quarter are fast-tracking automation programs to stem worker shortages arising from the COVID-19 pandemic. Industry 4.0 which includes connectivity, advanced analytics, automation, and advanced-manufacturing technologies – was gaining momentum before the COVID-19 pandemic, helping companies transform their operations in everything from production efficiency to product customization, with improvements in speed to market, service effectiveness, and new-business model creation.

As we can observe the role of Industry 4.0 becomes even more critical in the backdrop of a crisis such as the COVID-19 pandemic. Players utilizing digital solutions are better-positioned to weather the storm, having moved faster and further than their peers during the crisis. A recent McKinsey survey of manufacturing and supply chain professionals found that 93 percent plan to focus on resilience of their supply chain, and 90 percent plan to invest in talent for digitization (Agrawal et al., 2020).

To thrive in today's marketplace, the enterprise especially small and medium-sized enterprise must continuously strive to improve its position relative to its competitors in a business environment characterised by increased competition, a need for developing better products at reduced cost, and reduced time to market. This enterprise should seek rapid, flexible and cost-minimised solutions in the development and manufacture of products. Achieving the speed of response that is needed in today's global markets is firmly rooted in the internal and external flexibility a company can rely when responding to disturbances in its operating environment. The success of an enterprise results from the skillful use of processes, principles, rules of conduct and resources in response to opportunities and risks that arise, among these non-standard project-based orders. Therefore, the transformation of business conduct and the differentiation between routine tasks and tasks that are unique (project-based orders treated as projects) in a production system become necessary. It is main stream of the Industry 4.0 concept.

Therefore, it is interesting to analyze the Industry 4.0 idea acceptance within SMEs. The Industry 4.0, is currently widely described in the scientific literature and popular term used in the business world. The Industry 4.0 determines changes in production – from mass production to personalized production (customization) – which make the production processes more flexible and provide the means to meet the individual needs of different customers more effectively (Figure 5).



**Figure 5.** The process of manufacturing 4.0 in the smart factory. Adopted from: “Industry 4.0: Reimagining manufacturing operations after COVID-19” by Agrawal M., Elout K., Mancini M., Patel A., Copyright 2020 by McKinsey.

The crucial role in the supply chain is played by small and medium enterprises as their level of digitalization impacts on ability to compete by smart supply chain idea.

## 6. Summary

The COVID-19 outbreak is a complex crisis made up of multiple trigger points – health, policy, the economy in the world. Its impact on the enterprises and the supply chains is observed in the context of Industry 4.0. Enterprises can deploy digital solutions beyond the four walls of a manufacturing plant, reaching across the end-to-end value chain to address planning (and replanning) challenges related to disruptions at suppliers or production plants, operational challenges in managing workplace health risks, and delivery challenges posed at transportation modes or in warehouses, and it is more needed than before the crisis. A core element of manufacturing and supply-chain operations – planning – has traditionally been conducted in silos, with demand forecasting, supply planning, production planning, logistics planning, and sales and operations planning (S&OP) all handled by separate teams. Interrupted global trade flows and value chains have forced companies to break the silos to improve end-to-end visibility. As a result, the potential impact from optimized planning is more evident. But it also requires a more sophisticated analytical approach, and collaboration across multiple functions and stakeholders (McKinsey, 2020).

The manufacturing disruptions from the COVID-19 pandemic stem from many sources, ranging from safe-distancing measures and staggered worker attendance to restricted migrant-labor movement within and between countries. Digital technologies can help mitigate the effects in multiple ways, boosting employee safety, operational efficiency, asset productivity, and product quality. In most companies, and especially in SMEs, data collection is manual, using pen and paper or basic spreadsheets. The process is prone to errors and inaccuracies, which are naturally exacerbated during the stress of a crisis. Digital solutions allow manufacturers to automate data collection by adding sensors or directly tapping into machines' programmable logic controllers (PLCs) to collect data and display it on live dashboards (McKinsey, 2020).

Supervisors can then monitor factory performance remotely and in real time. They can deploy interventions when needed, conduct effective performance-management meetings, adapt daily plans to meet customer demands, and to improve labor productivity as well as operational efficiency – all remotely. In addition, process automation and physical automation or robotics can supplement labor capacity. In some instances, “brownfield” automation of existing operations has become a more attractive way to manage worker shortages and minimize potential business losses due to unmet orders. At one industrial manufacturing company, robots are now delivering raw materials and semi-finished goods to different production lines – helping the production team cope with a reduced workforce while preventing close contact between production and material-handling employees (McKinsey, 2020).

The COVID-19 crises reduced availability of transportation modes while introducing added complexities, such as new requirements for packaging and for safe, last-mile contactless delivery. In this context, digital and analytics solutions can increase visibility of both demand and supply for logistics services, improving real-time performance (McKinsey, 2020).

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