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THE 4IR: KEY-ISSUES IN THE POST-PANDEMIC ERA

Working Paper

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FORCE Project[1]

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[1] https://enaforce.eu/

Executive summary

In this paper we address the main challenges of the so-called 4th Industrial Revolution (4IR). These challenges are related to a multitude of areas such as the future of work, the mitigation of the climate crisis, the impact on standards of living and the security of personal data. Towards this end, the policies proposed and implemented by European institutions and organizations, as well as the corresponding approaches of the EU Member States, are presented.

Today, the rapid progress in the fields of artificial intelligence, robotics and digitization has led to the potential extensive and interactive automation of production in "smart" factories. In the public debate, the 4IR is related mainly to the technologies of digitization and artificial intelligence. However, they also include innovative approaches in other related scientific fields, such as genomic analysis and personalized medicine, renewable energy, and quantum computing. It is precisely the fusion of the above mentioned technologies and the strong interconnection of fields, such as nanotechnology, 3D printing, advanced materials, photonics, genetics and biotechnology that contribute to the 4IR.

These rapid technological developments introduce new approaches to the global division of labour and the mechanisms leading to the accumulation of capital. Besides the private sector involvement in the public debate, the profound structural transformations that 4IR will undoubtedly bring about require the citizens' participation in any relevant discussion. Promoting the public interest should be a priority.

In particular, within the 4IR framework, there are critical issues regarding education, the process of knowledge production and dissemination and the regulatory role of the State. Besides, concerns are expressed related to the probable devaluation of work and the emergence of new forms of social exclusion. To date, most of the international literature is claiming that regulatory interventions in the current business model and workforce specialization will guarantee both the productivity growth and social well-being. In addition, the new international landscape that is taking shape internationally following the outbreak of the Covid-19 pandemic is expected to result in a deep and probably uneven economic recession leading to wider structural changes enhanced by the acceleration of the adoption of new 4IR-related technologies.

Therefore, the relevant approaches, both at European and Member State level, should be accordingly revised:

- How will be integrated the novel way of working and living imposed by the pandemic with the aim of increasing productivity via the incorporation of 4IR technologies in production processes?

- How many and which jobs are threatened by the 4IR? Fewer purely manual tasks will definitely be available for low-skilled workers. But what are the expected consequences in terms of performance control, responsibilities and the psychological pressure that employees will face in the new, highly stressful, work environment of the 4IR?
- New business models need to be developed and implemented. What is the cost of converting production methods and who will bear the cost of possible failed initiatives? New types of relationships will need to be built between companies (suppliers, competitors, etc.) in a virtual environment, which requires unprecedented levels of "openness" and transparency on their part. The security and protection of know-how in the global competitive environment is also a critical parameter. Will governments and businesses be willing to invest if the innovative approaches that are expected to emerge can easily be replicated by countries or companies that have not invested in research and development (including developing and emerging economies)?
- Centralization or decentralization: The question remains whether the adoption of the 4IR in the EU will lead to the concentration of new industrial structures in specific regions of Europe or if it will lead, on the contrary to a balanced localization of facilities including in countries and areas with reduced industrial activity. Similarly, as far as it concerns the critical challenge of meeting the large energy requirements for the operation of the new industry model in EU: will the European (mainly south) regions with reduced industrial activity be just limited in the role of the renewable energy resources?

1. From the 1st to the 3rd Industrial Revolution

The 1st Industrial Revolution (1IR) was characterized by the industrialization of production through steam power in the late 18th century. The 1IR increased wealth in the western world, ended agricultural domination and sparked major social change: daily work environment changed drastically and the West became urbanized while radical philosophical and economic ideas succeeded traditional schools of western culture thought. Historically, the 1IR has contributed to the largest economic growth productivity from the Neolithic Age and the discovery of agriculture.[1] The new class that emerged (bourgeoisie) had various social references: it consisted of merchants who invested their growing profits in factories, inventors and skilled craftsmen who developed new technologies and people who, experiencing a rapid social evolution, became role models of the new era.

At the same time, a series of reforms and social struggles were needed to reduce the miserable economic and social conditions of the early industrial age.[2] The first reactions took place in England (1811 - 1813) by groups of weavers, known as the "Luddites"[3], who opposed the use of machinery in production, which would lead to job losses. However, the rise of both productivity and employment improved the position and prospects of the working class, paving the way for the emergence of utilitarianism and socialism theories.

Utilitarianism is based on the assumption that all social, political and economic models must strive to create the greatest possible benefit for the greatest possible number of people.[4] If applied correctly, the fruits of industrialization will, according to this assumption, be available to all. Socialism, on the other hand, is based on the principle that real economic equality could only be achieved if workers were able to control the means of production and distribution of goods.[5] According to the socialist ideal, the power of industrialization could be used to create a socialist society based on the practice of equal and rational distribution of goods.

