sfi Centre for Research-based Innovation
The Research Council of Norway
manufacturing

Trends influencing the Norwegian manufacturing industry in the next decade

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White paper

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SFI Manufacturing is a cross-disciplinary centre for research-based innovation for competitive high value manufacturing in Norway. The Research Centre was officially established on July 1st 2015. SFI Manufacturing's vision is to show that sustainable and advanced manufacturing is possible in high cost countries, with the right products, technologies and humans involved. For additional information, please visit https://www.sfimanufacturing.no/.

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1 Introduction

Manufacturing in the 21st century has been characterized as a complex and dynamic sociotechnical system (ManuFUTURE, 2019). The industry is currently being challenged by accelerated technological change, pressures, and regulations regarding reduction of its environmental footprint, novel knowledge demands, a turbulent economic landscape, and a pandemic creating a demanding and unforeseen context. For manufacturers to make sense of ongoing changes and how to position themselves within this changing landscape, it is useful to start with developing a knowledge basis on the most pertinent trends. This is the departure for this white paper, which aims to provide an overview of some of the key technological, environmental, social, and economic trends that both challenges and provides opportunities for the Norwegian manufacturing industry. Note that the paper does not provide an exhaustive analysis and discussion of the different trends. The selection of the different trends drawn out in this paper were based on interaction with the SFI Manufacturing partners through workshop presentation and work. Initially, through a practice-based approach, the researchers identified different social, economic, and environmental trends based on relevant global reports and research articles. These trends were in turn presented to the SFI Manufacturing consortium. Following the presentation of the trends, a Mentimeter survey was conducted, where the industrial partners could rate which trends they believed were most relevant for them in the years to come. Based on these results, and further iteration within the research group, the identified trends were complemented and written out. The final product is thus a result of academia–industry interaction which provides an overview of the trends that is believed to influence Norwegian manufacturing in the next 10 years and can act as a starting point for manufacturers who are eager to learn more about future developments within manufacturing. The In section 2, we present and briefly reflect on these trends individually. The trends are presented in the following sequence: Environmental trends, Technological Trends, Social Trends and Economical Trends. In section 3 we briefly discuss the interconnections between the trends and how recent challenges related to the COVID-19 pandemic influence them, before providing some final remarks.

The white paper has been written as a part of the Centre for research-based innovation on Manufacturing (SFI Manufacturing) within the research area on *Sustainable and Innovative Organizations* (RA3).

2 Trends in manufacturing industry

2.1 Environmental trends

The manufacturing industry in Norway is increasingly influenced by environmental pressures. To reach ambitious emission targets by 2050, change is needed in the existing ways of doing business. Moreover, the UNs sustainable development goals set the agenda for a sustainable future (UN 2020). The goals, in particular number 12 "Responsible production and consumption" address the manufacturing industry. As all industries and actors are parts of their greater external environment, manufacturing companies are forced to respond to these pressures. Despite the increased focus on sustainable products and production, manufacturing still requires a large amount of raw materials and energy.

The current economic model of production and consumption have been based on a linear model, often referred to as "take-make-waste-models" (WEF 2019). Scarcity of natural resources and increased energy demand are expected to increase in the coming decades. To address this sustainability challenge, the Circular Economy (CE) is gaining momentum as a response to environmental pressures. According to The Ellen Mac Arthur Foundation CE is: "*an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models*" (MacArthur, 2013). As resources are limited and production demands are high, the current system is on an unsustainable path. However, there are also several advantages for firms adopting the CE, e.g., better utilization of materials. The CE is also highlighted as one of the key priorities in the EU's new "Green Deal".[1]

2.1.1 Circular business models and circular value chains

Resource scarcity and climate change demand smarter use of resources in the future. The linear economy is traditionally based on a take-make-dispose-logic. In contrast to this logic, the CE is based on the notion of creating value while reducing the negative environmental impact. Key principles in a circular economy are eliminating waste and "closing the loop" (Nußholz, 2018). In addition to better utilization of resources, the transition to a circular economy is also expected to reduce emissions (Jahren, 2020).

The concept of CE implies new opportunities for value creation in the manufacturing industry. The development of circular business models and value chains can be explored through different strategies. Several approaches can be taken to create value based on circular economy principles. In figure 1, these approaches are categorized as strategies according to their levels of circularity. Based on the core idea of the circular economy; higher levels of circularity denotes smarter product use or less extraction of resources (Potting et al., 2017). Increased circularity may also be obtained through sharing resources.

[1] European Commission 2019. Communication from the Commission. The European Green Deal. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

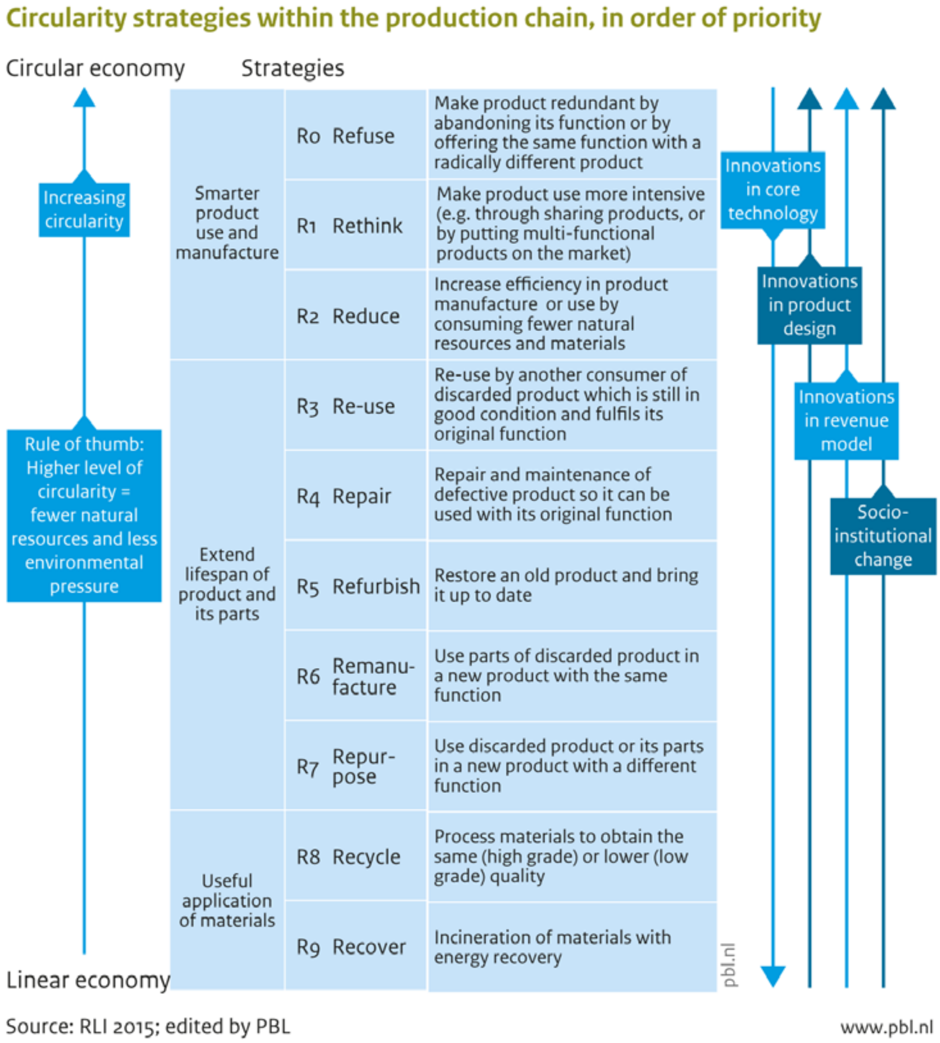

Figure 1 Circularity strategies within the production chain, in order of priority

To succeed with circular business models, the ecosystem around is emphasized through establishing circular value chains. Circular value chains require the integration of information about products along the value chain (ManuFUTURE, 2019). In this regard, the concept of Industry 4.0 is playing an important role, by enabling technologies that promote such value chain constellations, e.g., by digital data. Digital data tools include important information about products in the value chain and can also include information about opportunities for repair and disassembly, which can promote circular business models based on reuse and recovery. Examples of such tools could be blockchain-based provenance tools or product passports (Forum, 2019).

