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FORCE
Fourth Industrial Revolution:
Challenges & Opportunities for Europe

FOR A HUMAN-CENTRIC 4IR MODEL: SUSTAINABLE, FAIR & RESILIENT

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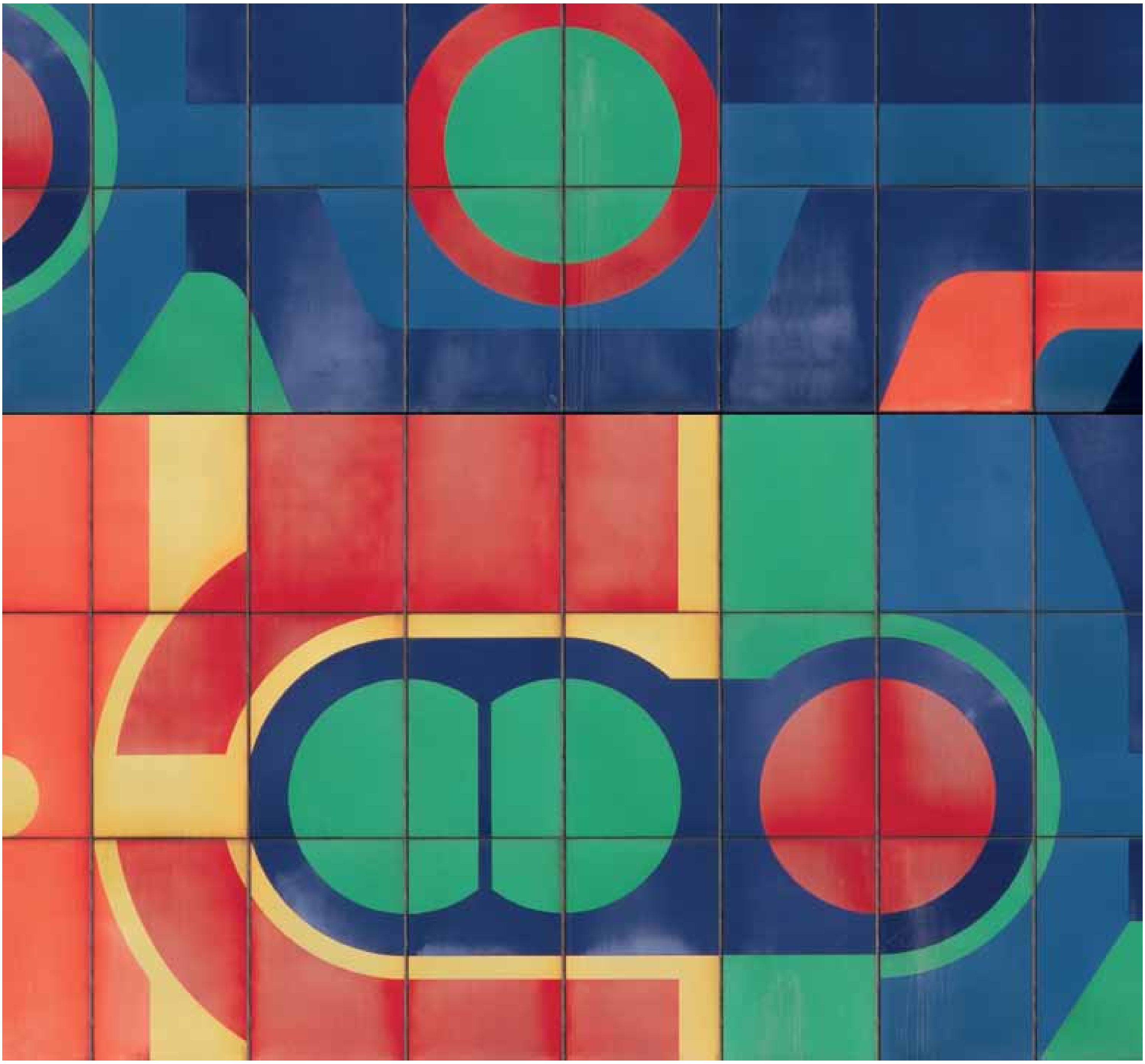

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PROJECT FINAL REPORT

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Abstract

Nowadays, the technologies of the 4th Industrial Revolution/4IR [artificial intelligence (AI), robotics, the Internet of Things (IoT), cloud, augmented reality, 3D printing etc.) are central in the public debate about the future of the economy, the society and the environment. At the center of this debate we find the actual and potential crucial contribution of new technologies for achieving the Sustainable Development Goals (SDGs). A growing number of publications and articles however reveals negative consequences and risks as well as critical vulnerabilities of new technologies. The weaknesses of the 4IR are often attributed to the prevalence of an an oligopolistic digital economy model that accumulates considerable technological, financial and market power. This policy paper, which summarizes the works and results of the FORCE project, presents the numerous opportunities and challenges for Europe emerging from the 4IR. These challenges cover a wide range of areas: From the European countries' digital sovereignty and economic resilience to the opportunities and consequences of new technologies on health, working conditions, employment, environment and human rights. In this context, a number of proposals are submitted on deepening and broadening the European Union's current initiatives to regulate the digital sector, unlocking the potential of new technologies for sustainable development while shaping a human-centric model of the 4th Industrial Revolution.

Contents

1. About the FORCE project

The interdisciplinary FORCE project, implemented by the ENA Institute for Alternative Policies, supported and coordinated during one and a half year the work of 30 experts from 6 EU member-states on the challenges of the 4th Industrial Revolution (4IR).

The initial idea for a research program on the economic, social, environmental and strategic dimensions of the 4IR was born from the systematic manifestation in recent years of a number of wide-spread concerns and questions in public debate regarding the use of new technologies. *What consequences will new technologies have on employment and work? Should human functions be replaced by machines to such a great extent? In what sectors will artificial intelligence be really useful and in what sectors its use should be regulated or even prohibited? Can the market regulate new technologies to the benefit of the common good? What are the actual opportunities that the 4IR can offer but also its weaknesses and risks? Are there any reliable alternative policies to address the new challenges?*

The FORCE experts, through the extensive material produced (policy papers, interviews with experts, presentations) and the events that took place in the context of the project (conference, workshop, round table, follow-up event) offered valuable information on the aforementioned questions, contributed to highlight key issues and contradictions of new technologies and submitted specific policy proposals to reinforce the contribution of the 4IR to sustainable development.

4TH INDUSTRIAL REVOLUTION

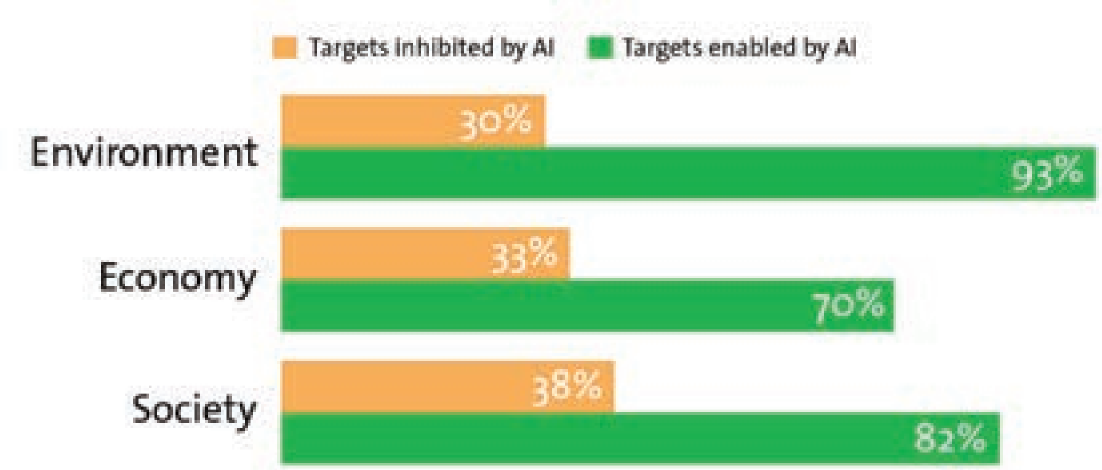
"At the core of the 4IR we find changes taking place in production means and in the ways of promoting and consuming products and providing services due mostly to the great technological advances in the fields of digitization and artificial intelligence. These changes are not limited only to the interactive function of machines or the interaction between humans and machines. The 4IR is not only about "smart" interconnected machines. Nowadays, there are significant developments not only in the promotion of artificial intelligence but also in other crucial fields, such as nanotechnology, photonics, advanced materials and biotechnology. These developments lead to new, "revolutionary" approaches to various scientific fields, such as genomic analysis and medicine for personalized treatment, renewable energy sources or quantum computers. It is exactly this combination of technologies and the strong interconnection between various fields related to physics, biology and information technology that define the 4IR".

SOURCE: ΦΩΤΑΚΗΣ & ΣΕΛΙΜΗΣ/FOTAKIS & SELIMIS (2018)

2. The contribution of the 4IR to sustainable development

The great majority of participants in the project confirmed the large contribution that the 4IR may have into sustainable development. According to the findings of an interdisciplinary study presented during the FORCE conference (Vinuesa, 2021), Artificial Intelligence (AI) applications have a documented positive contribution into 79% of 169 Sustainable Development Goals/SDGs (Vinuesa, Azizpour, Leite et al., 2020). However, the fact that non-negligible negative consequences are also documented in relation to 35% of the SDGs must not be disregarded.

NEGATIVE - POSITIVE IMPACT OF ARTIFICIAL INTELLIGENCE ON 169 SUSTAINABLE DEVELOPMENT GOALS



SOURCE: VINUESA ET AL. (2020)

The fact that 38% of SDGs related to "Society" may be negatively affected by AI confirms that fears about new technologies expressed by citizens and various actors are often well-founded and, thus, they should not be stigmatized a priori as technophobic. As shown in the figure below, AI can have negative consequences in crucial fields, such as the fight against poverty and the promotion of quality education.

DETAILED EVALUATION OF AI'S IMPACT ON SDGs FALLING UNDER THE CATEGORY "SOCIETY"

SOURCE: VINUESA ET AL. (2020)

Furthermore, it is explicitly recognized that the overall impact of new technologies in regard to human rights depends directly on the environment in which they are implemented. In other words, the outcome will vary depending on the values that prevail in every state (cultural, democratic, quality of institutions etc.). Potential dangers must not be considered as negligible. Rapid developments in biotechnology and bioengineering shape conditions, for the first time in history, under which it becomes possible to translate economic inequality into biological inequality (Harari, 2017). The possibilities to upgrade physical and cognitive abilities, combined with the unequal access of people to the said technologies, could even lead, in absence of strict global regulation, to a humankind split in biological castes. It is therefore imperative to establish a robust regulatory framework worldwide in relation to the development of new technologies and the minimization of its negative impact.