From the middle of the 19th century, electricity[6] and assembly lines[7] led to mass production and the 2nd Industrial Revolution (2IR). The inventions of that time helped the United Kingdom become a dominant economic and political power,[8] while in the United States[9] 2IR contributed to the expansion of the young nation to the West and created huge fortunes by expanding the use of railways[10] and cheaper steel.[11] It was the time when talented inventors became successful entrepreneurs, most notably Thomas Edison[12] and Henry Ford.[13] Electricity also seemed to play a key role in the development of the Soviet Union into the "first socialist state".[14]

From the mid-1970s onwards, the 3rd Industrial Revolution (3IR) is in progress, characterized by the growing and ever-expanding application of information and communications technology (ICT)[15] in the most industrially developed societies but also in developing and emerging economies. IT term means the combined use of computers, software and communications, as well as the increasing use of electronics in both industry and commerce (e.g. ATMs, credit cards). The penetration of computers in industry and commerce was enhanced by the reduction of their manufacturing costs and improvements in their performance[16] (the first low-cost PCs appeared in the 1980s). Computers thus became an integral tool at the workplace but also a widespread tool for home education or entertainment.

The second pillar of 3IR is the development of communication technologies,[17] with the drastic reduction of data transfer costs and the expansion of the possibilities of information dissemination around the world. The shift from electromechanical to digital technology has increased the capacity and transmission speed of communication networks, while the transition from copper cables to fiber optic technology[18] is also particularly important. A third component of 3IR is satellite communications,[19] which are an alternative to terrestrial and submarine systems further expanding possibilities.

The 3IR has unquestionably brought about significant changes in many aspects of life in developed countries. At the same time, however, it is penetrating dynamically in countries outside the western world.[20] Indicatively, South Korea and India have emerged as the most capable "players" of the new era[21] in the fields of microelectronics and integrated circuit manufacturing, while the Chinese economy is also growing dynamically.[22] Furthermore, the imprint of 3IR should not be underestimated in other sectors besides the economy. On one hand, social media overturned the traditional rules of socialization greatly enhancing individualism.[23] On the other hand, internet has made more efficient and easier the dissemination of knowledge, and ideas broadening thus the scope and quality of democracy. These contradictions highlight the role that social media have played in major politics events, developments and social mobilizations of recent years:[24] from the events in Athens in December 2008[25] and the so-called Arab Spring[26] to the 2016 US presidential election[27] or the Brexit referendum[28] and the complaints about the corporate use of personal data[29] and targeted advertising[30] through Facebook, the role of social media has been crucial.

Today, the emergence of the 4IR[31] is promoted in an economic environment of relative stagnation and crisis given the constant need to continuously improve productivity[32] with the help of technology. This environment becomes even more complex taking into account the imminent structural changes in the global ranking of national economies and the process of capital accumulation as the center of global economic power and industrial production shifts to Asia[33] while the US and EU experience signs of deindustrialization.

2. 4IR: The ''smart'' factory

The new production model is the so-called smart factory (or ''smart industry''),[34] where individual systems, based on the use of computers, are able to monitor physical processes, create virtual copies of the physical world and to proceed to decentralized decisions through self-organizing mechanisms. This idea is at the core of the increased digitization of the production process, in which physical objects are integrated with the information network, allowing decentralized production and any real-time adaptation. The "smart" factory and, consequently, the transformation of industrial production is characterized by:[35]

1. Horizontal integration (in other words the process of a company increasing production of goods or services at the same part of the supply chain) through networks: networks can be self-organized in real time, from the moment of receiving the order to the external supply.

2. Digitization throughout the value chain: from design and inbound logistics to production, marketing, outbound supply and after-sales services.

3. Vertical integration and networked production systems, where computer systems work together at the sensor level, controlling the production and execution of corporate design. Both production processes and automation are designed and operated virtually in an integrated process through the collaboration of producers and suppliers.