In 2020, Deloitte assessed the potential for the circular economy in Norwegian industries. This study indicates a high potential for increased circularity in several Norwegian industries. In particular relevance for the Norwegian manufacturing industry, is the potential for increased circularity in the workshop and metal processing and downstream in the value chain (Deloitte, 2020). As an incentive to promote circular value creation in Norway, extended producer responsibility (EPR)[i] is suggested for additional product categories (Deloitte, 2020). Such incentives are expected to both promote sustainable product design and reduce the amount of post-consumer waste. EPR is currently covering electronic and electrical products, packaging, and batteries in Norway.

Digital transformation and advanced manufacturing technologies are expected to support manufacturing sustainability, flexibility, and resilience. In parallel with the development of circular business models, the emergence of the sharing economy is opening new opportunities for business models allowing individuals or companies to have access to the same products. This gives companies access to assets without being the owner, which provides flexibility and lower risk for each company. In particular, this is relevant when the price of a specific asset, e.g., advanced manufacturing tools is high and the usage is low (Vision 2030).

2.1.2 Product as a service

As the sharing economy is growing, more and more manufacturers are adopting product-as-a-service business models. The buyer is no longer the owner, but the supplier delivers the physical products, software and/or support on-demand. However, this is nothing new. The automotive industry has been providing cars as a service for decades – through their leasing programmes. Nevertheless, in recent times such business models have reached new hights, due to three technological enablers. The first is feedback about product usage almost in real-time, by help of cheaper sensor technology that is embedded into the products (the sensors are projected to reach an average cost of $0.38 by 2020). The second driver has been better connectivity and computer processing through the cloud, coupled with AI. Thus, data can be quickly analysed, and the results can e.g. inform product development, sales, and improve customer support. The third driver is the convergence of hardware and software, as it can be harder and harder to distinguish the product from the technology on which the product runs. This enables the manufacturers to build a relationship with the customer over several years or even the entire lifecycle of a product. The manufacturer will provide software support and updates, thus sometimes providing new functionality to old products. (Microsoft Dynamics 365, 2019).

2.2 Technological trends

Technological change and process improvement are not unfamiliar for firms within the manufacturing industry, which have undergone great technological changes in the course of the last century (see Figure 1). However, current technological change is unravelling at greater speeds than that of previous periods. Often, these recent technological developments within manufacturing industries are associated with the concept Industry 4.0 (Kagermann et al., 2013, Schwab, 2016, Schwab and Davis, 2018). The concept embraces a range of technologies that are predicted to have disruptive effects on manufacturing, which is why Industry 4.0 proponents regard current developments as the fourth industrial revolution (Schwab, 2016). Examples of such technologies are artificial intelligence (AI), Big Data, the Internet-of-Things (IoT), additive manufacturing and cloud computing (Maynard, 2015). What sets current technological transformation processes apart from those of previous industrial revolutions is the coupling of different technologies through the use of sensors and the IoT, transforming previously individual technologies into cyber-physical systems (CPS). Cyber-Physical Systems are defined as transformative technologies for managing interconnected systems between their physical assets and computational capabilities (Baheti and Gill, 2011). In a manufacturing context, a CPS typically consists of both a physical and a digital production line, where physical assets have a digital representation which is updated in real-time throughout the manufacturing process, enabling monitoring of the manufacturing process from start to finish (Lee, 2008). In this section, we elaborate on current technological advances and their potential impact on manufacturing.

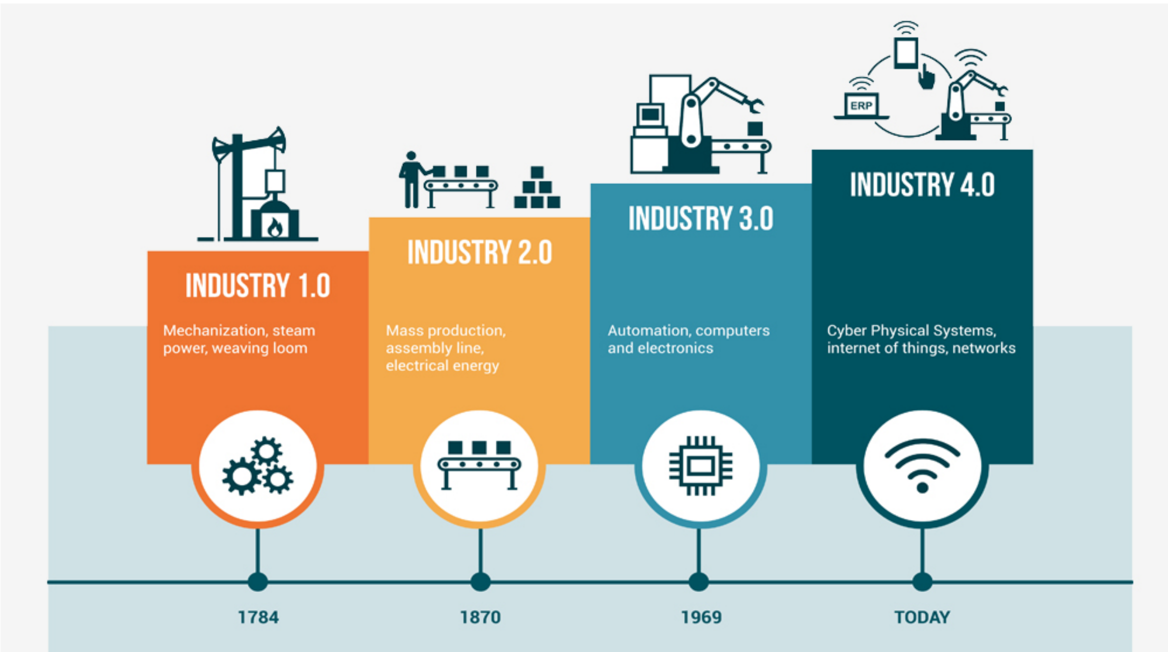

Figure 2 - Industrial revolutions (Source: SeekMomentum, 2019)

2.2.1 Big Data analytics is transforming manufacturing

While not a specific technology in itself, data, here meaning "machine readable digital information", is a key element in all the technologies and business models discussed below. Data can take a wide variety of formats, describing everything from steps in the manufacturing process through environmental impact, maintenance work, financial information, customer behaviour, supply chain etc. It can be updated in microseconds or years. But as steam was the power source of the first industrial revolution, data is by many considered to be data source of fourth (Brynjolfsson and McAfee, 2014). Thus, any manufacturing enterprise needs a data strategy. It needs to define what its key data is, how it should be obtained and stored and how security issues should be handled. Further, the company must handle aspects such as trust issues regarding with whom to share specific data (ranging from none to everybody), usage and ownerships models, how data can support its business models, and challenges with respect to data quality issues.

Utilization of Big Data will contribute to enhanced product quality, more efficient processes and more well-functioning organizations over the coming years (OECD, 2015). In manufacturing, massive sets of data could be used for analysis and evaluation measures of machine operations, optimization of operations, and to offer customers after-sales services (Kagermann et al., 2013, Mikalef et al., 2018). The access to large data sets is a prerequisite for AI and machine learning. Especially deep learning is dependent on vast amounts of data (Wooldridge, 2020). For smaller manufacturers producing in smaller volumes, building up a large enough data set to successfully exploit deep learning algorithms can be challenging. However, data will increasingly be shared and used in collaboration with value chain partners and lead to more integrated relationships/networks. Big international institutions, such as the OECD, encourage politicians, business managers and industry actors to design policies with the aim to make it easier to do investments which are directed towards utilization of data (OECD, 2017). At the same time, businesses should be encouraged to share data and to cooperate across corporate structures (provided that there is willingness to do this). Increased data sharing naturally requires a high degree of trust between the parties, and the challenges related to security issues must be given very high priority. Furthermore, the quality of digital infrastructure, which among other things includes access to "high-powered" computing, is of critical importance for the company's performance and results.