Overall, the aforementioned findings confirm the relevance of the European Parliament's approach to regulating AI. Defensive attitudes against new technologies of the 4IR are not at the service of the common good, given their outstanding innovation potential for the Society, the Economy and the Environment. Many of these applications were presented and discussed in detail during the events and in the publications of the FORCE project. They include applications in medicine and education, for adaptation to climate change (Devves, Eustathopoulos & Sotiropoulos, 2021), the protection of biodiversity and the prevention of natural disasters[2] and in other areas such as occupational health and safety[3], "energy democracy" (i.e. affordable "clean" energy through decentralized production [Doukas, 2021]), sustainable urban mobility[4] and productivity improvements in agricultural production[5]. For instance, innovative applications in telemedicine, such as remote treatment and robotics, can now improve substantially accessibility, affordability, quality and efficiency of health services, contribute in the prevention of non-contagious diseases, support patients' independence and protect health professionals (Voutyrakou, 2021).

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[2] The interconnection of large data bases is expected to play a crucial role in the adaptation of the society to climate change and the prevention of extreme weather events that endanger the environment and biodiversity.

[3] By reducing workers' exposure to dangerous tasks (e.g. work in offshore wind farms, access to pipelines, nuclear plants, transportation of pharmaceutical and medical equipment in emergency cases, etc.). See Jimenez (2020).

[4] See online event entitled "Electric mobility in Greece: Technological, economic, social & environmental aspects" organized by ENA Institute for Alternative Policies in May 2021.

[5] Smart agriculture and real-time data supply can contribute in the efficiency of farms, the resilience of value chains in the primary sector and food safety in general.

SOURCE: VOUTYRAKOU (2021)

New technologies also contribute in the improvement of public administration, by increasing the efficiency, the speed of service delivery, the quality and accessibility of public services subject to certain conditions (transparency and accountability of digital systems, adequate user support, equality of access and use of digital services, etc.).

Many of these promising possibilities remain, however, under-utilized making it imperative to ensure greater support from European, national and regional authorities. At the same time, the regulation of new technologies and digital economy, as examined below, is becoming a key-issue for the future of the 4IR and the minimization of their potential negative consequences.

Digital economy: a sector deviating from SDGs?

Most FORCE experts agreed that the wide-spread opinion arguing that new technologies can serve the common good by simply relying on free market dynamics is not validated by international experience. This opinion, that is diametrically opposite to the "technophobic" approach, often views technology not as a means but as a *value* and *end in itself.* With human sciences and values losing ground, moral qualities are often attributed to technology. A new hegemonic ideology of 'solutionism' promises technological solutions for addressing every problem, not only of individuals but also of institutions and ultimately humankind itself (Jourde, 2021). Solutionism -invoking for example the absence of alternatives solutions, time or resources- leads to the marginalization of politics to address the major challenges faced by humanity (Morozov, 2020). In the meta-ideological reality of solutionism, everything is under fundamental revision except from the market institution itself.

Under the current circumstances, and in absence of a comprehensive governance framework oriented towards the general interest, lies the danger that digital economy and certain applications of new technologies will end up being inhibitors instead of drivers of sustainable development (Vidalenc, 2021)[6]. Nowadays, a largely oligopolistic and profit-driven model of the digital economy tends to prevail worldwide (Σμυρναίος/Smyrnaios, 2018) accumulating market, technological and financial power at an excessive level.

These dynamics are reflected in the fact that six out of the ten biggest companies in the world, in terms of market capitalization, are operating in the sectors of new technologies and have dethroned the traditional "giants" of oil and financial sectors[7]. The fact that tech ultra-billionaires determine, due to their economic and technological prevalence, humanity's destiny according to their personal vision or interest is a direct consequence of the said dynamics and new balance of power emerging between economic, institutional and social actors worldwide (Crispin, 2021· Maçães, 2021· McCarthy-Jones, 2020· Naughton, 2021).

[6] For example, the endless increase of data, the invisible aspect of infrastructures and the governance of this sector by digital corporate giants make digital economy an inhibitor and not a driver of energy transition.

[7] https://companiesmarketcap.com/

10 BIGGEST COMPANIES IN THE WORLD IN TERMS OF MARKET CAPITALIZATION [8/9/2022]

Rank	Name	Market Cap	Price	Today	Price (30 days)	Country
1	Saudi Aramco	$2.382 T	$11.92	-1.78%		S. Arabia
2	Apple	$2.307 T	$142.56	-2.69%		USA
3	Microsoft	$1.909 T	$255.35	-2.00%		USA
4	Alphabet (Google)	$1.489 T	$2,263	-0.70%		USA
5	Amazon	$1.087 T	$2,139	1.48%		USA
6	Tesla	$754.21 B	$728.00	-0.92%		USA
7	Berkshire Hathaway	$678.41 B	$461,631	-1.36%		USA
8	Meta (Facebook)	$546.75 B	$191.24	1.32%		USA
9	Johnson & Johnson	$468.04 B	$177.87	0.95%		USA
+1 10	TSMC	$454.74 B	$87.69	-0.16%		Taiwan

Source: https://companiesmarketcap.com/

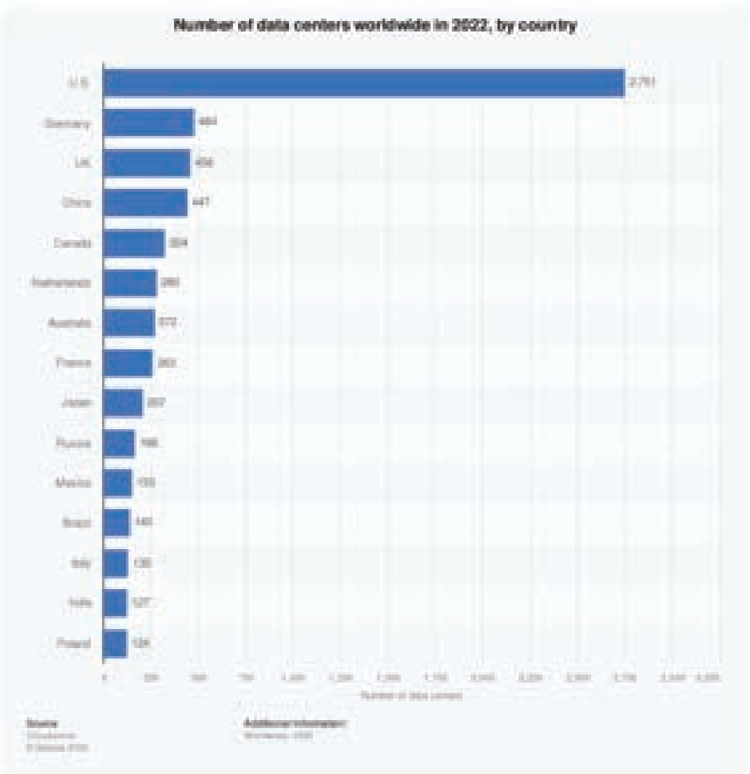
4. Strategic dependencies, vulnerabilities and dangers

The control that the digital oligopoly attempts to exercise over crucial strategic sectors is giving rise to increasing concern.

Data and digital sovereignty

Data control by digital and big-tech companies leads to the weakening of the states' digital sovereignty (in sectors such as cloud, semiconductors, etc.). As a result, tackling this problem is now among EU's top priorities (see French Presidency of the Council of the European Union, 2022). In particular, Europe is significantly lagging behind as regards data centers, which raises issues related to the accessibility, safety and protection of the European citizens' data (Delépine, 2017). In this context, the EU's European Data Strategy and recent regulation "Data Act" lay the foundations in order to ensure fairer terms of data access and use for the economy and society (Deutsch, 2022· Yun Chee, 2022· van der Klugt, 2022).

NUMBER OF DATA CENTERS PER COUNTRY IN 2022 WORLDWIDE



SOURCE: STATISTA

In order to address the aforementioned weaknesses, the European Union has launched a series of initiatives through Important Projects of Common European Interest (IPCEI) and Industry Alliances to support investments and infrastructures that are crucial to its technological and digital sovereignty, such as addressing the absence of sufficient cloud infrastructures in Europe[8] and reducing dependency on electronic equipment (e.g. semiconductors)[9] from third countries.

Privatization of space

A growing number of analysts describe an attempt to "privatize" space (Delépine, 2021). For example, Elon Musk's private company SpaceX already owns 1,500 satellites that are in orbit (i.e. 1/3 of the total number of satellites) and plans to launch 12,000 new satellites into orbit until 2025. In the same direction, Jeff Bezos' Blue Origin (Amazon) also plans to launch over 3,000 satellites in the years to come. The main commercial purpose of the said activity is the provision of satellite Internet services. Given the importance of space for a series of activities of major importance, such as navigation, mapping, telecommunications and defense, the expansion of private companies to the space and the vertical control that the latter exercise over this crucial sector (from the construction and launch of satellites to the provision of services) is giving rise to concerns.

The expansion of SpaceX is based on its innovation superiority which lies in the launch of reusable rockets drastically reducing costs and threatening the sustainability of SpaceX's competitors.

[8] Cloud IPCEI και European Alliance for Industrial Data, Edge and Cloud

[9] See: IPCE on Microelectronics, Alliance on Processors and Semiconductor technologies, Digital sovereignty: Commission proposes Chips Act to confront semiconductor shortages and strengthen Europe's technological leadership

It should also be noted that the rapid increase in the number of satellites (China announced that it will launch 13,000 satellites [Jones, 2021]) increases, in its turn, the risk of collisions in space. A collision of satellites, compared to a collision of vehicles on Earth, has multiple negative consequences. Debris from a collision of satellites constitute an imminent threat to other satellites, which leads to the risk of producing new –uncontrolled-debris. This risk is described as "Kessler syndrome": a state in which it would be impossible to use space for many decades and generations due to a vicious circle of mass launches, collisions and spread of debris. Therefore, it is imperative to assume supranational initiatives aimed at managing space as global common good.

STARLINK CONSTELLATION SATELLITES IN ORBIT AS SEEN FROM THE EARTH WITH A NAKED EYE

SOURCE: GROCHOWSKI (2021)

Autonomous weapon systems and hyper wars

Serious ethical issues and risks for humanity that result from AI military and robotic applications ("killer robots") are an additional burning issue of the 4IR. AI-based autonomous weapon systems are expected to be the "backbone" of coming hyper-wars (Mahnkopf, 2021). These systems are rapidly becoming more intelligent, more precise, more lethal and cheaper (Lee, 2021). Thus, the trend of disengaging technology from moral criteria, and the dynamics of AI in the defense industry give rise to serious concerns in a period of geopolitical instability and massive rearmament following the war in Ukraine.