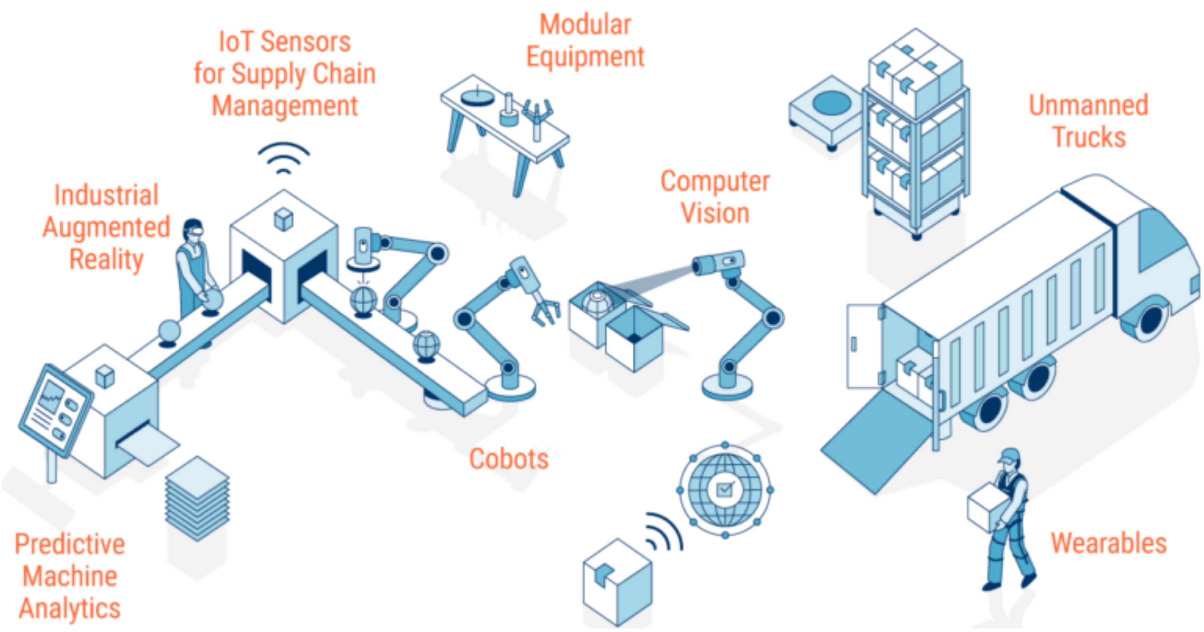


Fig.1: The ''smart'' factory

Relevant terms used internationally include Internet of Things (IoT), Internet of Services (IoS), Advanced Manufacturing, and smart factory.

The terms ''Internet of Things'' and ''Internet of Services'' refer to the digital integration of production and services respectively:

- Internet of Things[36] refers to information systems connected to all subsystems, processes and networks of suppliers and customers, which communicate and collaborate both with each other and with people, using built-in sensors to collect data and take action within a network.
- Internet of Services[37] refers to internal and inter-system services provided and used by the entire value chain through the processing of big data and cloud computing technology.

The integration of the above technologies in the process of industrial production is expected to give it the following characteristics:[38]

- **Interoperability**: Cyber-physical systems (humans and robots), consisting of (i) software integrated into sensors, mobile devices, assembly stations and products and (ii) communication technologies, enable people and "smart" factories to connect and communicate between them.
- **Virtuality**: A virtual copy of the "smart" factory is created by connecting the sensor data to virtual installation models and simulation models.
- **Decentralization**: Cyber-physical systems can make their own decisions and proceed to local production thanks to technologies such as 3D printing.
- **Ability to act in real time**: There is the possibility of collecting and analyzing data and providing the information directly.
- **Adaptability**: ''Smart'' factories have the flexibility to adapt to changing requirements by replacing or expanding individual units.

3. 4IR in Europe and the world

This chapter summarizes the main features of the relevant policy programs announced and implemented by EU Member States, as well as the US and China. Special attention is provided to the features of the German model while positions and proposals of the European Parliament are also described.

3.1 Dominant approaches

Digital technology is not used by EU Member States to create a new industry but rather to transform existing industries and businesses.[39] The low rate of digital technologies use is just one example of the various challenges European companies face in moving to 4IR.[40] The governments of most Member States have adopted large-scale policies to increase productivity and improve the skills of the workforce in terms of advanced technologies. Although common objectives are often found, national policies differ regarding their design, funding approaches and implementation.