2.2.2 Internet-of-Things (IoT) – A "game changer" for the manufacturing industry?

An increasing number of objects are becoming connected to the internet, thus opening up for information exchange (Giusto et al., 2010). Sensors and actuators (which both could be part of the IoT) in combination with data analysis and cloud computing enable intelligent and autonomous machines and systems. Over the next decade, intelligent systems will be able to detect and possibly eliminate many of the errors taking place in the production processes. More advanced sensors could gather data about individual elements or products in the production, and the data can then be analysed and used to detect deficiencies. In this way, one avoids that entire batches must be tested for errors. Further, these novel methods of equipping machines with sensors could contribute to a new paradigm in terms of maintenance – moving away from classical *preventive maintenance* to what is often referred to as *predictive maintenance* (Schwab, 2016). Predictive maintenance, i.e. predicting an error before it has happened through analyzing sensor data, could reduce downtime on machinery and equipment and bring the total costs down as a result from lower maintenance costs, less working hours, and a more stable production (Yan et al., 2017).

The focus on predictive maintenance could be further strengthened if more manufacturers change their business models to Product-as-a-Service (PaaS) or similar approaches. If manufacturers are renting out their products with a fee that includes service, they naturally want their products to last for as long as possible, and with as little maintenance as possible. This would be rational from both an environmental and economic aspect and is in stark contrast from the traditional business models where manufacturers do not have the same incentives to develop long-lasting products (the longevity must of course satisfy the demands of the customers) (de Man and Strandhagen, 2017).

According to a study conducted by Vodafone in 2015, manufacturers could reduce their average costs with 18% by adopting IoT-technologies. The same study found that 10% of IoT-adopters had reduced their costs with more than 25%, indicating the inherent potential of IoT. On an aggregate scale, estimates are suggesting that the IoT could bring 10 to 15 trillion dollars to global GDP over the next 20 years (Evans and Annunziata, 2012). Estimates from this study are showing that a 1% increase in maintenance efficiency in the aviation industry, brought about by IoT, could save commercial airlines 2 billion USD per year. Empirical evidence which support these rather optimistic estimates actually already exists. For instance, an American car manufacturer managed to reduce costs by nearly 2 billion USD over a period of two to four years with the help of IoT and Big Data analytics (OECD, 2017). Further, according to Mayer-Schönberger and Cukier (2013), UPS reduced their maintenance costs in the US by more than 20 percent by introducing predictive analytics in their fleet of cars.

2.2.3 Artificial intelligence (AI) and machine learning in manufacturing

Artificial intelligence and machine learning have a potential to support processes across the entire manufacturing value chain. Manufacturers could use machine learning-based solutions to detect a broad set of issues in their value chain – from bottlenecks to unprofitable production lines. By combining machine learning tools with the Internet-of-Things and Big Data, it is possible to get new insights in the realm of logistics, inventory, and supply chain management (OECD, 2017). These insights may uncover potential opportunities not just in the manufacturing process, but in the packaging and distribution as well. In production processes where the environment of production or raw materials is constantly changing, sensors and computer systems will identify patterns in the data. These data patterns could be analysed by machine learning algorithms which pinpoint the best performing production scenarios, and this knowledge can then be used to optimize processes (Weichert et al., 2019).

AI and machine learning are also well suited in the product development phase. The design and planning stage of new products, and the improvement of existing ones, are tied to a multitude of information which must be taken into consideration to yield optimal results. Several machine learning solutions can analyze gathered consumer data to understand demands, uncover hidden needs, and detect new business opportunities. Furthermore, AI could be used to automatically improve designs when limitations are removed (e.g. by using additive manufacturing instead of traditional machining if possible). More AI-applications will be integrated in CAD-platforms (computer-aided design) in the coming years, which provides a basis for faster and better design processes, as well as automation of repetitive and standardized tasks. Machine learning is especially good at reducing the risks associated with the development of new products, as the insights it provides constitutes a basis for better and more informed decisions in the planning phase (Wuest et al., 2016). Moreover, machine learning could be used for quality control, improving the final product quality considerably, especially in discrete manufacturing industries (Cioffi et al., 2020). By utilizing vision technology and machine learning, manufacturers can find anomalies in products and their packaging, and through a deep examination of the manufactured products they can stop defective products from reaching the market (Deloitte, 2020). Manufacturers could also use machine learning algorithms to carry out monitoring and predictive maintenance. By leveraging the data accumulated from sensors placed on machinery and other industrial equipment, machine learning algorithms are able to predict when failures to equipment are likely will occur (Ding et al., 2020). Relevant actions can then be taken, thereby optimizing periodic maintenance operations and avoiding or reducing downtimes, which in turn will reduce overall costs.

2.2.4 Cloud computing

Many industrial applications which are entering the market in the near future, such as autonomous machines/systems and complex simulations, will be computationally intensive (OECD, 2017). Thus, the demand for computing power and so-called supercomputers is likely to increase considerably. In parallel with increased demand for supercomputers, the supply of cloud-based solutions is anticipated to be broadened in the years towards 2030 (OECD, 2017). This is especially fortunate for small and medium-sized enterprises (SMEs) which often are having difficulties of finding affordable solutions in today's market (Buer et al., 2021). Cloud based solutions could be scaled both "up and down" and adjusted to the needs of the users. Cloud computing takes place though "software-as-a-service", "platform-as-a-service" and "infrastructure-as-a-service" and could be distributed via both public and private channels (Thames and Schaefer, 2017).

Cloud computing could help companies to overcome silo thinking and make their organisations more cohesive and automated by enabling data to be stored and accessed from a common repository in the "cloud" (Rüßmann et al., 2015). The data could be utilized by human workers, machines, and robots when necessary. The interoperability of the cloud-based solutions must improve to succeed with this vision. This could be managed through available "application programming interfaces" (APIs). Today, the lack of international standards, supplier lock-in (often due to proprietary solutions) and risks of security breaches, are preventing many firms from using cloud computing or other advanced ICTs (OECD, 2017). This is also making interoperability more difficult. Especially the security aspect is considered as a major problem among companies (e.g., issues related to privacy, theft of data and company-specific secrets). These challenges must be handled to succeed with cloud computing. Cybersecurity (see 3.2.7) as a research field and practical tool, will become even more important in an ever-increasing interconnected world (Thames and Schaefer, 2017).

2.2.5 The next era of industrial robotics

Traditionally, industrial robots have been implemented in predetermined and demarcated areas (cells). To put up a robot park could take several months or even years. Traditional robots usually had to be pre-programmed before being deployed. This could radically change over the next years with the advances in artificial intelligence that are making robots more flexible and autonomous, and thereby capable of handling a wider range of tasks (OECD, 2017). Recent developments in areas such as vision technology, smart sensors and actuators, wireless communications and AI have extended the capabilities and increased the productivity and flexibility of industrial robots (Dotoli et al., 2019). Additionally, more vendors and decreasing hardware costs are contributing to the increased diffusion of industrial robotic systems. For instance, recent developments have enabled auto-programming of robots directly from

CAD-models in order to reduce the extensive programming work, hence facilitating robots for low-volume and high-degree of variants of flexible manufacturing.

These trends are also reflected in the statistics regarding the number of industrial robots and the increasing robot density in the manufacturing industry (IFR, 2020). Especially China are expanding their base of industrial robots. Approximately 37% of the industrial robots installed in 2019 were installed in China, and their robot density almost tripled in the period from 2016 to 2019 (IFR, 2017, IFR, 2020). Figure 2 illustrates the global density of industrial robots as of 2019. The Norwegian manufacturing industry has a relatively low robot density, with the latest estimate being only 51 robots per 10 000 employees in 2016 (IFR, 2017). This is below both the world average and is especially low compared to the other Scandinavian countries. The phenomenon has previously been explained by the composition of the manufacturing industry in Norway. The manufacturing landscape in Norway is being dominated by industries related to oil and gas exploitation. Globally, these industries are rather small, niche industries. These industries are typically not in focus when global vendors of automation technologies develop new standardized solutions. This means that it might be more time-consuming and expensive for major parts of Norway's manufacturing industry to apply the available standard solutions (Iris Group, 2015).