DIGITALIZATION AND AI-BASED AUTONOMOUS SYSTEMS:
THE BACKBONE OF COMING HYPER-WARS

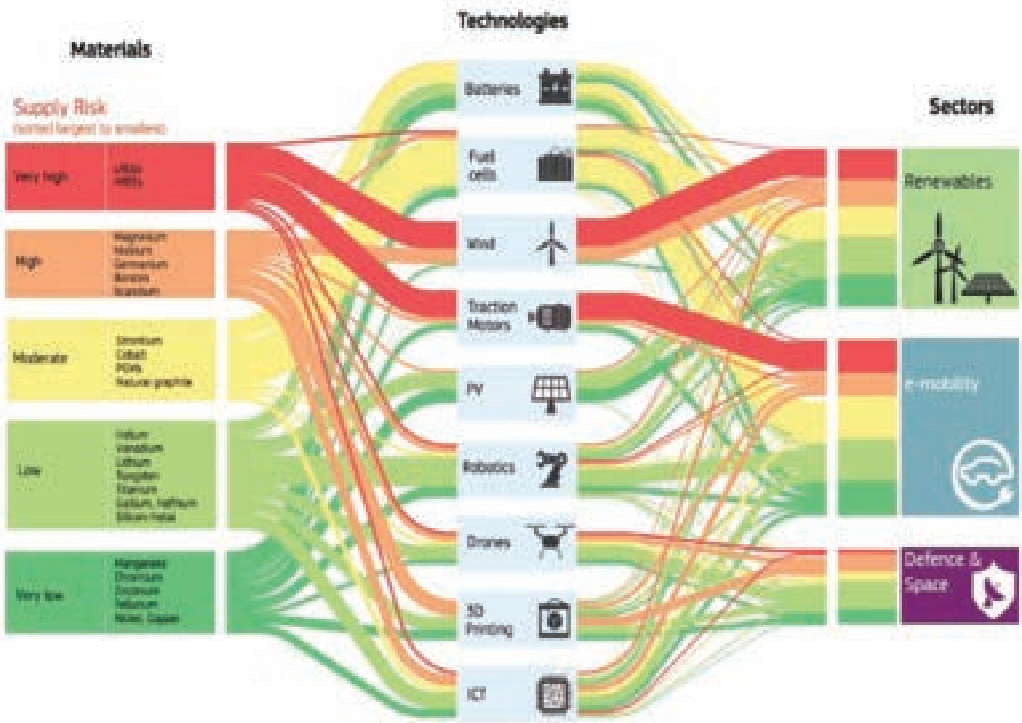
SOURCE: MAHNKOPF (2021)

It should be noted that companies of the digital oligopoly, such as Amazon and Microsoft, are also developing activities in the autonomous weapon systems sector (PAX, 2019).

Digital economy: resilient by nature?

A growing number of experts underline that the “digitalization of everything” does not sufficiently weigh up the risks arising from the said policy. Vital infrastructures are being exposed to threats such as cyber-attacks. Moreover, data production and storage infrastructures are largely located outside Europe. It is also widely accepted that European countries are dependent on third countries for the supply of critical raw materials (e.g. graphite, cobalt, lithium) and semiconductors. In particular, the European Union is 86% dependent on third countries for cobalt and 100% for lithium (extraction and production) according to data from the European Commission (2020). EU is almost fully dependent on China for materials like magnesium (89%), which is used in the automotive and electronics industry, or rare earth elements (90%), which are considered critical for electric engines, digital technologies and wind energy (Maurice, 2022).

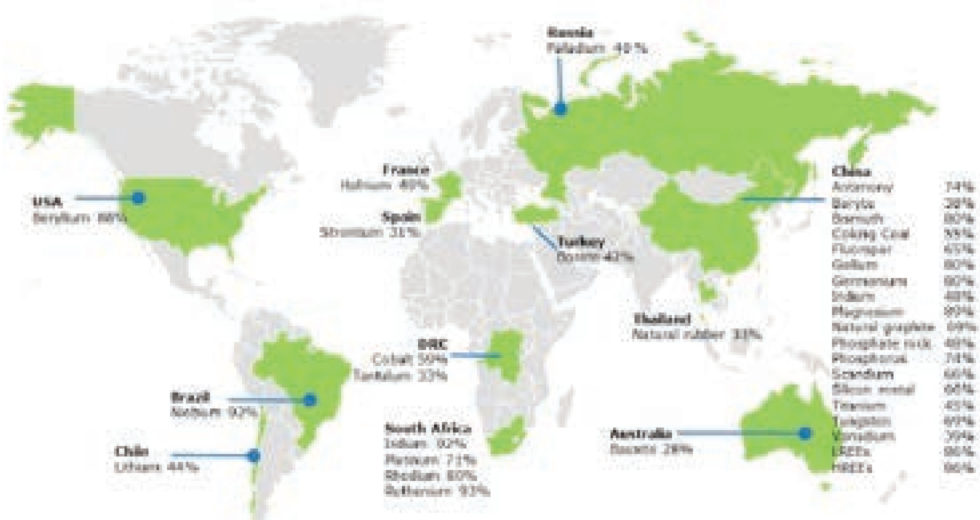
SEMI-QUANTITATIVE REPRESENTATION OF FLOWS OF RAW MATERIALS AND THEIR CURRENT SUPPLY RISKS TO THE NINE SELECTED TECHNOLOGIES AND THREE SECTORS



SOURCE: EUROPEAN COMMISSION (2020)

Demand for rare minerals, such as lithium, is expected to increase almost twenty-fold by 2030, while it will be 60 times higher by 2050 (European Commission, 2020b). This trend forebodes important geo-economic competition worldwide due to the unequal spatial concentration of critical raw materials at a worldwide level.

COUNTRIES ACCOUNTING FOR LARGEST SHARE OF GLOBAL SUPPLY OF CRMs

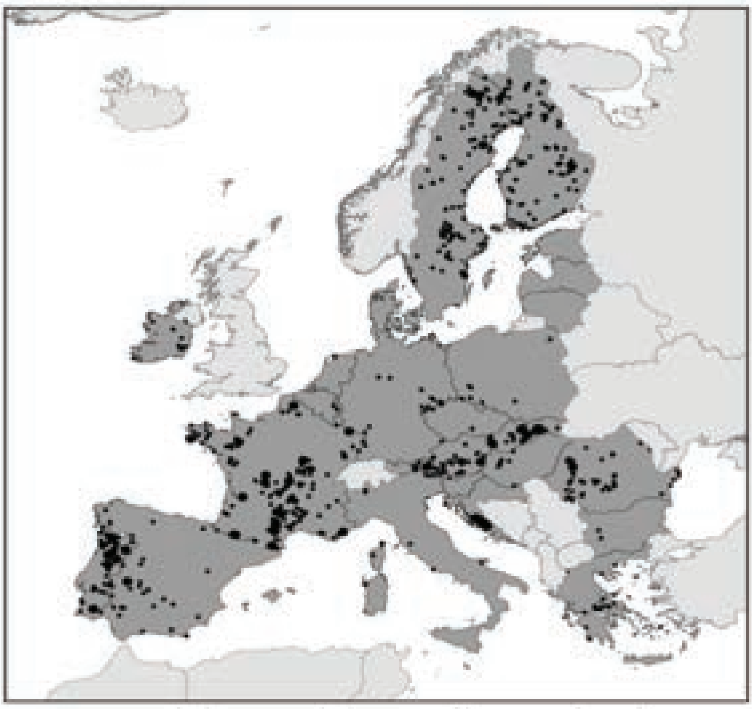


SOURCE: EUROPEAN COMMISSION (2020)

Due to the immense needs in raw materials and the risks involved to the safety of European economies and societies against potential external disruptions in critical supply chains the possibility of developing new extraction activities in Europe aimed at reducing dependency from third countries on imports cannot be excluded[10].

[10] As characteristically noted in a communication from the European Commission (2020) on critical raw materials: *"Europe has a long tradition of mining and extractive activities. It is well-endowed with aggregates and industrial minerals as well as certain base metals such as copper and zinc. It is less successful in developing projects to source critical raw materials, even though there is significant potential for these. The reasons are multi-faceted: lack of investment in exploration and mining, diverse and lengthy national permitting procedures or low levels of public acceptance. Looking at the geographical distribution of critical raw materials in Europe, the development of battery raw materials such as lithium, nickel, cobalt, graphite and manganese provides interesting opportunities. Companies in several Member States are already participating in the European Batteries Alliance, benefiting from private sector, EU and national funding, both for the exploitation of the raw materials and for their processing in Europe".*

CRITICAL RAW MATERIALS RESOURCES
POTENTIAL IN THE EU



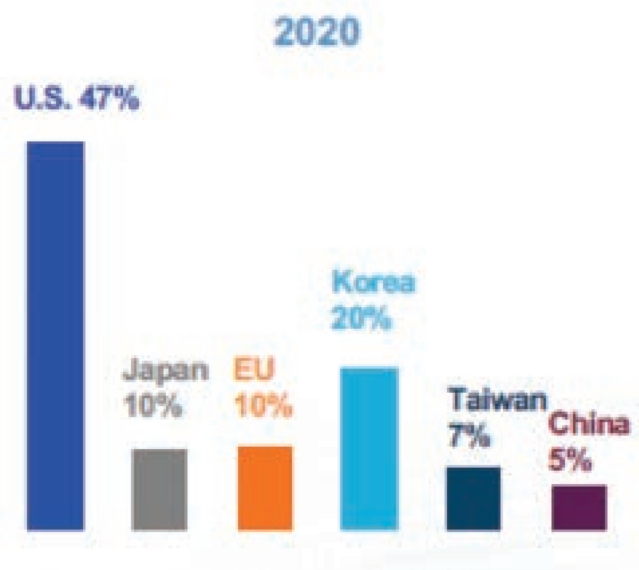
Data provide by EuroGeoSurveys combined with
other EU data sources

SOURCE: EUROPEAN COMMISSION (2020)

It should be noted that the crisis in Ukraine brought again at the forefront policies that were about to be abandoned in Europe on environmental grounds, such as hydrocarbon extraction. A large-scale exploitation of Europe's mineral resources would increase contradictions between the "twin transitions", i.e. between digital and green transition, due to the consequences of new extractive industries on local societies.

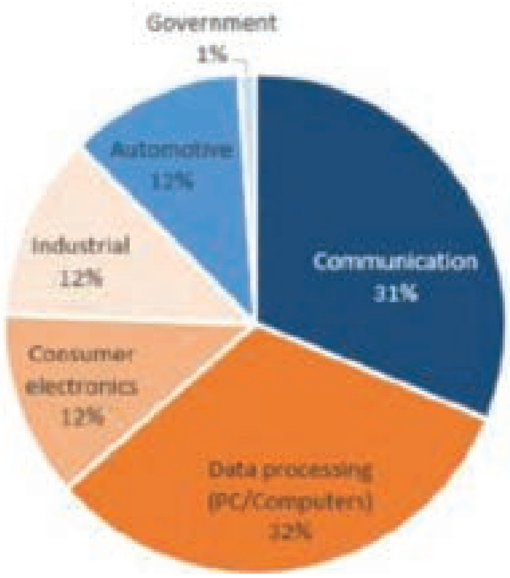
Finally, in regard to semiconductors, Europe's share is limited to 10% of the global market despite their criticality for numerous sectors and products (computers, smartphones, industry, automotive industry, etc.).

SEMICONDUCTOR GLOBAL MARKET (2020)



SOURCE:
SEMICONDUCTOR
INDUSTRY
ASSOCIATION
(2021)

SEMICONDUCTOR MARKET SEGMENTS
BY END-USER SECTOR DEMAND



SOURCE: EUROPEAN COMMISSION (2022)

The aforementioned weaknesses and vulnerabilities are now recognized at a great extent by institutions, policy makers, academics and research organizations, challenging as a result the wide-spread opinion according to which digital economy is sustainable and resilient by nature. In other words, it is recognized that the said sector is exposed to several categories of risks, despite its proven capacity to enable the operation of many basic and critical activities under the peculiar conditions of the pandemic. In particular, the exposure of citizens, businesses, public administration and strategic infrastructures (energy, water, communications, transportation, public services, health, education, food supply, military and defense systems etc.) to significant risks of *technological nature* (cyber-attacks) as well as *economic* and *geopolitical* nature (rarity and depletion of raw materials, concentration in third countries, technological dependency on the digital oligopoly and suppliers of microprocessors, rapid increase in energy consumption in the digital sector etc.) challenges the overall resilience of the digital economy.