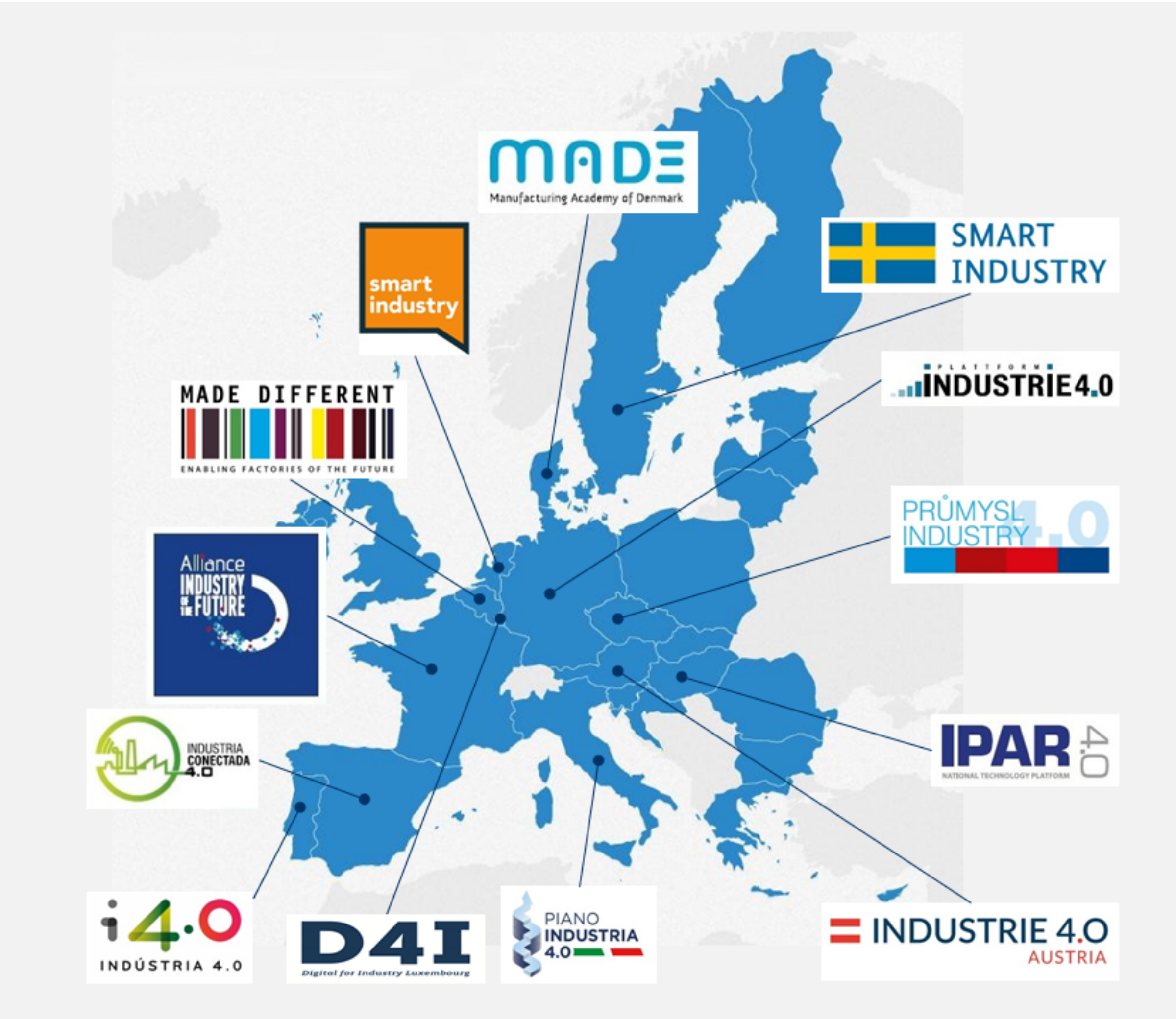
The individual policies are part of a broader strategy, which in turn serves each Member State's holistic approach to research, innovation and industry. In France, for example, declining investment and problems in the development of competing digital industries have dictated the basic guiding principles of the Industrie du Futur (IdF). In contrast, in the Netherlands the relatively low rate of employment in the manufacturing sector led to the creation of the Smart Industry program. In the case of Spain, the national digitization policy has gradually evolved into Industria Conectada 4.0. In the United Kingdom, the launch of the High Value Manufacturing Catapult (HVM Catapult) program was the government's initiative to set up technology centers in different industrial sectors.

Overall, the Member States policies have much in common in terms of their aspirations and objectives. Most of them aim at strengthening the competitiveness and modernization of the national industry taking into account the social and environmental parameters. The objectives of the national programs include the provision of new generation technologies (Italy, United Kingdom), the development of new products and the improvement of industrial processes (Germany, Italy), as well as the support of small and medium-sized enterprises in innovation (United Kingdom, France and Spain).

However, each initiative also has special characteristics that differentiate it from the others. The relevant initiatives of France and Spain follow a market-based approach which consist in providing loans to companies. France provides additional tax exemptions for investment in R&D and encourages public-private partnerships. The Swedish P2030 project is coordinated and funded by industry to ensure the 4IR footprint in industrial production and its long-term viability. In the UK, industrial-scale know-how is provided to companies through seven technology centers to reduce the risk of adopting innovative techniques.

In the USA, the private sector plays a key role in promoting 4IR. The Industrial Internet Consortium was established in 2014 by major companies such as General Electric, Cisco, Intel and IBM with the aim of collaborating between businesses, academia and the state to modernize a number of areas such as manufacturing, energy, transportation, the health care system, non-profit organizations and agricultural production. European technology companies, as well as government agencies from China, India and Germany, are also taking part in the initiative. At government level, the initiative is co-funded by the National Network for Manufacturing Innovation (NMMI).