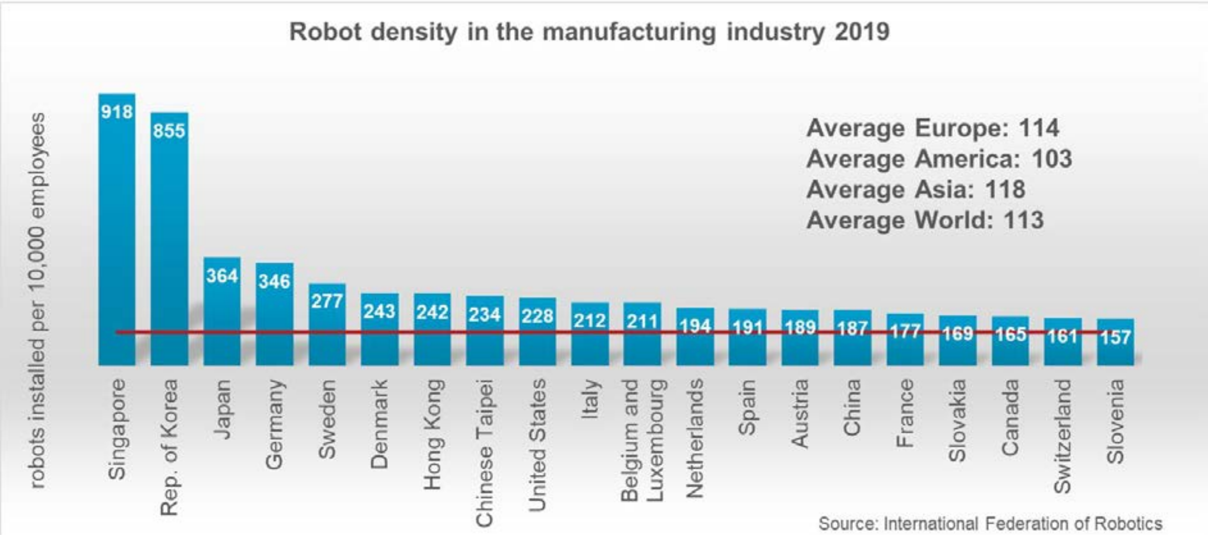

Figure 3: The global robot density in the manufacturing industry 2019 (IFR, 2020).

Modern collaborative robots (co-bots) can operate together with human workers, creating a closer interaction between man and machine. This enables robots throughout the manufacturing shop floor, not necessarily only in dedicated robot cells, as co-bots do not pose a danger to their human colleagues (Evjemo et al., 2020). We have already seen examples of co-bots being introduced in manufacturing, and researchers are anticipating that the prevalence will increase considerably over the next decades.

The price of co-bots (and industrial robots in general) is expected to fall, making them affordable to small- and medium-sized actors in manufacturing with less financial means (McAfee and Brynjolfsson, 2017).

2.2.6 Additive manufacturing

The field of additive manufacturing (AM) is rapidly expanding due to factors such as better quality of printed objects, ease of customization, more sophisticated printing techniques, (re)design and creation of end-use products with improved functionality and more (OECD, 2017). While AM in general is more expensive than conventional manufacturing, especially as the production volume increases, it can be cost-effective by adding value to the product that otherwise is impossible from conventional manufacturing processes (Wohlers Associates, 2021). As illustrated by EY (2019) in Figure 4, AM can deliver three levels of benefit. At level 1, AM could be used to improve efficiency in existing operations and supply chains, for instance through better prototypes, molds and parts, or used for small lot production. At this level, products are not redesigned. At level 2, AM is enabling the (re)design and creation of end-use products with new or improved functionality. Or even completely new products that previously could not be made. At level 3, AM can enable a transformation where companies can change their business models, reposition themselves in the value chain or even become an AM vendor, and thereby contribute to competitive advantages.

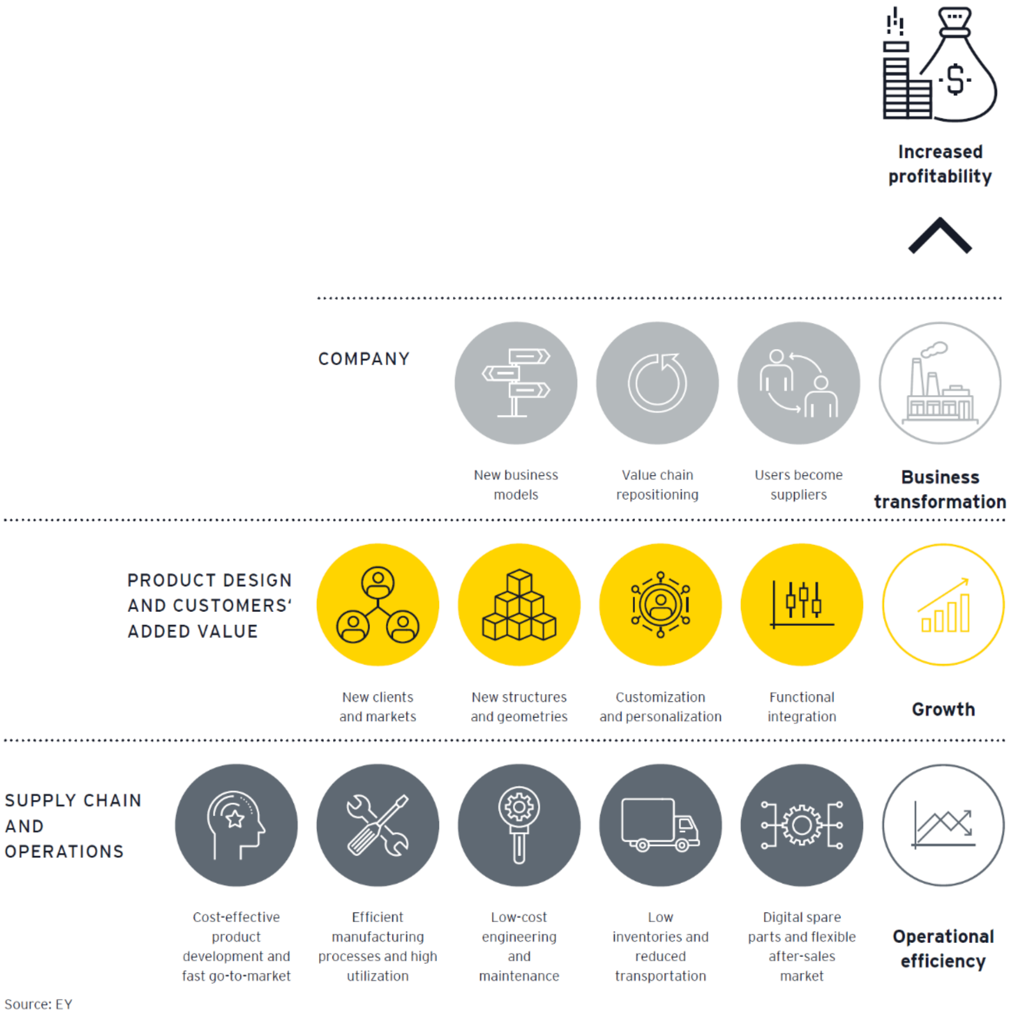

Figure 4: How AM can give business a competitive edge (EY, 2019)

Today, new AM applications have facilitated a shift from prototyping to functional part manufacturing in various industries such as automotive, aerospace, medical and consumer goods (EY, 2019). Moreover, recent innovations make it easier to print with materials such as glass and metals, as well as printing of multistructure multi-material objects (OECD, 2017). Productivity could be augmented through AM. For instance, the steps of production processes could be reduced by the additive manufacturing of already-assembled mechanisms/components, and design processes can potentially be shortened due to rapid prototyping (Gibson et al., 2014). These improvements clearly state the potential of AM, which in turn lead to big expectations. An example of a promising area for the use of AM is related to the production of spare parts of discontinued products. Manufactures might be obligated to supply spare parts for discontinued products for several years after the production was terminated. Because of that, manufacturers typically decide to keep this production line or manufacture a large number of items to keep in stock. Both alternatives typically require a large area and have significant related costs. By using AM for spare parts production, manufactures can quickly deliver spare parts whenever there is a need for it, without the need to carry excessive stock. Studies also show that AM is increasingly being used for spare part production. A recent survey by EY (2019) shows that 14% of the surveyed companies use AM for spare part production, almost double than in their 2016 survey.