5. Labor, environmental and social aspects

In addition to the aforementioned strategic and ethical issues arising from new technologies, the current digital economy model is also blamed for:

- mass production and promotion of low social value services with significant negative externalities
- controversial labor practices in the platform economy
- unsustainable growth of negative environmental consequences of digital services and infrastructures.

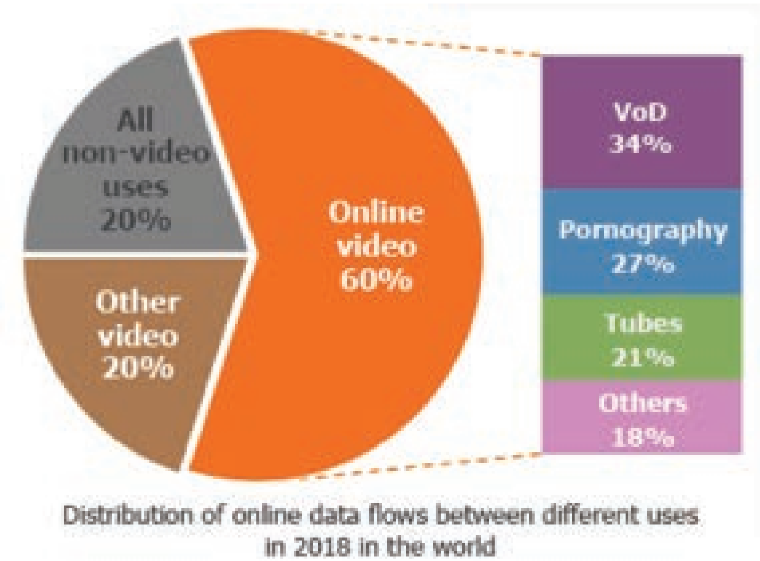
Mass consumption of low social value services

First, this model preoccupies more and more the public opinion as regards its consequences on public health due to new forms of addictions to the Internet, video games, etc. Uncontrolled exposure to digital devices and services is increasingly linked with consequences on children's developmental health, school performance and social skills highlighting the need to subject algorithms to strict ethical values. As experts stress, the design of digital services is subject to the practices of attention economics[11] consciously pushing to addictive designs through tools such as autoplay, embedded videos, pop-up, thumbnails, etc. These practices aim to maximize content consumed by users. Artificial intelligence applications are used to personalize the content received by users aiming to reinforce the feeling of reward and increase the addiction on services (Simičević, 2019). It should be noted that, based on a research conducted in nine EU member-states, one out of four Internet users (25%) shows symptoms of Problematic Use of the Internet. The PIU phenomenon describes maladaptive behaviors, including addiction to gambling, digital consumption, pornography and social media.

[11] See: Paying Attention: The Attention Economy (2020, 31 March). Berkeley Economic Review. Retrieved from https://econreview.berkeley.edu/paying-attention-the-attention-economy/

Therefore, it is important to understand that uses are, to a great extent, a result of the dominant economic model in the digital sector and not only of consumers' individual behaviors (The Shift Project, 2019b). In this context, it should be noted that entertaining videos accounts for 60% of global data flows, as shown in the figure below. The control of the Internet by entertainment companies in detriment of other potential uses of higher value is accompanied, as analyzed later on, by the environmentally un-sustainable increase in energy consumption due to the flow and storage of a rapidly increasing volume of data.

DISTRIBUTION OF ONLINE DATA FLOW BETWEEN USES IN THE WORLD (2018)



SOURCE: THE SHIFT PROJECT (2019)

Digital Labor

The concentration of labor demand in the hands of a few big multinational digital platforms -combined with the internationalization of competition as regards labor supply enabled by the said platforms- has caused a “race to bottom” characterized mainly by flexibility, uncertainty and inequality for a great part of digital workers.

As analyzed in detail in the FORCE workshop, digital labor presents risks related to the spread of labor surveillance practices aiming at hindering workers’ trade union activity or monitoring their behavior and performance in detriment of their privacy and mental health (Flinders & Blunkett, 2020). Gig economy and labor demand via apps are further increasing workers’ social heterogeneity as well as natural and physical distance, placing additional obstacles to their collective organization and representation (Mahnkopf, 2019). It should be noted that the European Commission’s current initiatives to improve the working conditions of people working through digital platforms (European Commission, 2022) constitute an important first effort to regulate the sector to the benefit of workers, as recognized by European social actors (Voet, 2022).

Consequences on employment

The prediction according to which workers will be replaced by robots in a large number of jobs is probably one of the most discussed aspects of the 4IR. A CEDEFOP (2021) research identifies, in particular, occupations which are more likely to be automated. More prone to automation risk are employees, workers in the service sector and in retail, skilled agricultural and fishery workers and industrial workers (machine operators and assembly line workers). Overall, it is predicted that the new generation of technological progress, spearheaded by AI, will disproportionately affect workers in low-paid/low-skilled occupations. These estimates are coherent with the findings of studies identifying potential negative impacts of AI on economic inequalities (Vinuesa et al., 2020).

Consequently, public authorities should give particular attention to the prevention and management of social consequences resulting from technological restructurings. These policies should ensure conditions for a just digital transition and prevent a further increase in already high levels of income inequality.

In the context of the 4IR social agenda, the introduction of a Universal Basic Income in order to address the permanent consequences of automation and artificial intelligence on employment is under discussion. However, it is estimated that the proposed solution poses important risks. The loss of economic and political importance of the masses is a counter-incentive for public investments in health, education and welfare state (Harari, 2017). The creation of a huge underclass of 'useless' people whose future will depend on the goodwill of a small elite is considered to be a dangerous political and societal choice. In a context of consecutive crises -and with an escalation of the climate crisis being already tangible-, these people could be left at their fate sooner or later.

Artificial intelligence and human rights

Increasing digital surveillance and misinformation are among the risks posed to human rights by new technological applications. The establishment of an apparently data-driven depoliticized model of technocratic governance (Flinders & Blunkett, 2020) undermining the citizens' ability to operate as independent beings capable of taking rational decisions in a fully digitized society (Kottelat & Molinoz, 2020) reflect wider concerns in relation to the social outcome of the digital transition.

In this context, it should be noted that the European Commission presented in 2021 a proposal for a Regulation laying down harmonized rules on Artificial Intelligence (European Commission, 2021), based on a risk analysis of AI applications for human rights.

RISK ANALYSIS OF ARTIFICIAL INTELLIGENCE APPLICATIONS

SOURCE: EUROPEAN COMMISSION (2021)

The proposal for a regulation includes a list of AI applications that are explicitly prohibited:

- AI systems that deploys subliminal techniques beyond a person's consciousness in order to materially distort a person's behavior;
- AI systems that exploits any of the vulnerabilities of a specific group of persons due to their age, physical or mental disability;
- The placing on the market, putting into service or use of AI systems by public authorities or on their behalf for the evaluation or classification of the trustworthiness of natural persons over a certain period of time based on their social behavior (social scoring);
- The use of 'real-time' remote biometric identification systems in publicly accessible spaces for the purpose of law enforcement.

However, it should be noted that the AI Regulation does not apply to systems developed or used exclusively for military purposes.

Environmental footprint

Nowadays, digital economy produces around 4% of global greenhouse gases, a percentage which is double than global emissions by civil aviation, according to the calculations of "The Shift Project" think tank (2019a). It is estimated that total emissions by the digital sector will double by 2025, approaching those of the world fleet of passenger cars. This trend, which is not sustainable in the long-term and is contrary to the decoupling of GDP from greenhouse gases, is directly linked to the rapid increase in energy consumption of the sector (+6% annually) (The Shift Project, 2021).

This trend is fueled by a growth model that pushes to an overconsumption of digital services and devices ("digital obesity"). The said trend is overwhelmingly identified in advanced economies. On average, one US inhabitant owns 10 connected devices (smartphone, tablet, computers, smart TVs, game consoles, etc.) corresponding to an average consumption of 140 gigabytes, compared to only one device in India and a consumption of two gigabytes (The Shift Project, 2018). Subsequently, the massive entry of China's and India's populations into the digital era is expected to rapidly deteriorate the digital sector's global environmental footprint, combined with the 5G network expansion, that is estimated to generate a substantially increased energy consumption compared to the 4G (Data Forum Center, 2021).

THE SHARE OF DIGITAL SECTOR
IN GREENHOUSE GAS EMISSIONS

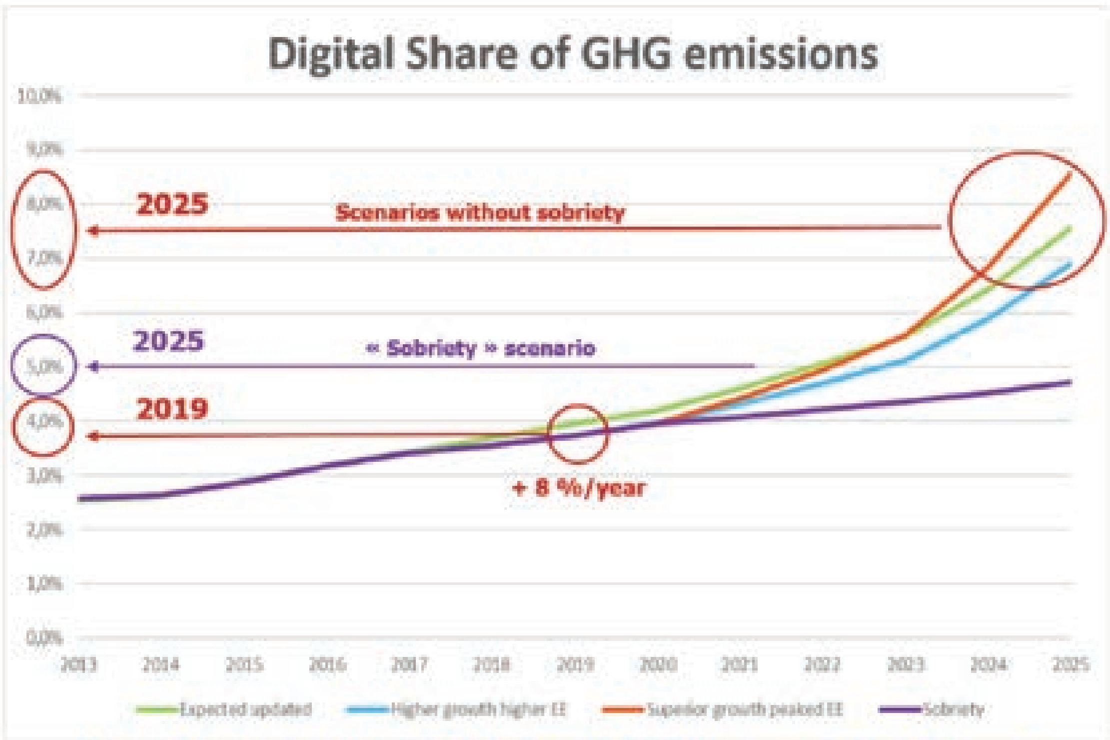
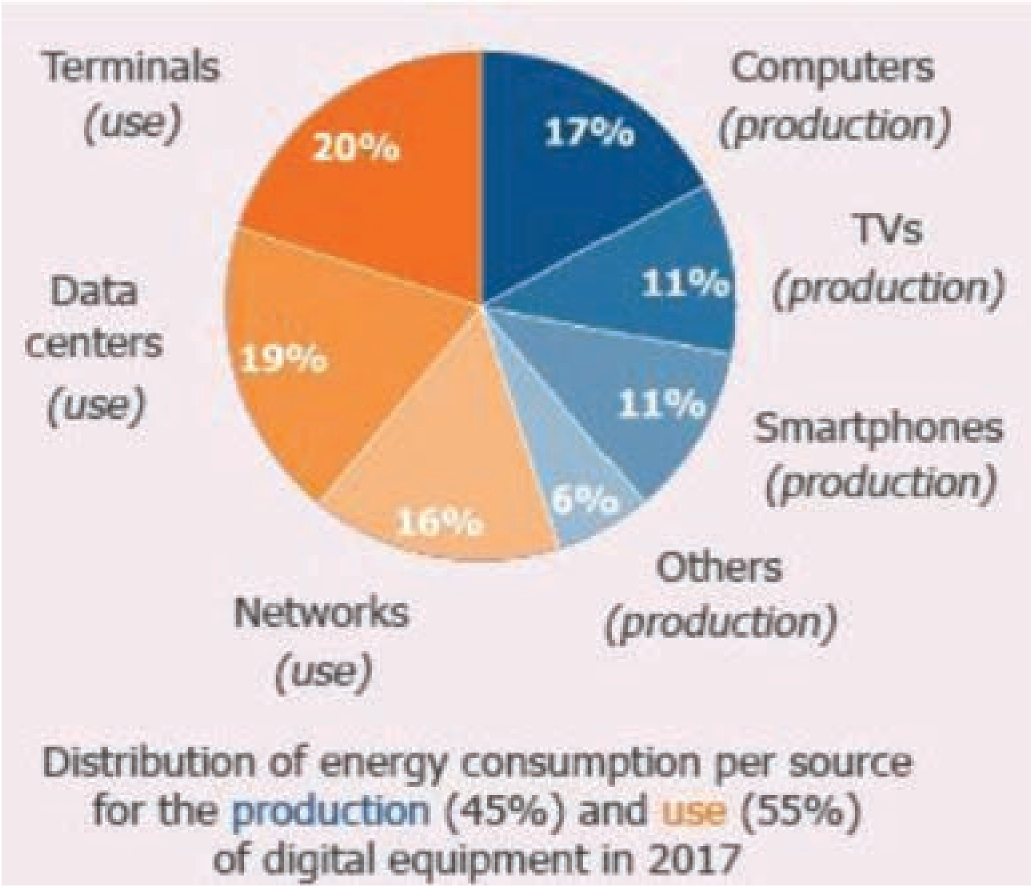


Figure 1: Evolution from 2013 to 2025 of the share of digital technology in world GHG emissions [Source: "Lean ICT – Towards Digital Sobriety" (The Shift Project, 2018)]

SOURCE: THE SHIFT PROJECT (2018)

In this context, it should be noted that data flows consume 55% of total energy needs of the digital sector worldwide (transfer via networks and data storage in data centers) and are increasing by 25% annually on average. In particular, videos account for 80% of data flows and pertains mainly, as already mentioned, to uses of commercial/entertaining nature.

DISTRIBUTION OF ENERGY CONSUMPTION OF THE DIGITAL SECTOR IN 2017 BETWEEN DEVICES (45%) AND SERVICES (55%)



SOURCE: THE SHIFT PROJECT

In order to better understand the size of consumptions arising from the development of digital entertainment, the following indicative examples are given (The Shift Project, 2019b):

— 10 hours of high definition video include more data than all Wikipedia texts in English

— based on the more recent available data (2018), carbon dioxide emissions from online videos were equivalent to Spain's total emissions (i.e. 1% of global emissions)

— carbon dioxide emissions of Vod (Video on Demand) suppliers, such as Netflix and Amazon, are equivalent to the emissions of countries like Chile.

6. For a Human-centric 4IR Model

Nowadays, it has become clear that only an entity like the EU is able to shape a relatively favorable balance of power to protect the interests of European societies against attempts to oligopolize and instrumentalize new technologies. The EU is a leading force at global level in relation to regulating the digital and technological sector (Satariano, 2022· Κοτσακά/Kotsaka, 2022). The Digital Market Act (European Parliament, 2022), the Digital Services Act (Zsiros, 2022), GDPR, the aforementioned legislative initiatives on regulating labor through digital platforms and managing digital data (Data Act), the proposal of the French Presidency of the EU on the development of digital commons (French Presidency of the Council of the European Union, 2022) and the European Commission's work on shaping a human-centric 4IR model (European Commission, 2020c) are major indicative initiatives in this direction.

In this context, and based on the work of the FORCE project, it is possible to submit a package of guidelines/proposals on deepening and enriching these critical efforts[12]. The following guidelines aim to overcome the current techno-centric approach that leads to the acceptance of everything that is feasible from a technological perspective and everything that is marketable and profitable from a business perspective, and to make the transition towards a human-centric approach that will promote and serve everything that is a) environmentally sustainable, b) resilient in economic terms, c) essential and necessary based on social needs and d) compatible with human rights.

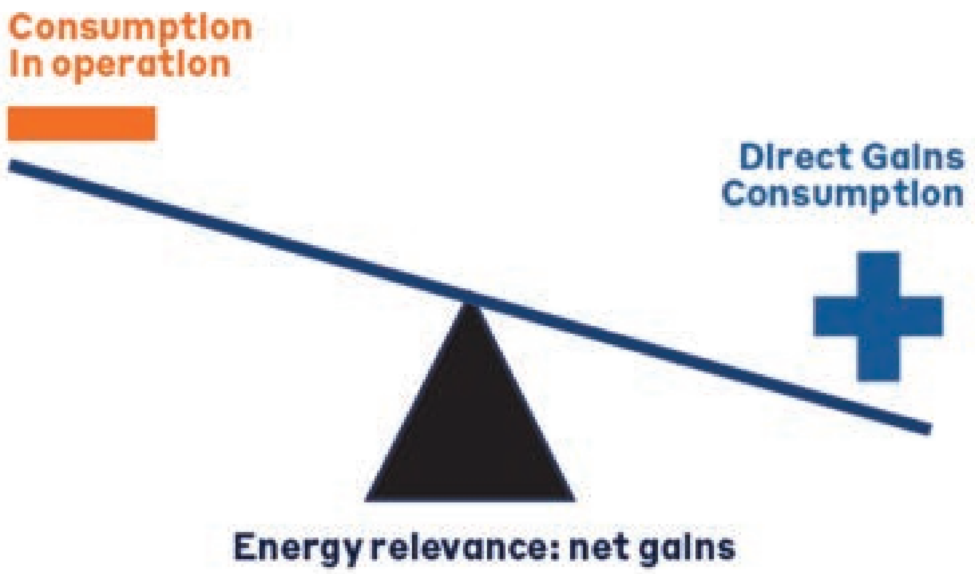
[12] Some of these proposals were discussed during the round table that took place in December 2021 in the context of the FORCE project: https://enaforce.eu/force-round-table/

Assessment of new technologies based on social value

A new evaluation system is necessary in order to clarify to what extent technological innovations are able to produce net social value. Therefore, the relevance of a technology in terms of sustainable development should be assessed on the basis of social, economic, environmental and strategic criteria. A reliable methodology to holistically assess new technologies will provide valuable information to European and national authorities regarding technologies that should be supported as a matter of priority and will contribute to timely identifying technological applications that have negative externalities for sustainable development.

From an environmental perspective, evaluation should take into account the full life cycle of products/services (production, consumption, maintenance, waste/recycling) and relevant infrastructures (data centers, networks). In a period with more and more products and services falling into the category of "smart" systems and solutions, it is necessary to provide for reliable cost-benefit analyses as regards the actual contribution of these devices into resilience and sustainability. This necessity arises from the fact that total energy consumption of a smart technology (from manufacture to use) may exceed the energy savings that it offers. Therefore, assessments must take into account factors such as total energy cost, actual benefits compared to non-interconnected technologies, indirect consequences of uses (maintenance cost, new infrastructures cost, etc.), problems that may arise from uses contrary to their purpose, such as rebound effects (increase in consumption resulting from more efficient uses and low production cost), and, overall, the net social value of smart technologies compared to other social needs and uses.

ASSESSMENT OF SMART TECHNOLOGIES



SOURCE: THE SHIFT PROJECT (2020)

Correspondingly, evaluation in terms of digital sovereignty and resilience must take into account potential vulnerabilities of new technologies against crises and external disruptions. The European Commission's Joint Research Center could, for instance, in collaboration with other agencies, bodies and institutions, play a pivotal role in the scientific support of the said works.

Empowering citizens-users of digital services

Users of new technologies and, in particular, of social media, contribute for free in the production of surplus value for digital companies ('free labor') through the commercial utilization of their personal data and the collection of their social activities (Σμυρναίος/Smyrnaios, 2017). On the contrary, their views are not taken into account sufficiently as regards policy-making, in contrast with the views of the big tech. The answer to the reasonable concerns expressed in the public sphere requires, therefore, to organize and conduct wide, open, inclusive and structured public debates and deliberations in relation to the 4IR's orientation in the post-pandemic era, taking into account the new economic, energy and geopolitical context caused by the Ukrainian crisis.

Contrary to approaches insisting on a "top-down" policy design, social participation can serve as a privileged tool for policy makers in order to achieve consensual policies on new technologies and for the assessment of their social value.

The new role of regulatory authorities and institutions

The establishment of powerful regulatory institutions at European and national level, able to monitor rapid technological advances and to intervene efficiently and timely, is regularly highlighted in public debate due to the asymmetry of information between tech giants and public authorities. For example, insufficient staffing of the competent European Commission's agencies is estimated to jeopardize the substantial compliance of digital companies with the European Union's flagship legislation "Digital Market Act" that will enter into force from 2023 onwards (Delépine, 2022).

The necessity to renew and reinforce regulatory institutions and policies is not new, as it has been underlined in public debate since 2000s, as a result of imbalances and inequalities that had already started to appear in the "liberalized" sectors of utilities (telecommunications, energy, transport). The adoption of a democratic and pluralistic form of regulation is a recurrent proposal in the public sphere overtime, aimed at overcoming the limiting framework imposed by regulation authorities for strategic sectors and 'services of general economic interest' exclusively based on EU Competition Law (Ευσταθόπουλος/Eustathopoulos, 2009). In this context, regulation authorities need to assume a broader role aiming, inter alia, to ensure a balanced relationship between general interest priorities and competition rules. In particular, public and regulation authorities could approach digital services and infrastructures based on the EU's "common values" in relation to 'services of general interest' (high level of quality, safety and affordability, equal treatment and the promotion of universal access and of user rights)[13].

[13] See: Consolidated version of the Treaty on the Functioning of the European Union, Protocol (No 26) on services of general interest (26 October 2012). Official Journal of the European Union Available at https://eur-lex.europa.eu/legal-content/EL/TXT/?uri=CELEX%3A12012E%2FPRO%2F26

This evolution would require a thorough reform of digital technologies governance framework involving both public policy makers (ministries) and regulatory authorities as well as the integration of a larger number of stakeholders (social partners, environmental organizations, local authorities, consumer and social actors, etc.) in consultation procedures. Assisting the said stakeholders and procedures through independent research bodies in order to provide the necessary scientific knowledge and expertise (technological, economic, legal, environmental, sociological and from a public health perspective) is crucial to the efficiency of the regulatory policy.

Supporting the production of social value

The digital economy's contribution to the sustainable development agenda requires an overall reshuffling of the sector's priorities aimed at freeing up resources from commercial uses of low social value in favor of modern applied policies of high social and collective value, such as (Francou, Gauthier, Jublin, Kaplan & Marchandise, 2019):

— concentration and utilization of health data for a more rapid and more efficient research, diagnosis and treatment of chronic diseases

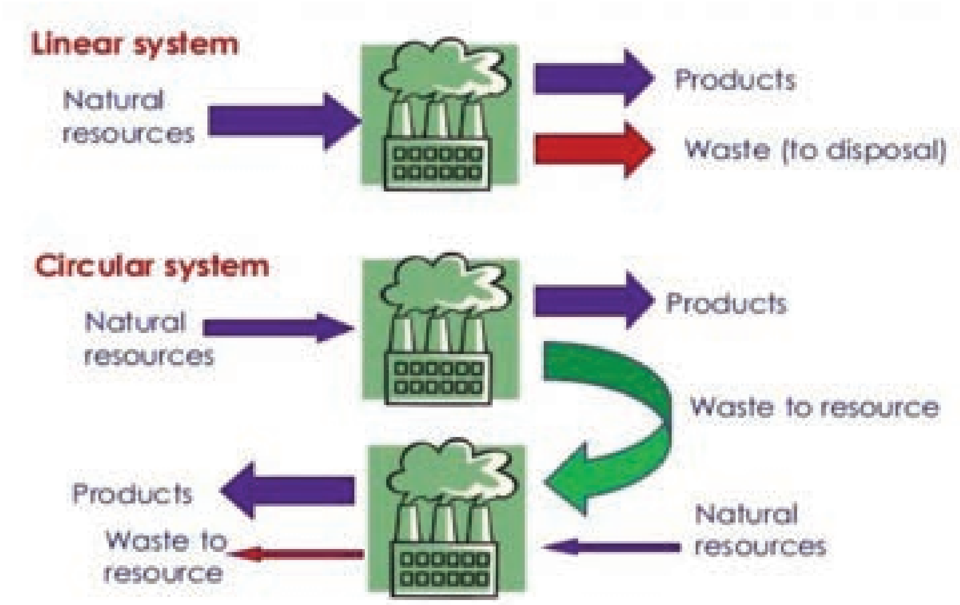
— development of telemedicine

— tackling social and spatial digital exclusion

— access to data in order to plan sustainable urban development policies and use of digital technologies to support and interconnect green development initiatives at local level (digital agriculture to support small value chains in the agricultural sector, support of energy production networks, etc.)

— development of applied technological solutions for the ecologic transformation of industry, such as the development of industrial symbiosis ecosystems and the use of new technologies to prevent and manage natural disasters and climate threats (Devves, Eustathopoulos & Sotiropoulos, 2021).

FROM THE LINEAR MODEL TO INDUSTRIAL SYMBIOSIS



SOURCE: Furn 360

For a just digital transition strategy

Tackling various inequalities related to the digital divide (income, social, spatial, age, between large and small enterprises) necessitates the implementation of a comprehensive strategy for a just digital transition, following the example of the just green transition that is already being implemented for climate and energy policy (European Commission, 2021). The establishment of a universal European and national digital public service to tackle the digital divide, with the aim to allow all citizens to efficiently and safely use quality and affordable digital services, could be a first step in this direction (e.g. access to universal and affordable high speed broadband (Kottelat & Molinoz, 2020). The said approach of the digital economy -based for example on the EU framework of services of general interest (CESI, 2012)- would rationalize public policies (Bauby & Moncomble, 2020).

In a more innovative version, public digital service could also include, in addition to actions ensuring the affordability (economic and spatial) and quality of services, a series of training activities to ensure that citizens, SMEs and educational and other bodies are able to use adequately digital tools. Indicative actions include the provision of tools for public bodies in order to support their capacity to evaluate the consequences of their technological choices or the training of citizens and parents to address digital practices that lead to addictions on the Internet (The Shift Project, 2019b).

Management of digital restructurings

The second part of a European strategy for a just digital transition must focus on timely preventing the social consequences of automation on employment. This strategy must include, inter alia, measures such as: a) management of digital restructuring at sectoral level, b) retraining of workers in areas for which high demand and skilled labor shortage are expected and c) reliable income support of workers after redundancies, in particular in declining regional and sectoral labor markets. The said interventions could be financed through measures such as the taxation of digital companies (EU digital levy) (Valero, 2021) and the introduction of a tax on jobs replaced by robots («robot tax»).

Applied digital ecology

The growing environmental footprint of new technologies makes it imperative to establish a virtuous circle between digital and green transition by utilizing the principles and applied policies of modern digital ecology (Vidalenc, 2021· Vardakoulias, 2021). Digital ecology summarizes numerous priorities, including the circularity of digital devices (see the right to repair under the European Green Deal) (Šajn, 2022) and the overall planning of public policies promoting moderation and sustainability in the development of digital economy, such as “lean ICT” and green innovations (“green ICT”).

In particular, strengthening the circularity of digital economy aims at designing environmentally responsible products and services: repairable and recyclable products with a significantly increased life cycle (Σωτηρόπουλος/Sotiropoulos, 2019). Right now, the collection and treatment of digital economy waste ranges at a very low percentage worldwide (only 17.4% in 2019) (Forti, 2020). The EU initiatives for the establishment of a “right to repair” are moving in the right direction. European countries could benefit from the aforementioned priorities aiming to develop enterprises that collect, repair, reuse and recycle materials in the digital economy sector, utilizing the potential of social and cooperative economy[14].

[14] See: Lundgren (2012) on the prospects of cooperative economy in the sector of electronic waste recycling.

However, strengthening circularity in digital economy does not seem possible without a powerful and comprehensive regulation of the sector (facilitating repair, extending guarantees and the duration of software, increasing taxation on the consumption of natural resources and rare raw materials, educational actions in relation to the sustainable use of digital services, etc.) (Vidalenc, 2020). Overall, the "ecological by design" approach is not only about reducing the environmental footprint related to the manufacture of equipment but also about minimizing consequences arising from their use. It is noted that the significant improvement in the energy efficiency of digital infrastructures achieved in recent years does not necessarily contribute in reducing total consumption. On the contrary, cost reduction leads to an intensification of uses, which is known as the«rebound effect».

Digital Commons, Commons Based Peer Production and Public Commons Partnerships

Nowadays, ensuring the openness of digital economy and collective ownership of data is becoming a key issue with regards to digital sovereignty and democratic regulation of the digital sector in Europe. The establishment of Public Commons Partnerships may drastically strengthen the potential of the 4IR and the production of higher and more diffused economic and social value (Kostakis, 2021· Kotsaka, 2021a· Kotsaka, 2021b· Papanikolaou, 2021). Commons Based Peer Production (CBPP) describes productive ventures in which people collaborate as peer partners to produce common value accessible to everyone and in open cooperative systems served by digital technology networks (Κοτσακά/Kotsaka, 2021).

CBPP practices mark a value shift from models based on ownership and oligopolistic players "fencing off" digital resources (through intellectual property rights and patents) to a model that promotes the right to use and access to a product or service. This model contributes to the production of value based on social needs, in contrast with the existing model privatizing resources, including knowledge and digital ones. This privatized model limits the potential for important scientific discoveries and innovations which do not meet the profitability criteria of the market. It should be noted that the extremely high concentration of digital resources and the role of digital commons as an alternative model are now explicitly recognized by European institutions, such as the European Council, in the context of the recent Building Europe's Digital Sovereignty Conference:

"In an age when a growing share of digital resources (e.g. software, data and physical infrastructure) is increasingly offered or captured by non-European firms, the conference will highlight the digital commons as well as non-rivalrous and non-excludable infrastructure, which represent an alternative to the monopoly-dominated tech offering." (French Presidency of the Council of the European Union, 2022).

4IR & intra-European inequalities

A central question posed during the FORCE conference refer to the geographical positioning of the 4IR's new activities and the role that member-states of the "EU periphery" with limited industrial and research activities will assume in the new division of labor. In particular, four categories of countries in Europe were specified depending on the progress they have made as regards the 4IR (Selimis, 2021): The Front-runners, the Potentialists, the Traditionalists and the Hesitants. The said categorization highlights the unequal starting points from where European economies enter the 4IR, which is depicted, inter alia, in the composition of Important Projects of Common European Interest, such as the IPCEI on microelectronics.

PARTNERS OF IPCEI ON MICROELECTRONICS

SOURCE: www.ipcei-me.eu

Overall, it is widely accepted that, in absence of a genuine industrial policy aiming to strengthen the innovative and productive base of the European periphery, the 4IR will become an additional aggravating factor for intra-European inequalities due to the concentration of new industrial activities in the center of Europe. On the contrary, a holistic industrial policy would allow all member-states and regions to equally benefit from new technologies, not only as consumers/users of imported digital and green innovations, as it is the case for less developed member countries, but as active actors in the production of technology-intensive goods and services. Supporting domestic production of cutting-edge technologies in Greece, for example, can contribute in the creation of highly skilled and highly paid jobs for the youth, reinforce the competitiveness of the domestic industrial basis and strengthen the country's security and defense (Ξηρογιάννης & Νικολαΐδης/Xirogiannis & Nikolaidis, 2022). As underlined in the FORCE conference, it is estimated that the EU smart specialization strategy cannot contribute to the necessary leapfrog of less developed EU member-states due to the em-phasis placed on existing static competitive advantages. The development of a new industrial policy aiming at a balanced diffusion of new knowledge-intensive activities throughout Europe requires wider and deeper changes in the overall approach to the industrial policy in Europe (Georgopoulos & Labrianidis, 2021):

• **First,** overcoming narrow policy approaches which focus on 'horizontal' measures only (e.g. deregulation of markets, privatization, business environment). The transition to an active and targeted form of support to new industrial activities requires the mobilization of a wider range of tools, including public procurement policy, provision of guarantees and subsidies, introduction of incentives for R&D, as well as targeted interventions in favor of SMEs.

• **Second,** and consequently, more holistic industrial policies are required which will serve broader social and environmental goals based on predefined missions, such as supporting climate neutrality, ensuring quality jobs, reducing inequalities and reversing population aging and brain drain, or more targeted applied industrial policies, such as promoting "industrial symbiosis", decentralizing the energy system and supporting the "green" restructuring of carbon-intensive industries and regions.

• **Third,** implementing a renewed industrial policy requires drastic changes in other public policy areas, such as competition and regional policy, as well as a reorganization of public administration so that the latter can meet the new increased strategic and operational challenges. Overall, European and national authorities must find again their ability to design and implement in the long-term, aiming to support social changes and fundamental productive transformations (Pontikakis, 2021). Reducing inequalities between the European center and the periphery requires the development of ambitious interventions that will address inherited structural problems in the South, including the underdevelopment of industrial activities, the extensive brain drain, the predominance of traditional economic sectors such as tourism and agriculture, the limited role of exporting sectors, poor performances in terms of economies of scale and entrepreneurial innovation and the shortage of critical infrastructures.

4IR DIMENSIONS	CURRENT MODEL	PROGRESSIVE MODEL
Assessment of new technologies	Based on market criteria (profitability)	Based on social needs and resilience
Regulation of the digital sector	Inefficiency of regulatory bodies/authorities against technological advances and big tech Regulation based on Competition Law Consultation mainly with internal stakeholders (market players)	Strengthening regulatory bodies to reduce information asymmetries Regulation based on the general interest (EU Law) Participatory-pluralistic-democratic regulation with the participation of external stakeholders (non-market/non-specialist players)
Contribution of technologies in sustainable development	Under-exploitation of 4IR opportunities to achieve SDGs Prevalence of a purely profit-oriented model producing low social value services	Supporting 4IR applications enabling the creation of social value for citizens
Conditions under which digital transition takes place	Digital divide and inequalities (social, income, spatial, age, between SMEs and large enterprises)	Juts digital transition strategy
Environmental footprint	Unsustainable increase of the climate and environmental footprint of digital sector	Transition to a policy framework based on digital ecology principles
Data	Privatization of users' data to produce corporate value	'Openness' and production practices based on commons in order to produce higher and more diffused economic and social value
Socio-cultural dimensions	Artificial Intelligence and surveillance of citizens Autonomous weapon systems Addictions to the Internet	Prohibition of services and applications that infringe human rights and harm public health
Labor	Inequalities Deterioration of labor conditions and terms (digital labor)	Ensuring labor and trade union rights
Resilience	Technological dependency (semiconductors, cloud, etc.) Dependency on raw materials	Strategy for strengthening critical industrial infrastructures and services, resilience and security
Diffusion of 4IR technologies	Based on the priorities of the market and with a high concentration in the core of Europe	Holistic industrial policy enabling the participation of European periphery in the 4IR

References

5G will prompt energy consumption to grow by staggering 160% in 10 years. (2021, 10 December). Datacenter Forum. Retrieved from https://www.datacenter-forum.com/datacenter-forum/5g-will-prompt-energy-consumption-to-grow-by-staggering-160-in-10-years

Bauby, P.& Moncomble, J.E. (2020). Les services publics, fondation cardinal de l' Europe. *La lettre mensuelle du CIRIEC-France (Juin 2020)*. Retrieved from http://www.actionpublique.eu/index.php/des-idees/148-les-services-publics-fondation-cardinale-de-l-europe-d-apres

Crispin, J. (2021, 5 August). Move over, space. Tech billionaires have a new utopian boondoggle: the "metaverse". *The Guardian.* Retrieved from https://www.theguardian.com/commentisfree/2021/aug/05/move-over-space-tech-billionaires-have-a-new-utopian-boondoggle-the-metaverse

Delépine, J. (2017, 6 July). Le cloud, enjeu majeur de souveraineté. *Alternatives Economiques*. Retrieved from https://www.alternatives-economiques.fr/cloud-enjeu-majeur-de-souverainete/00079066

Delépine, J. (2021, 15 November). L'espace en voie de privatisation. *Alternatives Economiques.* Retrieved from https://www.alternatives-economiques.fr/lespace-de-privatisation/00100087

Delépine, J. (2022, 26 April). La nouvelle arme anti-Gafa de Bruxelles est-elle à la hauteur. Alternatives Economiques. Retrieved from https://www.alternatives-economiques.fr/nouvelle-arme-anti-gafa-de-bruxelles-a-hauteur/00103101

Deutsch, J. (2022, 23 February). EU Unveils Rules to Force Firms to Share Product Usage Data. *Bloomberg.* Retrieved from https://www.bloomberg.com/news/articles/2022-02-23/eu-unveils-rules-to-force-firms-to-hand-over-product-usage-data

Devves, S., Eustathopoulos, Y. & Sotiropoulos, A. (2021). The dual aspect of the 4IR – environment nexus. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/07/SESSION-3_4IR-Environment-nexus.pdf

Doukas, H. (2021). Towards a consumer-centric approach. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Doukas-Presentation.pdf

European Commission (2020). *"Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability": Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.* Retrieved from https://eur-lex.europa.eu/legal-content/EL/TXT/HTML/?uri=CELEX:52020DC0474&from=EN

European Commission (2021). *Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts. Retrieved from* https://eur-lex.europa.eu/legal-content/EL/TXT/HTML/?uri=CELEX:52021PC0206&from=EN

European Commission (2022). *"A Chips Act for Europe": Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.* Retrieved from
https://eur-lex.europa.eu/legal-content/EL/TXT/PDF/?uri=CELEX:52022DC0045&from=EN

European Centre for the Development of Vocational Training (Cedefop) (2021). *Digital, greener and more resilient. Insights from Cedefop's European skills forecast.* Luxembourg : Publications Office of the European Union. Retrieved from http://data.europa.eu/doi/10.2801/154094

European Commission (2020a). *Critical raw materials for strategic technologies and sectors in the EU: A foresight study*. Retrieved from https://ec.europa.eu/docsroom/documents/42881

European Commission (2020b). *2020 Strategic Foresight Report: Charting the course towards a more resilient Europe*. Retrieved from https://ec.europa.eu/info/sites/info/files/strategic_foresight_report_2020_1.pdf

European Commission (2020c). *Industry 5.0: What this approach is focused on, how it will be achieved and how it is already being implemented.* Retrieved from https://ec.europa.eu/info/research-and-innovation/research-area/industrial-research-and-innovation/industry-50_en

European Commission (2021). *The Just Transition Mechanism: Making sure no one is left behind.* Retrieved from https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

European Commission (2022, 9 December). *Commission proposals to improve the working conditions of people working through digital labour platforms* [Press Release]. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6605

European Confederation of Independent Trade Union (CESI). (2012). *Providing high-quality public services in Europe based on the values of Protocol 26 TFEU. Brussels: CESI Académie Europe.* Retrieved from https://www.cesi.org/wp-content/uploads/2012/10/121129_Brochure-Protocole26-2-EN_DEF.pdf

European Parliament (2022, 24 March). *Deal on Digital Markets Act: EU rules to ensure fair competition and more choice for users.* Retrieved from https://www.europarl. europa.eu/news/en/press-room/20220315IPR25504/deal-on-digital-markets-act-ensuring-fair-competition-and-more-choice-for-users

Ευσταθόπουλος, Γ. (2009). Ο εκσυγχρονισμός των επιχειρήσεων & υπηρεσιών κοινής ωφέλειας: Μεταξύ ανταγωνιστικότητας & δημόσιου συμφέροντος. *Τετράδια Εργασίας του INE, 30,* 10-55. Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiu_52ykaL3AhUpu6QKHU_YCZUQFnoECAIQAQ&url=https%3A%2F%2Fwww.inegsee.gr%2Fekdosi%2Fepixeirhseis-dhmosioy-symferontos-apotelesmata-toy-g-kps%2F&usg=AOvVaw3xFaUhMRYhvRrcCtaC17i9

Flinders, M. & Blunkett, D. (2020, 13 November). Time to ditch the Dominic Cummings technocratic, mechanical vision of government. *The Conversation.* Retrieved from https://theconversation.com/time-to-ditch-the-dominic-cummings-technocratic-mechanical-vision-of-government-148836

Forti, V. (2020, 10 July). Global electronic waste up 21% in five years, and recycling isn't keeping up. *The Conversation.* Retrieved from https://theconversation.com/global-electronic-waste-up-21-in-five-years-and-recycling-isnt-keeping-up-141997

Francou, R., Gauthier, E., Jublin, A., Kaplan, D. & Marchandise, J.-F. (2019). L'agenda pour un futur numérique et écologique. *Fondation Internet Nouvelle Génération* (FING). Retrieved from https://fing.org/publications/l-agenda-pour-un-futur-numerique-et-ecologique.html

French Presidency of the Council of the European Union. (2022, 5 February). *The building Europe's digital sovereignty conference.* [Press Release]. Retrieved from https://presidence-francaise.consilium.europa.eu/en/news/the-building-europe-s-digital-sovereignty-conference/

Georgopoulos, D. & Labrianidis, L. (2021). Industrial policy in the context of globalization, climate change, international decoupling & the new technological revolution. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/07/SESSION-2_Industrial-policy_4IR.pdf

Grochowski, S. (2021, 5 May). *60 SpaceX Starlink satellites spotted across Metro Vancouver skies.* Retrieved from https://www.peacearchnews.com/news/video-60-spacex-starlink-satellites-spotted-across-metro-vancouver-skies/

Harari, Y.N. (2017, 24 July). Are we about to witness the most unequal societies in history?. *The Guardian.* Retrieved from https://www.theguardian.com/inequality/2017/may/24/are-we-about-to-witness-the-most-unequal-societies-in-history-yuval-noah-harari

Ινστιτούτο Εναλλακτικών Πολιτικών ΕΝΑ, Παρατηρητήριο Βιώσιμης Ανάπτυξης (2020, 15 Σεπτεμβρίου). Η συμβολή και το μέλλον της ψηφιακής οικονομίας στη μετα-covid19 εποχή. *Huffington Post*. Retrieved from https://www.huffingtonpost.gr/entry/e-semvole-kai-to-mellon-tes-psefiakes-oikonomias-ste-meta-covid19-epoche_gr_5f607f91c5b68d1b09c73561

Jimenez, I.W. (2020, 18 November). The transformative impact of tech firms' technologies. *Social Europe.* Retrieved from https://www.socialeurope.eu/the-transformative-impact-of-tech-firms-technologies

Jones, A. (2021, 21 April). *China is developing plans for a 13,000-satellite megaconstellation.* Retrieved from https://spacenews.com/china-is-developing-plans-for-a-13000-satellite-communications-megaconstellation/

Jourde, F. (2021, 11 November). La technologie sauvera-t-elle le monde? Solutionnisme technologique et autres mythes de la Silicon Valley. *Contretemps.* Retrieved from https://www.contretemps.eu/solutionnisme-technologique-mythes-silicon-valley-facebook-zuckerberg/

Kostakis, V. (2021). Interviews with experts. FORCE Interviews. Retrieved from https://enaforce.eu/videos/

Κοτσακά, Δ. (2021). Μια καινοτόμος οικονομική κουλτούρα από τα κάτω. *Ινστιτούτο Εναλλακτικών Πολιτικών ΕΝΑ.* Retrieved from https://www.enainstitute.org/%CE%BC%CE%B9%CE%B1-%CE%BA%CE%B1%CE%B9%CE%BD%CE%BF%CF%84%CF%8C%CE%BC%CE%BF%CF%82-%CE%BF%CE%B9%CE%BA%CE%BF%CE%BD%CE%BF%CE%BC%CE%B9%CE%BA%CE%AE-%CE%BA%CE%BF%CF%85%CE%BB%CF%84%CE%BF%CF%8D%CF%81%C E%B1/

Κοτσακά, Δ. (2022, 30 April). Modus Operandi/Hic sunt dracones;. *Η Αυγή.* Retrieved from https://www.avgi.gr/koinonia/413882_hic-sunt-dracones-1

Κοτσακά, Δ. (2021a). Knowledge commons, open access and social innovation. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/policy-papers-2/

Kotsaka, D. (2021b). Interviews with experts. *FORCE Interviews*. Re-trieved from https://enaforce.eu/videos/

Kottelat, Y. & Molinoz P. (2020). Services publics, services au public et aménagement des territoires à l' heure du numérique. *Les avis du Conseil Economique, Social et Environnemental (CESE), 16.* Retrieved from https://www.lecese.fr/travaux-publies/services-publics-services-au-public-et-amenagement-des-territoires-l-heure-du-numerique

Lee, K.F. (2021, 11 September). *The third revolution in warfare.* Retrieved from https://www.theatlantic.com/technology/archive/2021/09/i-weapons-are-third-revolution-warfare/620013/

Lundgren, K. (2012). *The global impact of e-waste: Addressing the challenge.* International Labour Office, SafeWork, Programme on Safety and Health at Work and the Environment. Geneva: ILO. Retrieved from https://www.ilo.org/sector/Resources/publications/WCMS_196105/lang--en/index.htm

Maçães, B. (2021, 29 September). The spirit of the age: Why the tech billionaires want to leave humanity behind. The New Statesman. Retrieved from https://www.newstatesman.com/long-reads/2021/09/the-spirit-of-the-age-why-the-tech-billionaires-want-to-leave-humanity-behind

Mahnkopf, B. (2019). The "4th wave of industrial revolution" – a promise blind to social consequences, power and ecological impact in the era of "digital capitalism". *Euromemo Group.* Retrieved from http://www.euromemo.eu/discussion_papers/index.html

Mahnkopf, B. (2021). The 4IR key-issues in the post-pandemic era. *FORCE Conference* (Athens 8.7.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Mahnkopf_FORCE. pdf

Maurice, E. (2022). Strategic dependencies, a question of sovereignty. *Fondation Robert Schuman.* Retrieved from https://www.robert-schuman.eu/en/european-issues/0630-strategic-dependencies-a-question-of-sovereignty

McCarthy-Jones, S. (2020, 11 September). How tech billionaires' visions of human nature shape our world. *The Conversation.* Retrieved from https://theconversation.com/how-tech-billionaires-visions-of-human-nature-shape-our-world-144016

Morozov, E. (2020, 15 April)*. The tech "solutions" for coronavirus take the surveillance state to the next level. The Guardian*. Retrieved from https://www.theguardian.com/commentisfree/2020/apr/15/tech-coronavirus-surveilance-state-digital-disrupt

Naughton, J. (2021, 24 July). Jeff Bezos's vision of life among the stars won't mend a broken world. *The Guardian.* Retrieved from https://www.theguardian.com/commentisfree/2021/jul/24/jeff-bezoss-vision-of-life-among-the-stars-wont-mend-a-broken-world

Ξηρογιάννης, Γ. & Νικολαΐδης, Α. (2022). Η Ελλάδα μπορεί να πρωταγωνιστήσει, με αιχμή την ταχύτερη υλοποίηση στρατηγικών από Πολιτεία και επιχειρήσεις. Προτάσεις για την ταχύτερη προσαρμογή της Ελλάδας στη Βιομηχανία 4.0. *Οικονομία & Επιχειρήσεις, Special Report, 72, ΣΕΒ.* Retrieved from https://www.sev.org.gr/ekdoseis/4i-viomichaniki-epanastasi-i-ellada-borei-na-protagonistisei-me-aichmi-tin-tachyteri-ylopoiisi-stratigikon-apo-politeia-kai-epicheiriseis/

Papanikolaou, G. (2021). Interviews with experts. *FORCE Interviews.* Re-trieved from https://enaforce.eu/videos/

PAX (2019, 19 August). *Major tech companies may be putting world at risk from killer robots.* Retrieved from https://paxforpeace.nl/news/overview/major-tech-companies-may-be-putting-world-at-risk-from-killer-robots

Paying attention: the attention economy. (2020, 31 March). *Berkeley Economic Review.* Retrieved from https://econreview.berkeley.edu/paying-attention-the-attention-economy/

Pontikakis, D. (2021). Understanding and managing industrial transitions. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Pontikakis-FORCE.pdf

Šajn, N. (2022). *Right to repair.* European Parliament, European Parliamentary Research Service. Retrieved from https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698869

Satariano, A. (2022, 24 March. E.U. takes aim at Big Tech's power with landmark Digital Act. *The New York Times.* Retrieved from https://www.nytimes.com/2022/03/24/technology/eu-regulation-apple-meta-google.html

Selimis, A. (2021). The 4IR: Key-issues in the post pandemic era. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/07/SESSION-1_Key-challenges.pdf

Semiconductor Industry Association (2021). 2021 state of the U.S. semiconductor industry. Retrieved from https://www.semiconductors.org/wp-content/uploads/2021/09/2021-SIA-State-of-the-Industry-Report.pdf

Simičević, V. (2019). The growing threat of internet addiction. *European Parliament, European Parliamentary Research Service, European Science-Media Hub.* Retrieved from https://sciencemediahub.eu/2019/01/09/the-growing-threat-of-internet-addiction/

Σμυρναίος, Ν. (2017, 24 June). *Digital Labor: Η φάμπρικα του 21ου αιώνα;.* Retrieved from https://thepressproject.gr/digital-labor-oligopolio-ergasia-kai-ekmetalleusi-sto-diadiktuo/

Σμυρναίος, Ν. (2018). Το ολιγοπώλιο του διαδικτύου & οι προκλήσεις της ψηφιακής εποχής. [Κείμενο συνέντευξης]. *Ινστιτούτο Εναλλακτικών Πολιτικών ΕΝΑ.* Retrieved from https://www.enainstitute.org/publication/%CE%BD%CE%AF%CE%BA%CE%BF%CF%82-%CF%83%CE%BC%CF%85%CF%81%CE%BD%CE%B1%CE%AF%CE%BF%CF%82-%CF%83%CF%84%CE%BF-%CE%B5%CE%BD%CE%B1-%CF%84%CE%BF-%CE%BF%CE%BB%CE%B9%CE%B3%CE%BF%CF%80%CF%8E%CE%BB%CE%B9%CE%BF/

Σωτηρόπουλος, Α. (2019). Κυκλική οικονομία: ένα μοντέλο για βιώσιμη ανάπτυξη & ευημερία. *Ινστιτούτο Εναλλακτικών Πολιτικών ΕΝΑ, Παρατηρητήριο Βιώσιμης Ανάπτυξης.* Retrieved from https://www.enainstitute.org/publication/%ce%ba%cf%85%ce%ba%ce%bb%ce%b9%ce%ba%ce%ae-%ce%bf%ce%b9%ce%ba%ce%bf%ce%bd%ce%bf%ce%bc%ce%af%ce%b1-%ce%ad%ce%bd%ce%b1-%ce%bc%ce%bf%ce%bd%cf%84%ce%ad%ce%bb%ce%bf-%ce%b3%ce%b9%ce%b1-%ce%b2%ce%b9%cf%8e/

The Shift Project (2018). *Lean ICT: Pour une sobriété numérique.* Retrieved from https://theshiftproject.org/article/pour-une-sobriete-numerique-rapport-shift/

The Shift Project (2019a). *Lean ICT: Towards digital sobriety.* Retrieved from https://theshiftproject.org/en/lean-ict-2/

The Shift Project (2019b). *Climate crisis:* The unsustainable use of online video. Retrieved from https://theshiftproject.org/en/article/unsustainable-use-online-video/

The Shift Project (2021). *Impact environnemental du numérique: Tendances à 5 ans et gouvernance de la 5G.* Retrieved from https://theshiftproject.org/article/impact-environnemental-du-numerique-5g-nouvelle-etude-du-shift/

Yun Chee, F. (2022, 23 February). EU rules take aim at illegal data transfer to non-EU governments. *Reuters.* Retrieved from https://www.reuters.com/technology/eu-rules-take-aim-illegal-data-transfer-non-eu-governments-2022-02-23/

Valero, J. (2021, 12 July). *EU puts its digital tax on hold after US pressure.* Retrieved from https://www.euractiv.com/section/economy-jobs/news/eu-puts-its-digital-tax-on-hold-after-us-pressure/

van der Klugt, G. (2022, 3 February). Data Act tightens conditions for EU – US data transfers even further. *Techzine.* Retrieved from https://www.techzine.eu/news/privacy-compliance/72395/data-act-tightens-conditions-for-eu-us-data-transfers-even-further/

Vardakoulias, O. (2021). Interviews with experts. *FORCE Interviews.* Retrieved from https://enaforce.eu/videos/

Vidalenc, E. (2021). Ecological and digital transition(s): Friends or enemies?. *FORCE Conference* (Athens, 08.07.2021).Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Vidalenc_FORCE.pdf

Vidalenc, E. (2020, 12 Φεβρουαρίου). Il faut imposer des limites au numérique. *Alternatives Economiques.*Retrieved from https://www.alternatives-economiques.fr/faut-imposer-limites-numerique/00091342

Vinuesa, R. (2021). AI and Sustainability. The 4IR key-issues in the post-pandemic era. *FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Vinuesa_FORCE.pdf

Vinuesa, R., Azizpour, H., Leite, I.and al. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature Communications,* 11 (233). doi.org/10.1038/s41467-019-14108-y

Voet, L. (2022, 21 March). *In the EU, platform workers scored a victory.* Retrieved from https://www.ips-journal.eu/work-and-digitalisation/platform-workers-in-the-eu-scored-a-victory-5811/

Voutyrakou, D. (2021). *Robotics & the SDGs. FORCE Conference* (Athens, 08.07.2021). Retrieved from https://enaforce.eu/wp-content/uploads/2021/11/Diana-Voutyrakou.pdf

Φωτάκης, Κ. & Σελίμης, Α. (2018). Η Ελλάδα μπροστά στην 4η Βιομηχανική Επανάσταση. *Ινστιτούτο ΕναλλακτικώνΠολιτικώνENA.* Retrieved from https://www.enainstitute.org/publication/%CE%B7-%CE%B5%CE%BB%CE%BB%CE%AC%CE%B4%CE%B1-%CE%BC%CF%80%CF%81%CE%BF%CF%83%CF%84%CE%AC-%CF%83%CF%84%CE%B7%CE%BD-4%CE%B7-%CE%B2%CE%B9%CE%BF%CE%BC%CE%B7%CF%87%CE%B1%CE%BD%CE%B9%CE%BA%CE%AE-%CE%B5%CF%80/

Zsiros, S. (2022, 9 February). *What is the EU Digital Services Act and how will it impact Big Tech?.* Retrieved from https://www.euronews.com/my-europe/2022/01/20/what-is-the-eu-digital-services-act-and-how-will-it-impact-big-tech

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