In China, rising wages are leading to production robotization, while the 13th Five-Year Plan (2016-2020) announced the Internet Plus program which aims to adopt e-commerce by small and medium-sized enterprises, implement the Internet in the public sector and upgrade traditional units of industry and manufacturing. More specifically, it envisaged strengthening cybersecurity and the efficiency of social services, expanding internet access and improving the ''quality and efficiency'' of economic development. The goal is to complete by 2025 the transition from labor-intensive industry at the highest point of the value chain. Until then, the program envisaged the promotion of support measures and the establishment of new industrial modes of operation in mass entrepreneurship, the manufacturing sector, the agricultural production, biology and artificial intelligence. At the same time, the Made in China 2025 program is being implemented, designed by the Ministry of Industry and Informatics, in collaboration with the Chinese Academy of Engineering, and is focused on building and upgrading industrial companies in the chain value, as well as the development of domestic innovation capacity, aiming at a production revolution based on ‘’smart’’ technologies. In addition, the 14th Five-Year Plan (2021-2025) aims to increase China’s R&D spending by more than 7% per year, to generate new demand with innovation-driven development and high-quality supply, to upgrade services and, finally, to promote both high-quality economic growth and high-standard environmental protection.



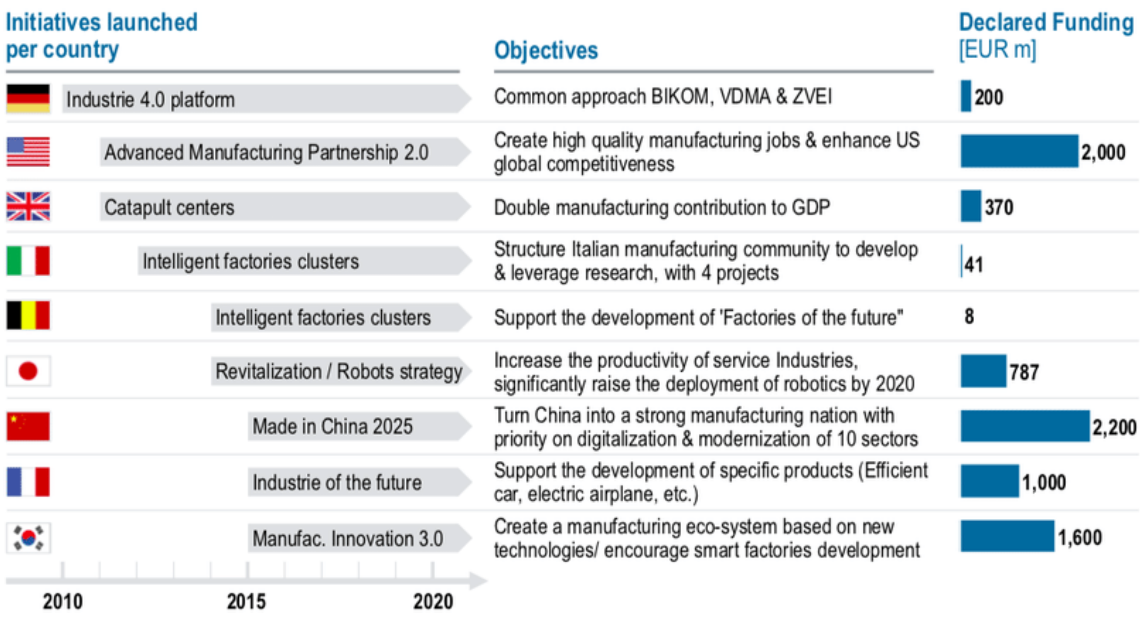


Fig.2: National 4IR initiatives

3.2 The German approach

To strengthen the competitiveness of the German economy, the German government has developed the Industrie 4.0 program aiming at shaping the means of production, promoting and consuming products and providing services based on the interaction and communication of machines both between themselves and with people. It is essentially a transition from the fragmented surveillance and control systems of the past to a new era, with all the individual points in the industrial facilities and production lines being interconnected and communicate with each other through an efficient interoperability of automated components.

More specifically, today, for the first time, it is possible to connect previously isolated elements of the production chain via RFID (Radio-Frequency Identification)[41] transceivers. This means that each product can have built-in digital information that can be shared via radio signals as it travels along the production line. Then the individual products will be able to communicate with each other without human intervention.

This information will be collected and analyzed through big data processing and cloud computing technology, which allow the detection of possible non-obvious mechanical failure and component wear. To the extent that this is done automatically, these "smart" devices can then manage production functions and optimize them autonomously adjusting their own parameters, as they "feel" some of the properties of the unfinished product. In this way, producers are allowed to respond quickly to changing customer requirements and market conditions.

At the core of the above applications lay the additive manufacturing/3D printing technologies of all their machines or components, which have recently been expanded to 4D printing[42] allowing a printed structure to change over time in terms of its shape or function.