There are also examples where customers have a small printer on-site to print parts locally when needed, which simplifies logistics even further, and payment could be linked to using the data model of the part. This could for instance be a viable solution for humanitarian and military missions in peripheral areas (Boer et al., 2020). Wohlers Associates (2021) conducted a survey to map how organizations are using industrial AM systems for a range of applications. The results show that end-use parts (31.5%) and functional prototypes (25.2%) make up 56.7% of the total produced volume. The remaining percentages are made up by education/research applications, cosmetic models, jigs/fixtures, polymer patterns/molds, metal tooling and other applications. According to market analysts, the global AM market is projected to reach 24.8 billion USD in 2024 (Markets and Markets, 2020). However, according to Wohlers Associates (2021), the Covid-19 pandemic has resulted in a considerable slowdown of the AM industry, with only 7.5% growth in 2020, compared to 33.5% in 2018 and 21.2% in 2019.

2.2.7 Cybersecurity

Cybersecurity is the sum of measures implemented to defend against malicious computer attacks (attacks on hardware, software, and data). Information security is a sub-branch of cybersecurity, and aims to maintain confidentiality, integrity, and accessibility of the stored information. As more data is generated, and companies store an increasing amount of data in the cloud, the risk of being exposed to data theft and hacker attacks increases (OECD, 2017). To mitigate this risk, security systems and procedures should be in place to reduce the likelihood of attacks. There are numerous technical options, strategies, procedures, and policies that can improve cybersecurity. However, a problematic issue regarding cybersecurity is the evolving nature of security risks. New technologies and novel application areas enable new avenues of attack. Handling these continual technological changes and more advanced attacks, can be challenging to organizations. Increasing cybersecurity threats are introducing another uncertainty dimension and could result in increased government regulation, which could in turn slow the pace of the 4th Industrial Revolution (PWC, 2020). According to PWCs survey of CEOs within industrial manufacturing, 69% of the respondents reported that the increasing complexity of cyber threats are having the greatest impact in shaping their cybersecurity strategy, while 55% said that cybersecurity and data privacy regulations were having the greatest impact (ibid.). Especially SMEs can find this challenging due to lack of resources dedicated to cybersecurity (Cisco, 2018).

2.2.8 The confluence of technologies – A new production revolution?

This section has introduced several technologies or technology domains that are expected to have a significant impact on the manufacturing industry in the years to come. Each of these technologies will have several application areas in manufacturing, and several technologies will be used concurrently for the same application area. Together, the increased diffusion of these technologies is expected to cause disruptive changes to the manufacturing industry. The implementation and integration of several of these emerging technologies are anticipated to enable the so-called "smart factory". According to Kagermann et al. (2013) smart factories will be characterized by "end-to-end engineering that encompasses both the manufacturing process and the manufactured product, achieving seamless convergence of the digital and physical worlds".

Figure 3 illustrates the classification between *core technologies* and *system technologies*. The core technologies are essential to achieve many of the prophesied benefits of digitalization. However, isolated, the technologies classified as core technologies have limited use in manufacturing. They are most useful when they are implemented into a larger system, what we typically refer to as system technologies. Technologies classified as system technologies are on a "higher" level, and typically make use of several of the core technologies to create a system. Together, when implemented in a manufacturing setting, both groups of technologies can enable numerous operational benefits to manufacturing companies. Moreover, these operational benefits will lead to several benefits also on a business level, creating a possible competitive advantage in the market.

Figure 3 shows how the convergence of technologies leads to unprecedented opportunities for the manufacturing industry. While several of the technologies and technology domains in isolation have great potential, the true benefits will become evident when they are integrated in a well-functioning system. Manufacturers should not focus solely on individual technologies, but rather have a holistic strategy considering the interdependencies between technologies which are enabling Industry 4.0.

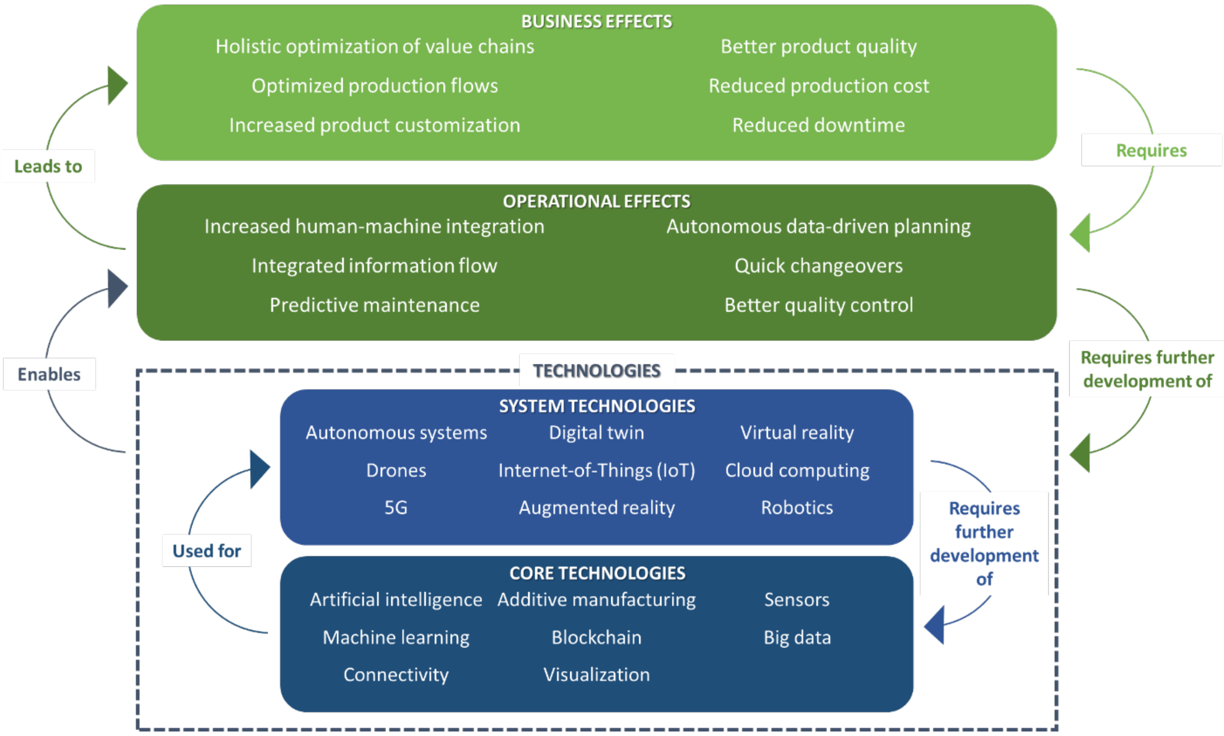

Figure 5: The relationships between core technologies, system technologies, operational effects and business effects, adapted from Digital21 (2018).

2.3 Social trends

"*Automation and artificial intelligence (AI) are changing the nature of work*" (Bughin et al., 2018). To succeed with technological trends and opportunities, humans need to play an important part. Most technological trends need some human interventions to generate efficient output. There is a symbiotic relation between man and machine, and innovation can be divided into both technological and social innovation. Efficiency is often based on a smooth combination within the area of human and machine interface (HMI). Since our fast-moving society is constantly changing, flexible and adaptive solutions have become most important to succeed. Manufacturing industry faces a vast variety of different technological trends, and many important choices must be made in the years to come. When making one option, you often disregard another. Altogether, the output will decide how competitive your business turns out to be.

2.3.1 Knowledge, skills, and lifelong learning

New knowledge and skills are needed.

For manufacturing industry, automation has been a driving force for years (Bughin et al., 2018), and this trend will continue to be an important part of how we choose to organize our Norwegian production in the future. In addition, digitalisation is changing the jobs in the industry which leads to the need of new knowledge and skills. Thus, it becomes important to understand what type of knowledge and skills is needed to be able to develop new technologies such as artificial intelligence, machine learning, Big Data, IoT, 3-D printing, and cloud computing. Another increasing trend is within sustainability and the notion of creating value while reducing the negative environmental impact and the transition to circular economy. This is a particularly complex endeavour for firms of all sizes, and it requires different knowledge, skills, and learning methods than what is prominent today.