3.3. The European Parliament for the 4IR

In its reports,[43] the European Parliament examines (a) technological change, (b) social change, and (c) the paradigm shift that 4IR implies. Although these reports are inevitably a product of compromise between Member States, their conclusions are indicative of the trends in the EU. More specifically:

(a) The European Parliament notes that digitalization has been a key driver of change across the value chain. However, while many companies recognize the need to adapt to new data, far fewer (especially small and medium-sized enterprises) are prepared for it. There are also significant challenges (costs and risks) regarding the protection of intellectual property, personal data and privacy, security, design and functionality of the systems, as well as the protection of the environment and public health. Even if the need to establish public institutions to improve cyber security and broad support for relevant research is recognized by all parties, it is pointed out that both at EU and Member State level there is still a long way to go.

(b) The social changes that 4IR is expected to bring about are not known, according to the European Parliament reports, except to large companies. As a result, larger companies tend to be friendlier towards it, while trade unions retain their reservations. A generally accepted condition for the successful outcome of 4IR is the completion of the digital single market. At the same time, however, there is a lack of skills (but also of willingness) to adapt to the digital single market, at a moment when the demands are extremely high.[44] New ways of working are emerging, with positive and negative effects on employees, while the skills shortage is currently being addressed with specialized immigration strategies.

(c) Small and medium-sized enterprises are facing the challenges of participating in the new production and supply chains envisaged by 4IR, which concern costs, risks, reduced flexibility and lack of strategic independence. There is both a lack of information about advanced technologies and an inability to purchase the required technology. In addition, small and medium-sized enterprises are unable to carry out pilot projects for testing 4IR technologies and have limited access to facilities for testing advanced solutions. They are not able to attract skilled staff and, as large companies can take advantage of their market position to test and patent new technologies, small and medium-sized enterprises need to overcome large barriers to avoid further dependence on the largest companies.

In conclusion, for a successful transition to the 4IR era, the European Parliament proposes:

(a) The adoption of measures to fill gaps and shortcomings at national and EU level (monitoring the latest developments, research funding, support for small and medium-sized enterprises, raising awareness of challenges and opportunities)

(b) Initiatives by Member States to support reindustrialization policies under the European strategy RISE (Renaissance of Industry for a Sustainable Europe), in order to achieve the goal of increasing the contribution of industry to GDP at 20%.

Recently, the European Union has planned and intends to implement the following:

a) For the operation of artificial intelligence (AI) applications with a specific risk profile, the Commission is seeking views on whether and to what extent strict liability, as it exists in national laws for similar risks to which the public is exposed (for instance for operating motor vehicles, airplanes or nuclear power plants), may be needed in order to achieve effective compensation of possible victims. The Commission is also seeking views on coupling strict liability with a possible obligation to conclude available insurance, following the example of the Motor Insurance Directive, in order to ensure compensation irrespective of the liable person's solvency and to help reducing the costs of damage. While in principle the existing Union and national liability laws are able to cope with emerging technologies, the dimension and combined effect of the challenges of AI could make it more difficult to offer victims compensation in all cases where this would be justified. Thus, the allocation of the cost when damage occurs may be unfair or inefficient under the current rules. To rectify this and address potential uncertainties in the existing framework, certain adjustments to the Product Liability Directive and national liability regimes through appropriate EU initiatives could be considered on a targeted, risk-based approach, i.e. taking into account that different AI applications pose different risks.[45]

b) To identify whether enterprises have made any attempts to adopt AI technologies or not as well as identifying the relevance of the given AI technologies for their business. This is especially important in order to shed further light on the dichotomy of enterprises between 'adopters' and 'non-adopters' in order to further disaggregate non-adopters into those that have made attempts to adopt or not.

c) The Commission will further simplify the existing state aid rules on combinations of national funds with InvestEU and Horizon funds. This will make it easier for SMEs to benefit from pooled resources to help them with the twin transitions. Furthermore, as part of its ongoing review of state aid rules, the Commission will revise state aid rules for risk finance and the Important Projects of Common European Interest (IPCEI) communication, to further support SME involvement, ensure crowding-in of private investment while avoiding distortions of the level playing field.[46]

d) The various challenges to be arisen from 4IR should be taken into account and, thus, a recent initiative has been launched. Industry 5.0 is characterized by going beyond producing goods and services for profit. It shifts the focus from the shareholder value to stakeholder value and reinforces the role and the contribution of industry to society. It places the well-being of the worker at the center of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet. It complements the existing "Industry 4.0" approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric and resilient European industry. Industry 5.0 complements the existing Industry 4.0 paradigm by highlighting research and innovation as drivers for a transition to a sustainable, human-centric and resilient European industry. It moves focus from shareholder to stakeholder value, with benefits for all concerned. Industry 5.0 attempts to capture the value of new technologies, providing prosperity beyond jobs and growth, while respecting planetary boundaries, and placing the well-being of the industry worker at the center of the production process.[47]

3.4 Multi-speed member states

Based on the criteria of ''industrial excellence''[48] and according to the progress made towards 4IR, the member states fall into four categories:

- *Front-runners:* Germany, Sweden, Austria and Ireland. These countries are considered to have advanced more rapidly and continue to move successfully in the direction of 4IR.
- *Potentialists:* Belgium, Denmark, the Netherlands and France. Their industrial base is weakening, but their modern corporate sector has many potentials. Finland ranks between the pioneers and the potentialists.
- *Traditionalists:* These are mainly Eastern European member states such as the Czech Republic, Slovakia, Slovenia, Hungary and Lithuania. These countries are considered to have an adequate industrial base, but few have taken initiatives to move into the new industrial era, and some already provide workforce in the German program Industrie 4.0.
- *Hesitants:* These include Southern and Eastern European countries such as Greece, Italy, Estonia, Portugal, Poland, Croatia and Bulgaria, which are considered to lack a reliable industrial base, while the serious fiscal problems they are facing do not allow their development orientation towards the future. Some of these countries already provide labour to German industry.

4. The 4IR: Prerequisites - Questions – Challenges

The conditions for moving to 4IR, the questions that arise and the challenges that accompany it, as they have been recorded internationally, can be summarized as follows:

- **Standardization of systems**, protocols, connections and interconnections is vital.[49] Modern information systems rarely operate in isolation and various types of organizations frequently integrate two or more systems to exchange data or share information resources. A system interconnection is any direct connection between information systems; information system owners must document all system interconnections for their systems in the system security plan and determine appropriate security protections for each interconnection. System owners must document system interconnections between different information systems within the same agency or across agency boundaries, describing for systems at both ends of the interconnection the system name, the organizational unit responsible for the system, the type of interconnection, any agreements in place and their effective dates, the security categorization level, the security authorization status, and the name of the authorizing official.
- **The division and organization of work** will change radically due to changing business models. Real-time production control is expected to transform the content, the processes, and the work environment, requiring increased responsibility and continuous upgrading of staff skills. The traditional clear division of industrial labour is removed and a much more complex environment is formed: There will be new businesses and organizational structures, which will rely more on decision-making and coordination, control and support services. The need of virtual and real machines and installations coordination in production management systems needs to be taken into account. This work environment, where human will need to rule, collaborate and take orders from robots, has no precedent in the history of industrial revolutions. First, we can distinguish preprogrammed robots, such as the robots employed in the assembly halls of car manufacturers designed to perform well-described tasks in well-defined and controlled environments. Second, there are tele-operated robots that are under continuous control of human operators at a distance. Typical examples are drones, robotic submarines, and surgery robots. Third, autonomous robots are able to sense their environment and act with purpose, such as delivery robots in hospitals that distribute and register patient's medicines. A further category of robots is ''augmenting'' robots, which are connected or integrated with the human body. Such robotic skeletons can also be used to enable workers—e.g., soldiers—to use heavy gear.[50] Therefore, the future industrial workforce should act with increased management and problem solving skills, as well as excellent communication and organizational skills.

- **The ''optimistic approach''**, which often prevails, emphasizes the prospects for significant expansion and new kinds of jobs in the future, the possibility of increasing wages (but for a few highly skilled jobs), improved working time flexibility and better work-life balance. On the other hand, the tensions, challenges and threats associated with these changes are usually overlooked: Continuous work in a virtual reality environment creates a sense of loss of personal experience through the dematerialization of work, which in turn may lead to an intensification of the feeling of alienation and loss of control. Finally, within such a workplace, an extreme polarization between highly qualified employees and administrative/operational employees can take place while the risk of blurring the boundaries between family and professional life is visible with adverse effects on the physical and mental health of employees.
- **New business models** need to be developed and implemented: What is the cost of converting production methods and who will bear the cost of possible failed initiatives? New types of relationships will need to be built between the companies themselves (suppliers, competitors, etc.) in a virtual environment, which presupposes unprecedented levels of "openness" and transparency on their part.
- **Security and protection of know-how** in the context of the global competitive environment is also a critical parameter. Will governments and businesses invest if the innovative approaches that are expected to emerge can easily be replicated by countries or companies that have not invested in research and development (including developing and emerging economies countries)?
- **Availability of skilled workers** who can operate in the industrial facilities of the future. Who will invest in improving their skills and training? As advanced technological systems develop specific and ever-evolving skills, lifelong training of the workforce becomes an issue of crucial importance. There is a clear demand for a wide range of specializations across the spectrum of the value chain, extending from business infrastructure through systems design, modeling and management of production operations to the development of interaction with people. In any case, the convergence of information technology, industrial activity, automation and software requires the development of an innovative approach to the training of ICT technologists. Countries with large STEM workforce (Science, Technology, Engineering and Mathematics) are the ones disposing appropriate scientific staff for 4IR.
- **Who will carry out the research** required for further development under 4IR (public-private sector sharing)? The entry of small and medium-sized enterprises into the market and supply chains of industry through public investment in research and development, both at national and EU level, could be offset by private investment, helping to create a level playing field.