Employees of all ages need to develop their skills throughout their working career in order to gain advantage of new technology. The future demand for skills will divide into more significant categories in terms of level and direction. According to Bughin et al. (2018) skill trends will develop like:

- Basic cognitive skill will be less required as AI and automation will take over many processes in manufacturing industry
- Physical and manual operations will drop
- Basic digital skills required for technicians and others
- Advanced technological skills, and in particular higher technological skills like programming, will be more in demand
- Advanced data analysis and mathematical skills
- Higher cognitive skills such as creativity, critical thinking and decision making, applying quantitative and statistical methods, processing and interpretations, and project management
- An increased need for social and emotional skills, like interpersonal skills and empathy, adaptability and continuous learning, communication, and leadership, even though the content of these tasks has changed; for instance, leaders need knowledge of how to guide AI and automation processes.

Bughin et al. (2018) also claims that skill shifts will play out differently across different sectors. According to a study performed by OECD ("Which skills for the digital era 2018") indicates that skills that are especially rewarded in the digital intensive industries are workers having relatively high levels of self-organization and advanced numeracy skills.

Knowledge and skills within sustainable manufacturing imply a thorough understanding of the FN's sustainable development goals and the circular economy principles, as well as how to apply them. The maturity levels include: (1) the knowledge of what the goals and principles are, (2) the ability to model and measure the effects of the implementation of the goals and principles, and (3) the ability to effectively address the dilemmas that arise. At level 1, one would have a thorough understanding of what the UN's 17 sustainable development goals and the circular economy principles are, and what they mean in practice. At level 2, one would be able to apply (digital) modelling and measurement tools for integrated information about the material composition of products across their entire value chain, better utilization of side streams and by-products, etc. At level 3, one would be able to effectively address the dilemmas that arise when implementing the 17 sustainability goals to simultaneously safeguard the people, planet and the business profit.

Access of high-skilled workforce

It is obvious that organisations need to mobilize and develop their potential competence in order to cope with new tasks and responsibilities (Lai, 2013). In a future situation, shortage of specific competence stands out like a potential and most undesirable scenario. "*Competition for high-skill workers will increase, while displacement will be concentrated mainly on low-skill workers, continuing a trend that has exacerbated income inequality and reduced middle-wage jobs*" (Bughin et al., 2018). This statement shows us that there are different challenges hidden in the wake of digitalization. As we evolve our industry with ever more sophisticated solutions, shortage of competence will influence our ability to perform well. Companies in forefront of AI and automation will attract high skilled and competent workers. Competition for the best competence will be even tougher in the future. This will make the situation even more difficult for small and medium-sized businesses competing in an open market.

In Deloitte's poll at the end of 2020, 28% of the surveyed executives identified that upskilling the employees and learning how to manage hybrid work environments (a combination of increased automation, digitalisation, and remote work) are the top challenge they are facing today in managing work and workforce. 61% of surveyed executives were planning to develop a hybrid model for their production and nonproduction processes over the next three years. Most of manufacturing executives seemed unlikely to return to the pre-pandemic work arrangements. Furthermore, as during the COVID pandemic, many manufacturers have accelerated their adoption of robots, cobots, other forms of automation, and of more advanced digital technologies for supply network management, the need for an appropriate workforce to manage and interact with these technologies also increased. Thus, even “middle-skill” roles require technical expertise and regular upskilling. To this end, companies can develop a *talent ecosystem* - a network of external partners that can help with supplying workforce with the required skills. Examples include a manufacturer partnering with a technical school to provide training that is specific to a certain company (e.g., programming, operating, or maintaining robots) and results in a job offer upon successful completion (a train-to-hire program), whether that is programming, operating, or maintaining the robots and digitally enabled machinery they will be standing alongside in the production lines. The Deloitte study reveals that more than 80% of surveyed manufacturers believe talent ecosystems are critical to their competitiveness, and 41% have already started forming new relationships to develop robust talent ecosystems (Deloitte, 2020).

Good news for the smaller companies is that many people do not just think about salaries and tasks when choosing an employer. They increasingly focus on ethics, values and sustainability when making their choices. This opens an opportunity for companies with less resources. The increased focus on sustainability in manufacturing has resulted in a need for access to a workforce with education within sustainability. More specifically for the workforce, learn how to live more sustainable on this planet and to be able to make decisions and at the same time understand how those decision affects future generations and the life of others.

Operator 4.0

Whereas earlier visions of the future of manufacturing tended to focus on so-called "lights out" factories, running autonomously without any human workers present, the Industry 4.0 vision and the belonging literature tend to emphasize the importance of humans in manufacturing (Schneider, 2018). Improved human-machine interaction based on a new generation of flexible co-bots and sophisticated CPS-based assistance systems is anticipated to be a vital part of the transition towards Industry 4.0 (Kagermann et al., 2013). Moreover, human operators are very flexible and continuously improve and innovate, whereas machines traditionally are less flexible and tend to become obsolete after some time. However, following a transition towards the Industry 4.0 vision, the increased levels of automation and digitalization will change the manufacturing landscape and make machines more flexible. Many researchers and industry experts think these trends will lead to a decrease in standardized low-skill work, while the demand of high-skilled jobs in manufacturing will increase (Kagermann et al., 2013, Bonekamp and Sure, 2015). This means that organizations should focus on continuous training (lifelong learning) and education of the workforce to adapt to the qualification requirements resulting from Industry 4.0 and digitalization.

Emerging technologies have numerous opportunities to support operators both in training and in their daily operations. To illustrate how operators can utilize emerging technologies, the concept "Operator 4.0" has been proposed. Operator 4.0 refers to an operator who not only performs cooperative work with robots and machines, but who also are aided by machines and digital tools when needed (Romero et al., 2016). Through their novel work on this topic, Romero et al. (2016) proposed an Operator 4.0 typology which consists of 8 different types of augmentations of the original human capabilities. The different types are *super-strength operator, augmented operator, virtual operator, healthy operator, smarter operator, collaborative operator, social operator* and *analytical operator.* Romero et al. (2016) present an extended description of each of these.

The Operator 4.0 concept actualises the fact that in addition to the apparent need for workers with higher education background, there is also an explicit need for vocationally trained skilled workers in future manufacturing. In order to implement advanced manufacturing technologies and pursue incremental process innovations, manufacturers rely on skilled workers with a practical (tacit) knowledge base. Furthermore, manufacturers should engage in collaborations with vocational knowledge institutions related to upgrading of vocational education programmes if they are to succeed (Lund and Karlsen, 2019).

Research from Norwegian manufacturing indicate that there is a gap between vision and reality in terms of the anticipated digitalization and introduction of "Industry 4.0-technologies" on the shop floor. While most operators use computers and some ICT-devices, there is currently limited use of mobile solutions such as VR (virtual reality), AR (augmented reality), smart glasses, voice-based systems and interfaces which are supported by AI and machine learning (Torvatn et al., 2019). If the vision of Operator 4.0 is to be achieved, there is a need for a rethinking and upgrading of human-machine interaction. Human operators must be part of the cyber-physical system, and a crucial step to achieve this is by introducing more digital tools and well-functioning assistance systems at the shop floor.

Lifelong learning and reskilling

Lifelong learning and reskilling stand out as a key element to cope with continuous change and more advanced technology. Companies need to shift their engineering workforce to include people with more technological expertise, for example, within software and IoT, versus mechanical and electrical engineers without such skills.

Learning throughout your entire working life has become important in order to cope with new and advanced technologies. Learning can be described in numerous ways covering different areas in life. "*Political trends include a focus on lifelong and adult learning and the need for industry to transform in order to stay competitive"* (Sjödin et al., 2019).

The World Economic Forum estimates that, by 2022, 54% of employees are going to need significant training, with 35% needing to dedicate at least six months to developing new skills (WEF, 2018). 77% of the 22,000 workers surveyed by PwC are saying they are willing to o spend up to two days a month on training to upgrade their digital skills, while 53% of the workers report that they believe automation will significantly change or make their job obsolete within the next decade and (PWC, 2020). As technology evolves quickly, employers will need to find ways to swiftly integrate skills development into the jobs of their employees.

2.3.2 Increasing middle class

According to the European Commission, the rapidly declining levels of poverty in recent decades and the increase in average incomes led to an increasing middle class at global level. "The size of the 'global middle class' will increase from 1.8 billion in 2009 to 3.2 billion by 2020 and 4.9 billion by 2030. Most of this growth will come from Asia and sub-Saharan Africa" (ManuFUTURE, 2019). Thus, manufacturers who offshore production to traditional low-cost countries do so due to the size and rapid growth of these countries' customer markets, rather than due to the low production costs (Heikkilä et al., 2017, De Backer et al., 2016).

2.4 Economic trends

2.4.1 Reshoring and nearshoring

Although outsourcing and offshoring of manufacturing activities from high cost to low-cost countries continues to be the dominant trend in the organization of global manufacturing, there are some evidence of manufacturing moving in the other direction. Manufacturing reshoring, meaning the relocation of manufacturing activities from host locations to home locations, has in recent years received increased attention among policy makers and scholars. In relation to technological upgrading in the manufacturing industry, reshoring is now regarded as a potential outcome of upgrading processes. In a recent publication Lund and Steen (2020) identified advanced manufacturing technologies as one of the key drivers for manufacturing reshoring to Norway. However, these new and improved technological capacities only resulted in reshoring when coupled with key regional knowledge bases and human resources.

Furthermore, recent disruptions caused by the COVID 19 pandemic have further increased the interest in regionalization. A recent study shows that 33% of the supply chain leaders participating in the study have either moved some of their operations out of China or plan to move some out in the next two to three years (Gartner, 2020). However, along with reshoring and nearshoring, manufacturers are exploring other Asian markets like Taiwan, Japan, and India, due to the availability of skilled workforce and a growing customer base. Nevertheless, rising wages in developing economies is narrowing the profit margins of manufacturers who are relocating production to Asia mainly based on cost. Thus, more and more manufacturers are exploring how to expand their production closer to domestic markets. In Delloitte's poll from last December, 31% of USA executives mentioned that they will nearshore some part of their production back to the Americas in the next year (Deloitte, 2020). Potential constraints to nearshoring include securing the talent that is necessary to sustain production, as well as necessary infrastructure investments for smart manufacturing (ibid.). Moreover, 44% of USA executives plan shift towards a to a supply chain model with a higher number of local suppliers in 2021 (ibid.)

2.4.2 Protectionism and nationalism

After a period of extensive globalization, some countries are currently experiencing reverse forces like protectionism, nationalism, and trade disputes (ManuFUTURE, 2019). While new technologies enable companies to bring back production from low-cost countries, recent developments in international politics may also have the opposite effect. For instance, in the USA, a tariff on steel (25%) and aluminum (10%) may drive companies to manufacture or purchase certain goods abroad. Currently, the domestic demand for steel and aluminum exceeds the available supply. Because of the tariff, companies that manufacture goods in USA using imported steel may no longer be able to afford to do so. They may choose to import finished products from foreign manufacturers to remain price competitive. In a similar vein, in Europe, UK's decision to exit the EU could result in a loss of skilled labor that was previously filled by immigrants from other EU countries (Microsoft Dynamics 365, 2019). These protectionist and nationalist tendencies have, e.g., in the US following the 2016 Trump campaign and election, also resulted in increased political attention towards the reshoring of manufacturing. How a change in administration, following the election of Joe Biden as President in the 2020 US elections, will affect these trends remains to be seen.

2.4.3 Smart products

The concept of "smart products" is getting more and more attention from researchers and practitioners alike. Although the exact definition of a smart product is differing between sources, there is a common consensus that smart products are equipped with some form of IT. This can range from simple hardware used to present digitized information, to products with sensors and actuators capable of operating autonomously and which are self-optimizing (Raff et al., 2020).

Smart products bring along new opportunities both for the manufacturer and the customer. For the manufacturer, smart products may enable new business models, for instance moving from a pure product-based strategy to a service-based business model. Moreover, products equipped with sensors might also provide benefits throughout the supply chain, for instance by tracking the product through its life cycle. For the customer, smart products typically provide new and/or improved functionalities compared to traditional products, increasing its use value.

As smart products are enabling new service-based business models, this could also improve the sustainability of a business' operations. Companies utilizing traditional product-based business models would benefit from customers purchasing new products often. As such, designing for planned obsolescence could be a seen as an enabler of frequent rebuys. On the other hand, for service-based business models where the customer is "renting" the product, manufacturers would rather benefit from designing and manufacturing products with longevity in mind, as product breakdowns leads to costs for the manufacturer rather than the customer.

2.4.4 Customised products

A trend that we are becoming more and more aware of is a growing demand for customized/personalized and artisan goods, combined with a demand for shorter and shorter delivery times. For instance, when the elderly live longer and healthier lives at their own homes, the demand for products tailored to their special needs is increased (ManuFUTURE, 2019).

2.4.5 Maker economy

The creation of goods by people without the aid of professionals is becoming more common, and the *Do It Yourself* culture is spreading also in high-income countries. Thus, some companies are changing their business models by offering tools and services to users who want to create their own products instead of purchasing them (ManuFUTURE, 2019).

2.4.6 Online consignment stores

In recent times, internet platforms providing individuals the possibility to sell used goods have been flourishing. The platform users can sell online a wide range of used goods, including furniture, clothes, books, toys, and luxury fashion accessories (Microsoft Dynamics 365, 2019). Like the sharing economy (described in Subchapter 4.2.4), online consignment stores pose a unique threat to manufacturers, but also a unique opportunity for those willing to try different business models (ibid.). In Norway, a well-known website that provides a sale platform for used goods is FINN.no - established in March 2000.

2.4.7 Direct-to-customer (D2C)

To obtain larger profit margins and provide more personalized goods and services, some manufacturers reject the traditional retail channels, delivering products directly to the consumer. By cutting out the middleman, these manufacturers can collect more accurate data about their customers, thus building longer term relationships to them. Subscription box services have become very popular along the years. Thus, to succeed and remain competitive the providers of subscription services must be able to surprise and satisfy their customers time and time again. For instance, to compete with other men's grooming companies providing subscription and online services, Gillette launched its own shaving subscription club, Gillette On Demand. The new service allows customers to conveniently order refills via SMS (Microsoft Dynamics 365, 2019).

Furthermore, the COVID 19 pandemic unavoidably led to less face-to-face customer contact, and thereby to an increase in e-commerce channels. A recent survey shows that approximately 20% of manufacturers in the survey had their own e-commerce, direct channels. However, typically manufacturers are not moving to purely direct selling models, and rather use a mix of direct and indirect selling channels (Alexander Group, 2020).

2.4.8 Smart production close to the customer

Different types of local manufacturing that is close to the customer ("make where we sell") are becoming more common also in Europe (ManuFUTURE, 2019). PWC's Global Innovation 1000 study has found that companies that develop more products in labs in the countries in which they compete grow faster, because they are better aligned with unique local needs and the time-to-market is shorter (PWC, 2020). However, the production technology is advanced (e.g. AM technology, robots) and the R&D is increasingly global. Micro factories with capital-intensive equipment are increasingly becoming part of global networks of production service providers that are platform-based. Examples of mature platform-based manufacturing networks include 3D Hubs. The platform offers 3D printing, injection molding, CNC machining and sheet metal fabrication, and operates a network hundreds of manufacturing partners that are distributed throughout Europe, Asia, and USA. A platform-based Manufacturing as a Service network may be a singularly managed network of manufacturing equipment, or a network of self-managed manufacturers (Microsoft Dynamics 365, 2019). In the former case, a customer can send an order for a part, including appropriate design files and specs, and based on workload, materials, workforce availability, location, and scale, the network will route the order to the most appropriate facility(es) (e.g., 3DHubs). With manufacturer networks, customers can individually search for and submit projects to manufacturing members using a standardized set of files (e.g., Dassault Systemes's 3DExperience Marketplace). The manufacturers will then review the designs and the materials needed

- and provide quotes to potential customers (ibid.). The growth of micro-manufacturing has been driven by cheaper AM technology and robots, and the growing demand for faster and personalized/artisan goods. On-demand micro-manufacturing is not only attractive to customers; it minimizes the factories' inventory and production waste (Microsoft Dynamics 365, 2019).