- **How can a common European legal framework** be developed and implemented for the protection of corporate data, the settlement of liability issues and the handling of personal data?
- **The data of ‘’smart’’ machines** and the network security become important to ensure the protection of the environment, especially in the case of management of hazardous (e.g. nuclear or toxic) materials.
- **When people and "smart" machines** interact in the same workplace, it is crucial for the workers’ health and safety to predict the ‘’reaction’’ of the machines. Since networks and machines can be manipulated due to inadequate data security systems (e.g. cyber-attacks), it lurks always the risk of ‘’reacting’’ differently than predicted by the way they were originally programmed.
- **Intellectual property**: In industry, intellectual property and the big data that determine the production process of a product are just as valuable as the engineering and design plans, since they contain distinct and unique information on the product and its production. While design data is usually adequately protected, production data is often exposed to computer-backed machines. An infected computer system on the network or a simple USB stick is enough for data interception, while there is always the risk of hacker attacks on the computer network. In addition, the increasing interconnection of a company's machines, software and facilities raises reasonable questions about who can use business information and to what extent (can software companies, for example, use data?). Finally, the issue of intellectual property is raised between companies and customers, to the extent that it is given to the customers the ability to personalize the final product during the production process.
- **Protection of personal data and privacy**: As goods and services in the 4IR environment are often interconnected in the form of ‘’smart’’ products, a changing product model is created for which not only the product itself, but also the service connected to the product is of great significance (e.g. ‘’smart’’ home power meter or "smart" refrigerator). The various data reflect the habits and preferences of the customer-users, who are thus at risk of becoming either objects of either targeted unwanted advertising or social stigma.
- **Concentration or decentralization**: The question remains whether the implementation of 4IR at European level will lead to the concentration of new industrial structures in specific areas of Europe or whether, on the contrary, it will result in the dispersion of facilities in areas of currently reduced industrial activity in Europe. To date, the attraction of skilled labour in Germany from the rest of Europe shows, however, that the increased concentration of such activities in areas where there is already strong industrial activity is more likely.

5. The future of work and alternative perspectives: Between utopia and dystopia

The structural transformations, both economic and social, that 4IR will bring about make imperative to closely monitor the relevant developments and to ensure the wide participation of the social body. The private sector is definitely required to get involved in the relevant discussions, but the public interest should prevail as the emerging new industry model is in fact expected to lead to a crisis, due to the conflict of old and new values, attitudes and knowledge.

Most of the international literature claims that under the right conditions (adequacy of a skilled workforce and on-time transformation of the business model), productivity growth and social well-being are guaranteed. Immediate and medium-term forecasts, are impressive in terms of the opportunities that open up for humanity. The picture is reminiscent of the ambitious theory of Kuznets (1955),[51] according to which income inequalities will indeed automatically decrease, whatever the policies pursued or the intrinsic characteristics in each country, until they stabilize at a tolerable level. This has been a theory that was addressed to a world excited by "The Glorious Thirty" (1945 - 1975): As long as we have patience, ''wait a little'', and growth will benefit everyone ("Growth is a rising tide that lifts all boats'').

However, in the case of 4IR, ''wait a little'' can last several generations.[52]

Based on recent data, the widespread neoliberal argument that business prosperity is directly proportional to job creation and the well-being of society as a whole is weakening. The greatest impact is expected in the professions that require less specialization: organizational office work, production, construction and mining.[53]

In addition, Bank of America has predicted an increase in robot production automation worldwide, from 10% in 2015 to 45% in 2025. At the same time, it estimates that the use of robots with augmented intelligence could increase productivity by 30% in many sectors of industry, while reducing labor costs by 18-33%.[54] At a recent World Government Summit, Tesla co-founder Elon Musk said that "there will be fewer and fewer jobs that robots will not do better [than humans]," and that workers will need to increase their skills through a fusion of biological and mechanical intelligence".[55] In other words, humans will have to become more competitive than robots, as the upcoming wave of automation will cost in the long run many more jobs; not only low-skilled jobs but also highly-skilled ones in the tertiary sector of the economy.[56] Moreover, the intensification of inequalities and social exclusion is recognized by "crusaders" of the new model of industrial production, such as Bill Gates who has proposed taxing robots to fund a guaranteed basic income for all,[57] while leading corporate entrepreneurs have long spoken about a Universal Basic Income (UBI) for those who will be led to unemployment.[57]

During the previous industrial revolutions there was indeed a huge economic shift, which created new economic opportunities and led to the improvement of the standard of living through social struggles. However, in the so-called 4IR there is something fundamentally different: the development of artificial intelligence and robotics can in the long run make the human species itself ''obsolete'',[59] as the value of human labour is already determined by the cost of equivalent machine intelligence.[60]

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