2.4.9 Digital global networks

In the next decades, companies belonging to global manufacturing networks such as car producers and their parts and equipment manufacturers will be managing increasingly complex networks. Often their suppliers will have highly automated factories and will be located close to the customer markets. Moreover, the customers are expected to demand shorter and shorter delivery times combined with high flexibility to changes in demand and affordable prices. Companies that will manage such complex networks are expected to be increasingly reliant on enabling digital technologies, standardisation at the highest technological level, globally harmonised regulation, and governance, as well as on zero failure and resource efficiency approaches. For instance, they will be reliant on architectures that smoothly integrate the physical and digital worlds in real-time (digital twin, factory as a product, etc.) - all the way from the factory to the network level. (ManuFUTURE, 2019). These technologies should enable an extremely effective monitoring and coordination within the networks and increasingly better customer responsiveness (ManuFUTURE, 2019).

Until the COVID-19 struck, some manufacturers may have known little about their suppliers below Tier 1. But after they saw factories abruptly closing, many companies engaged in assessing the vulnerabilities of their suppliers further down the chain, and several considered diversifying their supply sources and relying more on suppliers that are close by. KPMG's survey of chief executives shows that the greatest threat to manufacturers' growth over the next 3 years, apart from the pandemic, is risk to the supply chain (KPMG, 2020). However companies will continue to pay close attention to the cost of inputs, so they will still rely on cost-competitive suppliers, both local and global.

Digital supply network solutions that enable a real-time understanding of activities across a complex supply network are regarded to be effective in coping with both increased network complexity and supply/ demand risk. Digital supply network solutions break down the silos of data and add connection points across the network that can detect and promptly respond to sudden supply or demand change and optimize operations accordingly (Deloitte, 2020). Through increased network visibility, manufacturers will be able to assess their supplier network more easily and develop an inventory strategy based on real-time or recent data and insights rather than on history and hunches. For example, for manufacturers experiencing a surge in demand these solutions should ensure visibility particularly across their supply network as they ramp up production, since the lack of a single part could derail an entire assembly-line production flow. In contrast, manufacturers that are experiencing a slowdown in demand may need an increase visibility into operations to streamline them and reduce cost (ibid.). Finally, technologies such as blockchain and data analytics can be used to further enhance not only the visibility but also accountability in supply networks, both in terms of quality and sustainability (ManuFUTURE, 2019).

3 Discussion and final remarks

In the above sections, we have presented the different trends that we believe will influence Norwegian manufacturers in the coming 10 years separately, sorted under the headings *environmental, technological*, *social,* and *economic*. This way of portraying the trends is useful in terms of providing a broad and easily accessible overview of the identified trends. At the same time, it is oversimplistic. Therefore, it is important to underline the interconnectivity between many of the described trends. In this section, some of the connections between the already presented trends will be discussed, before we provide some insights on how the ongoing COVID-19 pandemic is influencing, or is predicted to influence, some of the trends in manufacturing.

3.1 Interconnected trends

The interconnectivity between the different trends is nicely demonstrated through the application of the circular economy concept, which has gained prominence within the manufacturing community in terms of how to sustainably transition the industry. The transition away from the linear economy warrants increased knowledge on material flows. As such, traceability becomes essential. To trace the materials (products) through the value chain and reclaim them at the end-of-life, manufacturers rely on technology. By taking advantage of emerging technologies, such as **blockchain technology**, manufacturers can ensure traceability throughout their value chains, enabling the creation of sustainable business models where the origins and quality of the materials recycled can be guaranteed. Information about the origins and properties of the materials can enable manufacturing of high quality, high value products of recycled materials.

Cyber-physical system (CPS) is an additional concept that demonstrates the interconnectivity between the different trends within manufacturing. In a manufacturing setting, a CPS can be defined as a production line where computational, networking, and physical processes are integrated. This integration enables the creation of a digital twin, where the physical asset has a digital replicate, which is updated in real-time throughout the manufacturing process. This allows for monitoring of the entire manufacturing process. In order to achieve this integration, the CPS relies on (Industry 4.0) technologies such as the Internet of Things (IoT), Big Data analytics and cloud computing (Schwab, 2016, Gilchrist, 2016), which enables information feedback from sensors in the production processes, and the product itself, to the back-end cybersystem. Expected functionalities of CPS in manufacturing systems include machine connectivity and data acquisition, machine health prognostics, fleet-based asset management, and manufacturing reconfigurability (Lee et al., 2015). Although CPS and digital twins are not widespread within the Norwegian manufacturing industry, ongoing technological developments towards such a scenario are currently challenging the knowledge and competence of those working in manufacturing. In this regard, the technological trends and knowledge and educational/reskilling trends are closely connected, as implementation of novel technologies in Norwegian manufacturing rely on changes in existing educational programmes, and perhaps also novel ways of organizing vocational education (Lund and Karlsen, 2020).

3.2 The influence of COVID-19 on current trends

COVID-19 has impacted the global economy and manufacturing industry greatly and will most likely continue to do so for an extended period. Here, we discuss how some of the trends are influenced by the effects of COVID-19.

Digitalization, automation and the implementation of robotics in the manufacturing industry are expected to rise following the pandemic. Bloom and Prettner (2020) argue that replacing labour with technology will reduce the risk of production issues as technology is not susceptible to diseases, while labour is. Additionally, reshoring is predicted to rise as the vulnerability of global supply chains have been demonstrated during the pandemic (Bryson and Vanchan, 2020). Implementation of more advanced, and more autonomous manufacturing technologies has been seen as a prerequisite for successful relocation of manufacturing from low- to high-cost countries (Bloom and Prettner, 2020, Lund and Steen, 2020).

Following the outbreak of the COVID-19 pandemic, **the reshoring phenomenon** has gained increased relevance. There are several examples of reshoring of manufacturing to Europe that have been triggered by the ongoing pandemic. The relocation of production of glass thermometers from China to France and biodegradable facemasks from China to Italy, are only two illustrative examples (Barbieri et al., 2020). Manufacturing reshoring has been proposed as a strategy to reduce the risk of supply chain disruptions, particularly in critical industries such as pharmaceutical and medical protection equipment, but also in manufacturing industries where supply chain disruption have shown to have great impact on national economies (Barbieri et al., 2020). Some argue that the disruptions that followed the initial closures of factories in China have made companies reconsider their inherent just-in-time production, where supplies are delivered on time and manufacturers have very small stockpiles of products readily available. Now, companies are leaning more towards the “old” just-in-case production logic, where larger stockpiles of components are kept in warehouses at the production site, just in case there are disruptions in the supply chain (Brakman et al., 2020). In a broader sense, reshoring can be regarded as one expression of wider reconfigurations of global value chains and production networks. Although the pandemic has made these reconfigurations more relevant due to disruptions in the value chain, they also build on reconfigurations that have been underway also before the pandemic hit.

In the first months of the pandemic, we also saw an **increase in protectionist measures** put into place by national governments. In the United States, Donald Trump stopped 3M from selling face masks to Canada and Latin American countries and forced the company to produce more respirators. To do so, the president leveraged the Defense Production Act, a legislation stemming from the Korean War (1952-54) (Vasquez, 2020). Similar examples can be found in Europe and Asia, where France, Germany, Poland, South Korea and Taiwan banned domestic companies from exporting medical supplies (Busch, 2020).

3.3 Final remarks

In this report we have provided an overview of some of the ongoing trends that influence Norwegian manufacturers. We have not provided an exhaustive list of trends, for more detail on other trends and more in-depth knowledge, we urge the reader to look further into the references provided. However, we have made a conscious and thorough selection among those we believe are of greatest interest and have the strongest influence on the Norwegian manufacturing industry now and in the years to come. The intention has been to bring attention to the trends themselves, and the potential future challenges and opportunities they represent. As such, we believe that the white paper can act as a reference point for Norwegian manufacturers and provide them with a stronger foundation on which choice and strategies for the future can be made.

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[i] Extended producer responsibility (EPR) is a policy approach where manufacturers are given increased responsibility for the treatment or disposal of post-consumer products (OECD, 2020). Retrieved from: https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm