STUDY

Requested by the ITRE committee

European Parliament

Europe's Digital Decade and Autonomy

Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies
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Europe's Digital Decade and Autonomy

Abstract

This study on "Europe's digital decade and autonomy" aims to deliver an independent expert opinion and an assessment of the 2030 targets set by the Digital Compass and the overall Commission's Digital Strategy.

This document was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the committee on Industry, Research and Energy (ITRE) to establish an objective view on the progress made in recent years, ongoing actions, and the adequacy of future measures to be taken.

This document was prepared for the European Parliament's committee on Industry, Research and Energy.

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CONTENTS

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

5GIA	The 5G Infrastructure Association
AIDA	Artificial Intelligence in a Digital Age
CEAP	Circular Economy Action Plan
DA	Data Act
DGA	Data Governance Act
DEI	Digitising European Industry
DESI	Digital Economy and Society Index
DMA	Digital Market Act
DSA	Digital Services Act
DPP	Digital Product Passport
EC	European Commission
ECA	European Court of Auditors
ECSEL	Electronic Components and Systems for European Leadership
EIB	European Investment Bank
EIC	European Innovation Council
eID	Electronic Identification
EHR	Electronic Health Record
EP	European Parliament
ERDF	European Regional Development Fund
ERP	Enterprise Resource Planning
EU	European Union
EUV	Extreme Ultraviolet
FAB	Manufacturing plant that makes semiconductor devices

GAFAM	Google Amazon Facebook Apple Microsoft
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GPs	General Practitioners
IA	Impact Assessment
IaaS	Infrastructure as a Service
ICT	Information and Communication Technology
IDSA	International Data Spaces Association
IP	Intellectual Property
IPCEI	Important Projects of Common European Interest
ITRE	The Committee on Industry, Research and Energy of the European Parliament
IoT	Internet of Things
KETs	Key Enabling Technologies
MEP	Members of the European Parliament
MS	Member State
NIS	Network and Information Systems
NRRPs	National Recovery and Resilience Plans
OSA	Open Strategic Autonomy
PaaS	Platform as a Service
R&D	Research and Development
SaaS	Software as a Service
SDI	Sustainable Development Initiative
SME	Small and Medium Enterprises
STEM	Science, Technology, Engineering, and Mathematics

SWD	Staff Working Document
UK	United Kingdom
US	United States
VHCN	Very High-Capacity Networks

EXECUTIVE SUMMARY

Background

This is a critical moment for the European Digital Policy. In March 2021, the Commission presented Europe's Digital Compass, which lays out the ambitions for a successful digital transformation of Europe by 2030. This plan is critical to achieve the transition towards a climate neutral, circular, and resilient economy and highlights Europe's ambition to be digitally sovereign in an open and interconnected world, and to pursue digital policies that empower people and businesses to seize a human-centred, sustainable, and more prosperous digital future. The plan evolves around four cardinal points: 1) digitally skilled citizens and highly skilled digital professionals; 2) secure, performant and sustainable digital infrastructures; 3) digital transformation of businesses; 4) digitalisation of public services. It proposes ambitious digital targets in each area.

The communication follows President von der Leyen's address to make the following years Europe's "Digital Decade", responds to the European Council's for a Digital Compass and builds on the Commission's digital strategy of February 2020. More recently, the Policy Programme "Path to the Digital Decade" presented in September 2021 during the State of the Union's speech, aims to complement, fulfil, and implement the vision, targets, and actions of the Digital Compass, which proposes to engage in an annual cooperation mechanism with Member States to support them in achieving the targets set for 2030.

Aim

Given this strategic importance, the European Parliament Committee on Industry, Research and Energy (ITRE) requested this study on "*Europe's digital decade and autonomy*", which aims to deliver an independent expert opinion and enable the ITRE Committee to establish an objective view on the progress made in recent years, ongoing actions, and the adequacy of future measures to be taken. The present study will contribute to the current debate on Europe's digital policy in different ways. First, it provides an analysis of the trends, including promises, challenges, and risks of each of the four cardinal points of the Digital Compass. Second, the study presents a comprehensive overview of the different policy measures in each of the four dimensions, with a dedicated section on the funding needs and investment gaps. Third, an independent critical assessment of all the targets set by 2030 will integrate the recently published evaluation published in the Staff Working Document accompanying the new Policy Programme "Path to the Digital Decade". The quantitative assessment, carried out with advanced analytical techniques, is complemented with an overall critical assessment, which also considers the policy measures and the funding mechanisms in place. Finally, the study discusses the contested concept of digital strategic autonomy and digital sovereignty, which have become key terms in the European political debate.

Key Findings

The Digital Compass has set ambitious targets for 2030 and some of them do not appear feasible unless new policy measures are introduced, and additional investments are made. First, on digital skills, our quantitative forecast indicates that the three targets for 2030 are over ambitious. In addition, because of the COVID-19 crisis, there is also a risk that the gap, between men and women employed as ICT specialists, will widen in the coming years.

Second, the conclusions for the four targets, under the second cardinal point for infrastructure, are mixed. The connectivity target can be reached by 2030, especially for what concerns the coverage of Very High-Capacity Networks (VHCN) for all European households. For the target on edge nodes there is no available data for a quantitative forecast. While the cloud computing market is dominated by hyperscalers and is beyond Europe's reach to reverse the situation, edge computing is an open market with no incumbents, where Europe may play an important role and avoid dependencies on third countries.

The Gaia-X initiative is a positive example of how the EU digital sovereignty will be at least substantiated by an EU "digital jurisdiction" provided by Gaia-X servers, as the cloud services of the system will be required to comply with European regulation. Lastly, the target on the production of semiconductors, which calls for increasing the current 10% global market share to 20%, appears very ambitious given the investment gaps, the lack of public funding and the current minor role that Europe plays as compared to China and the United States (US). In addition, the analysis of the value chain shows that this market is very complex and there are no global independent players. Therefore, it is more important to strategically decide where to concentrate efforts rather than generically defining a 20% of production target. In this context, the recently announced European Chips Act will have to better define the target's strategic goals. For instance, the focus on a Semiconductor Research Strategy is a positive starting point, as it recognises the main European strength in this sector.

Third, there are different targets for the digital transformation of businesses. The target for SMEs with a basic level of digital intensity is ambitious but could have a large impact considering that the European economy is dominated by SMEs. Overall, the importance of SMEs should have been emphasised in the Digital Compass and other policy measures. There is still a large gap of digital intensity between SMEs and large enterprises. The figures from 2019 show that the share of large enterprises employing ICT specialists (76%) is more than 5 times higher the share of SMEs employing ICT specialists (14%). In addition, only 20% of enterprises provided training in digital skills to personnel, 68% of which were large enterprises and only 15% SMEs. Similarly, the use of cloud computing is close to 40% among large companies, and below 15% for SMEs. Finally, on the use of advanced technologies, European enterprises, especially SMEs, are lagging on the uptake of AI and Big Data. The Digital Europe Programme allocates €2.1 billion for AI in the next seven years, which is limited compared to the Europe's global competitors. Without new funding mechanisms and governance, also the target of doubling European unicorns by 2030 will be difficult to reach. A concrete strategic analysis of Europe's strengths and weaknesses should accompany this target and make it less generic. Strategic areas should be defined and supported by the EU. In this regard, it should however be considered the complementary investments that EU Member States should make. For instance, the Commission proposed that the EU invests in AI at least €1 billion per year from the Horizon Europe and Digital Europe programmes. EU-level funding on AI should then attract and pool investment to foster collaboration among Member States and maximise impact by joining forces.

Fourth, for what concerns targets on digital public services, the first target (i.e., all key public services should be available online by 2030) is conceptually flawed. What matters is not how many services are available online, but rather the extent to which these are used by citizens and businesses. In addition, a target that was discussed years ago but now seems forgotten is the reduction of administrative burden for citizens and businesses by online public services. Finally, this target may push public agencies that want to receive quick institutional recognition, to simply move their services online in silos fashion. In this way, urgency may force them to purchase services by large, non-EU tech companies, which goes against the overall European strategic objective of becoming less dependent. In this regard, the public sector should be considered not only as a service provider, but rather as an enabler facilitating the adoption and use of technologies, especially trough public procurement of emerging technologies, such as AI. In this respect, the upcoming Adopt AI Programme of the European Commission, which is a new programme to reinforce the uptake of AI in the public sector, is welcome.

Finally, the study also presents cross-sector general conclusions and recommendations, based on the limitations that were identified in the Digital Compass. For instance, it seems that there is an overall lack of sectorial and strategic analysis of the value chains to identify European strengths and weaknesses compared to other global leaders, as well as strategic control points where to focalise efforts. In addition, the funding mechanisms presented as part of the strategy are less prominent as compared to policy and legislative initiatives. In many cases, references are made to new funding mechanisms or the use of existing

possibility to allow for state subsidies that are yet to be operationalised. For instance, stakeholders lamented a lack of financial support for upgrading digital skills that are a pillar for the modernisation of European industry. More funds for SMEs and scale-ups are needed, considering that the number of European scale-ups is still less than a third of those in the US. Lastly, the proposed regulations should consider thoroughly the costs they may impose on businesses both in terms of administrative burden and conformity tests and audits. For instance, the proposal for the AI Act, if adopted, could be challenging for most companies. According to Obendiek (2021), for instance, the EU has focussed significant efforts on regulation to remedy the negative consequences of its weak position in digital governance. While many of these regulations will increase protection of civil liberties and consumers' rights, they are unlikely to enable Europe to regain a global position in online platforms or cloud computing.

1. INTRODUCTION

In this introductory chapter we present the rationale of the study, anticipate some of the key themes and briefly outline its content structure. This study has been written during a critical moment for European Digital Policy. On 15th September 2021, European Commission's (EC) President Ursula von der Leyen, in her State of the Union speech addressed to the European Parliament (EP), presented the Policy Programme Path to the Digital Decade. In addition, the drafting of an 'Inter-institutional declaration on Digital Principles' has begun and should be concluded by the end of 2021. This study integrates the latest policy developments that took place at the time of writing.

An independent opinion: the need to build a map

On 9 March 2021, the Commission presented the Communication on Europe's Digital Compass to a successful digital transformation of Europe by 2030 (European Commission, 2021a), which follows on the footsteps of the Digital Strategy adopted in February 2020 (European Commission, 2020ac). More recently, the Policy Programme *"Path to the Digital Decade"* presented in September 2021 aims to complement, fulfil, and implement the vision, targets, and actions of the Digital Compass (European Commission, 2021v). With the new programme, the Commission proposes to engage in an annual cooperation mechanism with Member States (MSs) to support them in achieving the targets set for 2030. The mechanism consists of the following elements: (i) a transparent monitoring system based on an enhanced Digital Economy and Society Index (DESI); (ii) an annual report on the "State of the Digital Decade" to evaluate progress and provide recommendations; (iii) multiannual digital decade strategic roadmaps for each Member State; and (iv) a mechanism to support the implementation of multi-country projects. Given this strategic importance, the Committee on Industry, Research and Energy (ITRE) of the EP requested this study on "*Europe's digital decade and autonomy*", which aims to deliver an independent expert opinion and enable the EP to establish an objective view on the progress made in recent years, ongoing actions, and the adequacy of future measures to be taken. To provide the ITRE Committee with an independent opinion of the policy review, what we performed is much broader than simply focussing on the Digital Compass, which in some ways appears as a "*Compass without a Map"*. Although the Compass identifies objectives and targets, it lacks policy interventions that are clearly integrated and coherent and furthermore includes some inconsistencies in both the objectives and targets. Instead, to assess the progress made so far and the adequacy of measures, a deep dive into other policies and regulations was needed to reconstruct a comprehensive Digital Decade Intervention Logic.

Key themes

Under the assumptions of major reforms and the investment of needed funds, it has been estimated that the digital transformation of Europe could yield 14% of cumulative additional GDP growth by 2030 (McKinsey & Co., 2020). These promises, however, also bring challenges in terms of needed investments and a level playing field. To reach the potential benefits from digital transformation the EIB quantifies the EU investment gap to €65 billion per year (EIB, 2016, 2020, 2021b). This gap may have increased due to investment cutbacks in the private sector due to the Covid-19 crisis (European Commission, 2020b). On the other hand, the Staff Working Document (SWD) that identified the financial recovery needs (European Commission, 2020b, p. 18), estimated that the Europe investment gap vis-à-vis US and China for the digital transformation is €125 billion per year. European industry faces some hard strategic dependencies such as in cloud computing and semiconductors (European Commission, 2021g), which also point towards the need of levelling the playing field with respect to unfair commercial practices (Ernst & Young, 2018) and state subsidies (European Commission, 2020ah). The issue of fair competition also concerns online platforms, where the dominance of American and Chinese players has already been established (Lechardoy et al. 2021).

There are also risks related to several technologies: those concerning AI and its data have received the most attention, as analysed in the Commission's Impact Assessment (IA) (European Commission, 2021d) supporting the AI Act proposal (European Commission, 2020aa).

Using a metaphor introduced by one of the authors of this report (see EIT Digital, 2020a and 2020b), a lot of new instruments are becoming available for the "*shapers*" (i.e., the regulators), but they should be complemented by more support for non-incumbent 'makers' (i.e., the innovators) to emerge. As one of the interviewed experts put it: "*You become sovereign because you are powerful, not because you regulate others.*" Because resources are limited, there is a need to make choices based on a thorough analysis of value chains to identify European strengths, weaknesses, and strategic control points that need more focussed actions. There are several roadmaps, agendas, and plans that remain too high-level and without clear focal points. High-level visions should be complemented with more strategic value chain analyses and operational plans. Europe faces three challenges and must make choices: how to leverage existing strengths through a strategic industrial policy? How to secure access to foreign suppliers through digital trade policy and digital diplomacy? How to increase its resilience in the global value chain?

Structure of contents

The reminder of this report is structured as follows. Chapter 2 presents the landscaping of the main domains. It starts with a rapid review of promises, challenges and risks in section 2.1, and proceeds with the landscaping of the domains grouped by the four pillars of the Digital Compass. Chapter 3 starts with the policy review in section 3.1 that focuses on all relevant policy packages and includes an assessment of investments needs and available funds. The inputs of this section are then used in the critical assessment of the policy instruments and targets presented in Section 3.2. Then, Section 3.3 consists in a short monographic zoom on the Sustainable Product Initiative (SPI) and the related proposal for a Digital Product Passport (DPP). Chapter 4 discusses the concept of Digital Autonomy and envisages a possible evolution of the European approach. We conclude in Chapter 5 with preliminary policy recommendations. Furthermore, in the Technical Annex (Section 6) we present a brief technical note on the quantitative analysis of the Digital Compass targets.

2. LANDSCAPING

2.1. Promises, challenges, and risks

2.1.1. Promises

When the Industry 4.0[1] initiative emerged a decade ago, the digitisation of industry was expected to deliver tangible economic gains related to efficiency, productivity, increased revenues, and investments (see EIT Digital, 2019). Furthermore, it was expected that digital networking would allow for the direct involvement of customer demands and the cost-effective customization of products and services. Similar potential gains were presented for the EU in the Commission communication on the Digitising European Industry (DEI) initiative (European Commission, 2016c).

Great expectations also surrounded the full deployment of IoT with an expected impact on automotive, industry, retail, and smart building equipment. They can help increase energy efficiency and public transport, as well as health outcomes through better remote monitoring of patients. They also hold the promise to make our cities smarter and more sustainable, as underscored in the communication on sustainable smart mobility and transport (European Commission, 2020af). The European Commission expects AI to significantly improve the lives of EU citizens and bring major benefits to society and economy through better healthcare, more efficient public administration, safer transport, a more competitive industry, and sustainable farming (European Commission, 2018c). According to an econometric study, during the Digital Decade Europe could gain €2 trillion in value and two million additional jobs by harnessing the power of data and international data transfers (Digital Europe, 2021a). According to the factsheet (European Commission, 2020r), supporting the Data Strategy (European Commission, 2020o), the creation of a single market for data seems poised to generate really 'big data': global data volume will grow from 33 zettabytes in 2018 to 175 zettabytes in 2025, with the value of data going from €301 billion (2.4% of EU GDP, 2018) to €829 billion (5.8% of EU GDP in 2025) and the number of data professionals will increase from 5.7 million to 10.9 million. Given the well-known shortages of specialists and the limited investments available, such increase seems overambitious.

In the presentation of the proposal of the Data Governance Act (DGA), the Commission presents a long list of potential benefits from data-driven innovation[2], of which we report the two most optimistic estimates: a) health data will save €120 billion a year in the EU health sector by improving personalised treatments, providing better healthcare, and supporting the cure of rare or chronic diseases; b) mobility data will save users of public transportation more than 27 million hours and up to €20 billion a year in labour costs of car drivers through real-time navigation. A study produced by McKinsey & Co for DG Connect produced a macro-economic simulation, under a set of conditions, according to which the digital transformation of Europe could yield 14% of cumulative additional GDP growth by 2030 (McKinsey & Co., 2020). The conditions are implementing reforms, as well as stepping up investments in Research and Development (R&D) and technological deployment. The European Investment Bank (EIB) (EIB, 2021a) considers that AI and blockchain could greatly contribute the creation of opportunities, growth and jobs for a green and digital economy. Furthermore, global gross domestic product (GDP) could increase by up to 14% (the equivalent of €13.3 trillion) by 2030 because of the accelerating development and take-up of AI (this considers only AI, whereas the McKinsey's report estimated the impact of global digital transformation).

[1] Industry 4.0 is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology.

[2] See: https://digital-strategy.ec.europa.eu/en/policies/data-governance.

2.1.2. Challenges

These promises, however, are based on the assumptions of realised reforms and suitable investments. In paragraph 3.1.6 of chapter 3 more details are provided on investment needs and gaps. Here we will just present an anticipation. Are the EC, European governments, and European companies capable and/or willing to make the investments needed to fully realise the promises of digital transformation? The reality, as it emerges from other EIB reports and the European Court of Auditors (ECA), casts some doubts on how realistic these scenarios are. According to a report from the ECA (2020), EU businesses are not fully exploiting advanced technologies to innovate. Furthermore, the uptake of advanced technologies by industry varies across sectors and between EU countries and regions. There are also wide disparities between large companies and small and medium-sized enterprises (SMEs), as 54 % of the former are highly digitised, against only 17 % of the latter. According to the EIB investment survey (EIB, 2021c), EU firms expect to reduce investments in the coming year. Almost half of EU firms (45%) say that coronavirus has negatively impacted their investment plans, leading them to delay or abandon plans at a time when they need to adapt to the green and digital transition. The gaps in cloud computing and semiconductors also point towards the need of levelling the playing field with respect to unfair commercial practices (Ernst & Young, 2018) and state subsidies (European Commission, 2020ah). The issue of fair competition also concerns online platforms since the dominance by American and Chinese players in cloud platforms has already been established (Lechardoy et al., 2021).

2.1.3. Risks

While the use of certain technologies poses risks, those concerning Artificial Intelligence (AI) and the related use of data have received the most attention, as reported in the Impact Assessment (IA) (European Commission, 2021d) supporting the proposal for the AI Act (European Commission, 2020aa). These risks concern EU safety and security regulations, and the breach of fundamental rights of citizens which violate EU values, such as: human dignity and personal autonomy; privacy and data protection; discriminatory outcomes; etc. Discriminatory outcomes have attracted particular attention. As put by the EP Special Committee on Artificial Intelligence in a Digital Age (AIDA): "*The occurrence of unintended bias being coded into AI algorithms and applications stems from bias present in the underlying data. Biased data sets create biased models and lead to biased predictions and decisions. There may be severe discrimination implications, affecting disparate groups, based on discriminatory factors or proxies for discrimination, such as gender, age, or other inherent characteristics*" (AIDA, 2021a, p. 3). Biases in algorithms, which produce discrimination, represent a clear concern since the right to non-discrimination is deeply embedded in the normative framework that underlies the EU. It can be found in Article 21 of the Charter of Fundamental Rights of the European Union (EU), Article 14 of the European Convention on Human Rights, and in Articles 18-25 of the Treaty on the Functioning of the EU. Although technological advancements will steadily correct such biases, until then, concerns remain regarding individual profiling and classification for the sake of surveillance or of discriminatory marketing practices. The workplace is another area where the risk of AI is concrete and much discussed. There are concerns about the risk of new digitised forms of workers' surveillance that might be discriminatory and violate their rights (De Stefano, 2019; Eurofound, 2020; Ponce del Castillo, 2020; Todolí-Signes, 2019, 2020). In healthcare, AI can help combat pandemics and disease outbreaks, enhance research, and develop new medical devices, drugs, and treatments. Yet, in applications where human lives are at stake, it must be monitored strictly to guarantee safety, prevent discrimination and biases, assign liability, and ensure the protection of personal data (AIDA, 2021c). There are also risks for democracy. As new technologies and forms of media emerge, existing models of governance - including democracy - are being challenged. New informational technology, that fundamentally rewires societies and technology's impact on governance, cannot be underestimated.

Coupled with disintermediation, a truth crisis and a perception crisis are emerging, amplified by the persuasive power of new AI applications that can lead to a paralysing information asymmetry that threatens democracies (AIDA, 2021b, p. 4).

2.2. Digital citizenship, digital skills, and labour market

In addition to the four pillars, the Digital Compass (European Commission, 2021a, pp. 12-13) discusses digital citizenship from which some digital principles are derived. Two of these principles – "universal Internet access" and "Universal digital education and skills" for people to take an active part in society and in "democratic processes" – deserve a separate treatment in view of what has emerged due to Covid-19 and related measures. The pandemic has provoked massive, immediate, and unprecedented changes in the use of digital technologies and media (Guitton, 2020). The digital surge has put our existing infrastructures under stress and made us aware that effective universal Internet access is not yet a reality (ITU, 2020).

New forms of digital inequalities

As a result, digital divides and inequalities have resurfaced as a social risk and policy concern (e.g., Beaunoyer et al., 2020; De' et al., 2020; Esteban-Navarro et al., 2020; Guitton, 2020; Hantrais et al., 2021; Lai & Widmar, 2021; Ramsetty & Adams, 2020; Seifert et al., 2021; Tsai & Wilson, 2020; Van Lancker & Parolin, 2020; Wenham et al., 2020). Low-income households, presumably less well equipped in quantity and quality of technological devices, suffer more severely from the immediate and long-term economic consequences of the crisis (Van Lancker & Parolin, 2020). Evidence regarding COVID-19 impacts on social health inequalities are already pilling up, with women, older adults, homeless populations, and low-income households more affected by the crisis (Tsai & Wilson, 2020; Wenham et al., 2020). Older adults who are frail and not online, many of whom are in long-term care facilities, struggle with the double burden of social and digital exclusion. A national representative survey conducted across 17 European countries showed that 51% of people aged 50 and older do not use the internet (König et al., 2018). The pandemic has accentuated the effects of the persisting regional divide and urban/rural divide (see Esteban-Navarro et al., 2020 for an extensive review of data and studies on this topic; see also Lai & Widmar, 2021). A recent document by the EC (2021s), shows that while on average the urban/rural divide was closing, in certain countries there are still rural regions that are excluded from access to broadband. So, digital citizenship is also a matter of having universal access to excellent and secure connectivity and everywhere in Europe. The following figures show the marked inequalities:

- Access to broadband varies from 74% of households in the lowest-income quartile to 97% in the highest-income quartile[3]; and
- While the ambition is that 90% of people, without formal education, should be regular internet users, formal education has a significant impact on the use of internet, as in 2019 68% of people with low or no education use the internet less than once a week, compared to 97% of people with high education[4].

Digital skills and new challenges

Beyond the necessary physical access, basic digital skills are also important to fully be a digital citizen. Basic digital skills have become a prerequisite for full participation in society due to the proliferation of digital technology and digital services and the pandemic generated digital surge.

[3] Eurostat, Survey on ICT usage in households and by individuals, 2019, as reported in European Commission (2020n).

[4] Eurostat, Individuals who are regular internet users (at least once a week), 2019.

There are still gaps to be filled as shown selectively by the following data:

- Although 85% of citizens used the internet in 2019, prior to the COVID-19 crisis, only 58% possessed at least basic digital skills[5];
- In 2020 adults with basic skills were 184 million and should go up by 25% and reach 230 million as per the European Skills Agenda[6]; and
- More than one in five young people fail to reach a basic level of digital skills across the EU[7];

Digital skills can be defined across three main categories (Gallardo-Echenique et al. 2015; Ilomaki et al. 2011): (i) basic functional skills that enable access and engagement with digital technologies, which can be applied both to the workforce and generally to individuals in knowledge society (as mentioned previously); (ii) generic skills that allow for meaningful and beneficial use of digital applications in a workplace; and (iii) higher-level skills that include both categories above and the skills needed in the digital sector to develop new digital solutions, products or services (Broadband Commission, 2017).

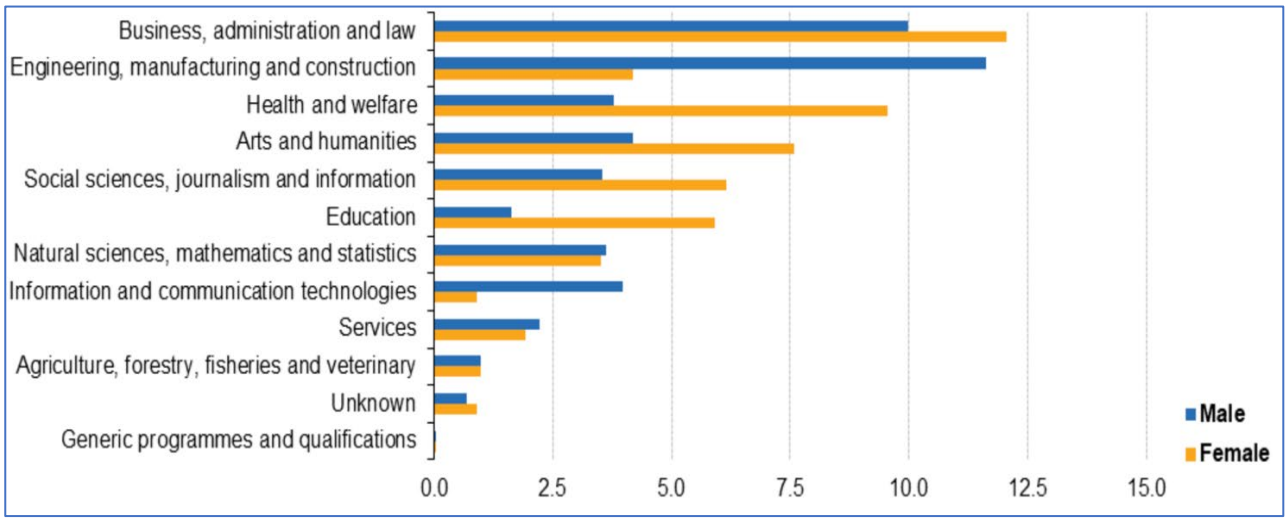
Digital skills and labour market transformation

Although there has been much discussion about the risk of automation and AI destroying most jobs, the advent of a singularity where machines fully substitute human work seems unlikely (Aghion et al., 2019). Instead, there will be a shift in desired skill sets with the implementation of AI and automation in the workplace; automation alone is expected to change 42% of the core skills required from workers (World Economic Forum, 2018b). According to the European Digital Skills Survey, 90% of employers reported that professionals, technicians, sales workers, or skilled agricultural workers are required to possess at least basic digital skills (European Commission, 2016g). Although in much smaller proportions, workplaces also often require basic digital skills for office workers (almost half of workplaces), plant machine operators (34% of workplaces) and even employees in elementary occupations (27% of workplaces). Since technological progress is fast, such skills are quickly becoming obsolete with new skills always being scarce (Deming et al., 2018). As reported in the SWD supporting the Digital Education Action Plan (European Commission, 2020a, p. 54), in 2018 there were around 7.4 million ICT specialists in employment across the EU, of which 1.7 million were employed in Germany and 1.1 million in France (1.1 million). According to Eurostat data (Eurostat, 2021a), in 2020 19% of European enterprises employed ICT specialists. Out of this percentage, 76% worked in large enterprises and only 14% worked in SMEs. Among the enterprises that employ and recruit ICT specialists, 29% of large enterprises reported having a hard-to-fill vacancy, whereas this percentage decreases to 10% for medium enterprises and shrinks to only 3% for small enterprises.

European institutions, of upper-secondary and higher education, are not yet responding to the new labour market needs. In 2018, only 3.8% of EU graduates received an ICT degree (Eurostat, 2020a). Furthermore, the situation of currently enrolled students does not show much improvement as shown by Figure 1, which also clearly demonstrates the existence of a severe gender gap in ICT.

5 See (European Commission, 2020h, p. 53).
6 See (European Commission, 2020q).
7 See (European Commission, 2020p).

Figure 1: Distribution of enrolled graduate students by field and sex (EU27, 2018)



Source: Eurostat (2020a), online source code: educ_uoe_enrt04.

Gender gap

As shown in the previous graph, women, which constitute just over half of all graduate students (54%), are particularly underrepresented in STEM and ICT education (Eurostat, 2020a). Despite large differences between countries, on average women hold only 17% of tech sector jobs (European Parliament, 2020b). The pace of change is not promising and indicates that, without intervention, the gap in Europe will widen (EIGE, 2018). Women are particularly underrepresented in specific sub-fields, such as cybersecurity (European Parliament, 2020b) and AI (World Economic Forum, 2018a).

2.3. Digital infrastructure

Although the Digital Compass places them as part of digital infrastructure, to highlight both their dependencies and opportunities, in this study we will discuss generic Key Enabling Technologies (KETs), semi-conductors, clouds, and edge computing in the section on industry.

Broadband and impact of Covid-19

The access to high speed broadband access can have many expected positive impacts, both on the micro and macro scale. For example, rural areas, which lag behind urban areas in terms of connectivity, can experience positive effects on employment growth (Whitacre et al. 2014). On the macro scale, access to high speed broadband can lead to macroeconomic growth due to the fostering of competition and the dissemination of ideas and information (Czernich et al.2011). Currently, the COVID-19 crisis has shed light on the disparities of the access and use to this type of broadband. When considering its uptake, there is a large gap in subscription; while two out of three households are potentially covered by ultrafast fixed broadband networks services, only one in four households are actually subscribed to them (European Commission, 2020h).

5G and 6G networks

The deployment of 5G networks has great economic and political (security, geopolitics) importance (Albrycht & Swiatkowska, 2019; European Commission, 2016a; ITU, 2018, 2019; Network and Information Systems (NIS) Cooperation Group, 2019, 2020). The new networks are deemed crucial to secure the strategic autonomy of the Union (NIS Cooperation Group, 2019, p. 3). As for the economic impact, according to Accenture's report "The Impact of 5G on the European economy", 5G could drive up to €2.0 trillion in incremental gross output (sales) in growth between 2021 and 2025. Since Europe's launch of the 5G Action Plan in 2016, which promoted early deployment of 5G infrastructure across MS, 5G deployment

has rapidly accelerated. This was especially seen in 2020, when many countries identified 5G as a key lever for their post-pandemic recovery strategies.

There are, however, several obstacles currently delaying the deployment of 5G networks, all of which were anticipated by the ITU (2018; 2019): cybersecurity, spectrum fragmentation, standards development, availability of devices, high capital/operating expenditure range. When considering 5G, it is critical to also consider 6G networks[8] which, while still in the research phase, are expected to comprise of a self-sustaining ecosystem of AI and bring unrestricted wireless connectivity (5GIA, 2021). For Europe to compete globally in 6G, the 5G Infrastructure Association (5GIA) calls for the strengthening of digital technology, software, communication guidelines, visualisation, cloud, microelectronics, photonics, and cloud in industry and academia.

Cybersecurity

Europe first began addressing overall cybersecurity through EU-wide legislation in 2016 when it launched the Network and Information Systems (NIS) Directive. The impact of this legislation has shown to be generally positive, as confirmed by a large survey of 251 organisations of operators of essential services and digital service providers (ENISA, 2020). In March 2019, the European Council supported a concerted approach to the security of 5G networks and the EC adopted the previously cited Recommendation, (NIS Cooperation Group 2019). This has been followed by a new definition of 5G network security tool box (NIS Cooperation Group, 2020) Furthermore, barriers to deployment of 5G include the need of sizeable investments (ITU, 2018; ITU 2019), which private players may not be willing to do or may undertake selectively adding to the emerging divide. In fact, the global roll-out is estimated to cost service providers $325 billion by 2025[9]. In Europe, the challenge for SMEs has been valued as a €4.6 billion annual gap in the funding of 5G-related business models (EC, 2021g).

IoT

The potential of IoT comes from the combination of hardware architectures (such as sensors, smartphones, and wearable devices along with 4G/5G and Bluetooth networks) and software such as "data storage platforms and analytics programmes that present information to users" (Walport, 2014, p. 13). The large trove of data generated by IoT connections and devices will create fresh resources for the growth of data analytics and AI uptake in Europe (Palovirta & Grassia, 2019). A study for the EC DG CNECT, which gave an overview of the European IoT ecosystem, found that factors that drive innovation include financing, funding and economic balance, operational and management best practices, among others. In particular, it found that while SMEs drive innovation as much as larger companies, many of them may not be able to sustain relevant investment costs due to their financial fragility and small size.

Quantum computing

Quantum computers are another technology of growing importance, and many governments and industries see their enormous potential. Currently, there is a global race to see who will lead the market of quantum technologies with the U.S. having invested more than $1.2 billion in the period 2019 – 2028 and China in the process of building a $10 billion National Laboratory for Quantum Information Sciences. Europe is also a viable contender since it has a history in quantum research with a key strength in focusing on a range of different fields in quantum technologies. However, the challenge remains of creation of

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8 Both 5G and 6G take advantage of higher frequencies on the wireless spectrum to transmit more data, faster. However, 5G occupies broadband frequencies at sub-6 gigahertz (GHz) and above 24.25 GHz – called low band and high band frequencies respectively. 6G will operate at 95 GHz to 3 terahertz (THz).

9 See, for instance, the article "5G and the Battlespace Dominance" available at: https://www.realcleardefense.com/articles/2019/03/23/5g_and_battlespace_dominance_114276.html.

successful business in this challenging field owing to the required extensive investments into postdoctoral-level workforce and sophisticated infrastructure.

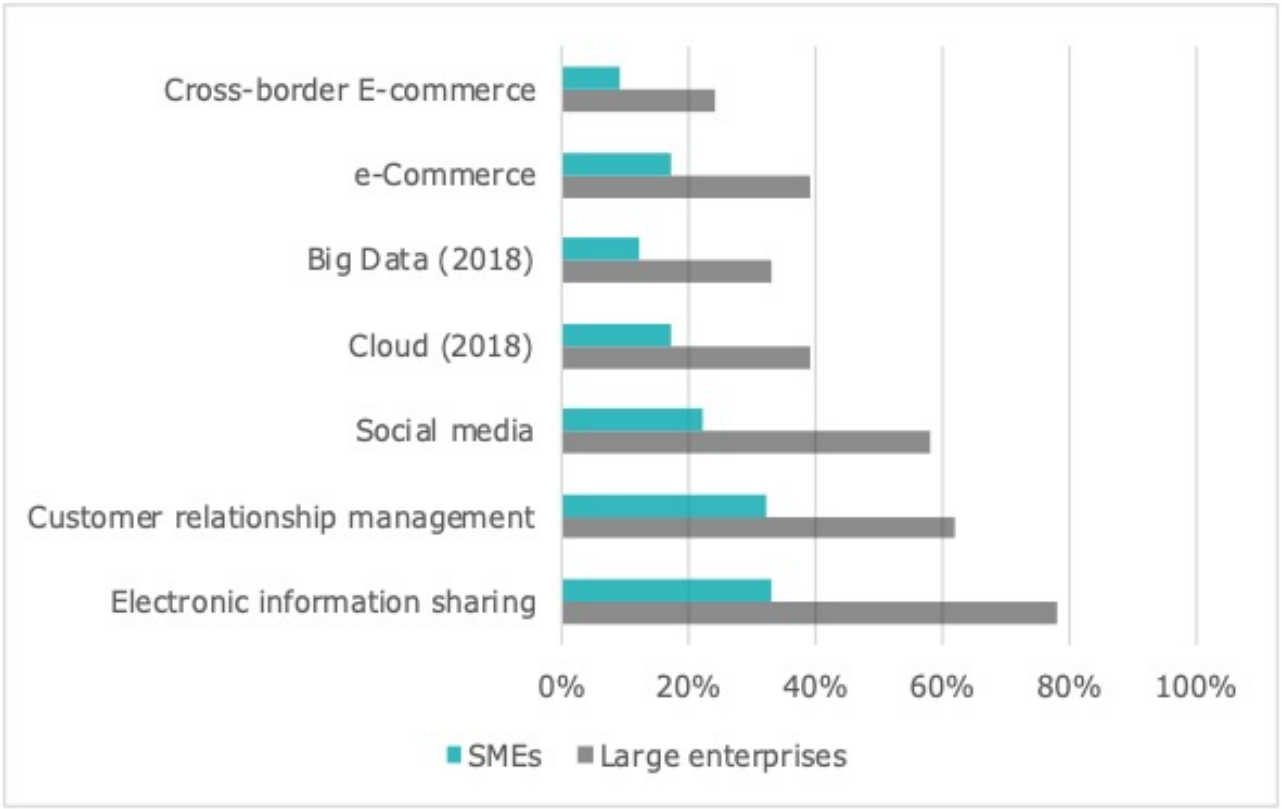
Apart from the successful market of cryptography of financial transaction, there are no existing markets in Europe that can financially support these operations (Räsänen etal.2021). These high investments pose the risk of increasing inequality in the free market economy since only large companies will be able to afford the high investments needed and, with the quantum technological advantage, they may push out individuals or smaller businesses (de Wolf, 2017).

2.4. Industry business transformation

General overview

As anticipated in section 2.1, according to ECA, business and, particularly, SMEs are not taking full advantage of advanced technologies to innovate (2020) and many firms are expected to reduce investments in 2021 (EIB, 2021c). According to Eurostat (Eurostat, 2021c), as of 2019 the vast majority (91%) of EU enterprises with at least 10 employees used a fixed broadband connection to access the internet. This share has remained between 91% and 92% since 2014, suggesting that at an EU level the uptake of this technology has reached saturation. Cloud computing was used by 36% of EU enterprises in 2020, mostly for hosting their e-mail systems and storing files in electronic form. Only 19% of enterprises use advanced cloud services. Compared to 2018, the use of cloud computing increased by 12 percentage points.

Figure 2: Adoption of digital technology by class size (2019)



Source: European Commission (2020g, p. 7), based on Eurostat, Community survey on ICT.

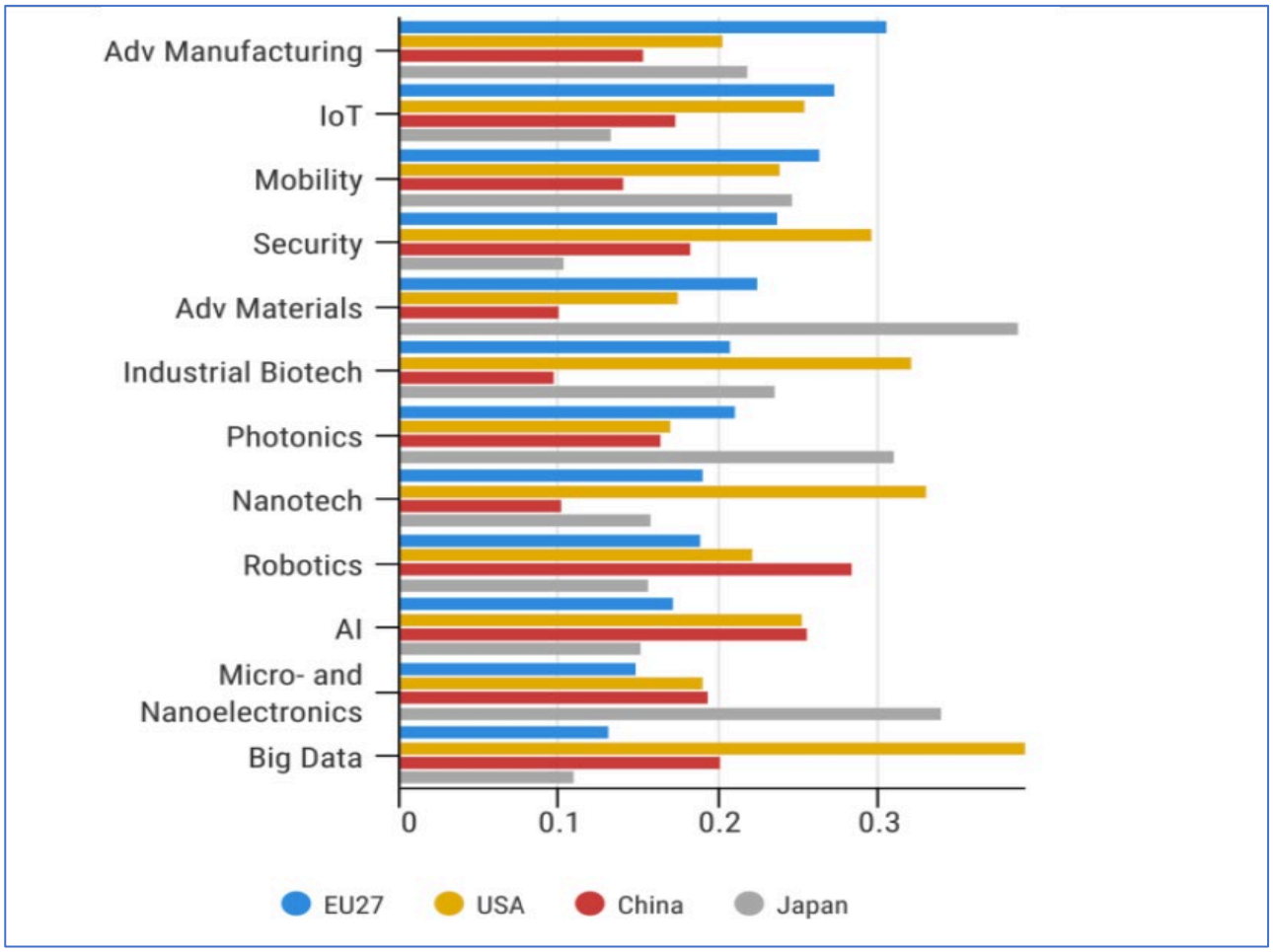
As visible in the graph above, the biggest gaps for SMEs are in the use of big data analytics, electronic information sharing and enterprise resource planning (ERP) cloud computing, and supply chain management. These are key applications for innovation and a more efficient and effective management.

Given the weight of the SME sector (25 million in EU27), increased take up of such an application would mean a boost to both the output of SMEs and the ICT sector.

EU performance in KETs

The data presented below comes from the ongoing Advanced Technologies for Industry[10] project that has now incorporated and centralised the Key Enabling Technologies Observatory and the Digital Transformation Monitor. The project monitors technologies considered strategic for the future of European industry (Advanced materials, Advanced manufacturing, AI, Big data, Cloud, Industrial biotechnology, IoT, Micro-and nanoelectronics including semi-conductors, IT for Mobility, Nanotechnology, Photonics, Robotics and Cybersecurity).

Figure 3: EU overall performance in Key technologies



Source: European Commission (2020a, p.10), based on EPO Worldwide Patent Statistical Database (PATSTAT).

As the graph shows, the EU has retained leadership in Advanced Manufacturing and demonstrated strength in advanced materials, IoT, mobility and a few others. In comparison with its global competitors, Europe shows particular weakness in semi-conductors, cloud computing, AI, and robotics sectors (IDC et al., 2020a).

[10] See the European Commission's Advanced Technologies for Industry website, available at: https://ati.ec.europa.eu/.

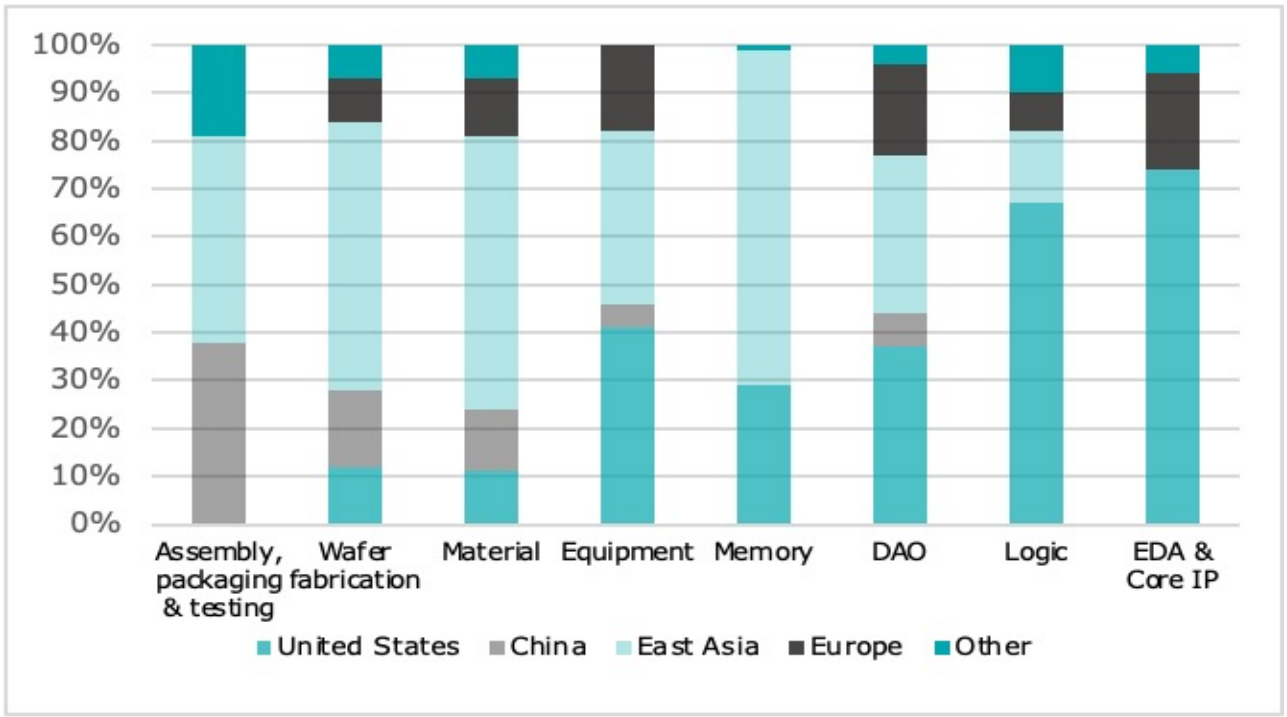
Focus on semiconductors

Semiconductors, such as processors or memory chips, are the building blocks of all digital products and services and the drivers of the accelerating digitalisation industry. For the past three decades, the European semiconductor industry had a world market share of between just 8 and 13 percent (SIA, 2020, 2021). Designing advanced chips can cost up to €1 billion, while building a state of the art fabrication plant ("Fab") can cost up to €20 billion with yearly operating costs of €5 million (European Commission, 2021g, p. 82). As a result, the market is dominated by a few leading-edge chip manufacturers: in 2020, only two firms TSMC (Taiwan) and Samsung (S. Korea) manufacture chips at 5nm. Europe has no foundries that offer manufacturing of components with feature sizes below 22nm (*Ibid.*). Production, of the different types of leading-edge semiconductors, is dominated by just a handful of companies. Essentially any personal computer, from laptops and desktops to servers, uses x86 processors from either Intel (82% market share) or AMD (18% market share). Mobile processors in smartphones or tablets are based on design and intellectual property (IP) from one company – ARM Holdings, which is headquartered in the UK but owned by SoftBank in Japan and may soon to be bought by Nvidia in the US. There are however some exceptions in Europe, as there are a few successful companies in design (e.g., IMEC incubator in Belgium), chip production machinery (e.g., ASLM with headquarters outside the EU, namely the UK), as well as manufacturers of microcontrollers and integrated circuits (e.g., Infineon in Germany and STM Microelectronics with headquarters in Switzerland). It is important to note that many companies focus on single steps of the production chain rather than on the entire design and fabrication process due to the complexity and increasing costs (Kleinhans & Basakova, 2020).

The two main types of semiconductor companies and business models are the following:

- Fabless companies that design the chips and rely on contract chip makers for fabrication and assembly. This segment is mostly dominated by US firms (i.e., Broadcom, Qualcomm, Nvidia and AMD, with new entrants such as Amazon, Google, Tesla, Baidu, Alibaba); and
- Fabs that package, assemble, test, and fabricate chips are located mostly in Asia (i.e., TSMC, Samsung, SK Hynix).

Figure 4: Share of revenues per region across the semiconductor value chain (2019)



Source: Alsop (2021), based on Statista.com - Semiconductor supply chain activity market share worldwide 2019, by region.

Looking at overall volume, European companies play a minor role in most of the semiconductor value chain (Figure 5) and in fact have fallen behind in wafer fabrication and chip design (Kleinhans & Basakova, 2020). European companies play a more important role on the supply side of crucial chemicals (Merck, BASF, Linde, among others) and equipment (such as ASML and Aixtron) that are needed for fabrication.

Furthermore, due to being a very R&D intensive sector (up to one third of revenues invested in research), it is also heavily subsidised: a) China aims at achieving 70% autonomy in chip-making by 2025 and to this purpose has placed USD 150 billion over 10 years under the "Made in China 2025"; b) South Korea government plans to invest $17 billion through 2029 for next generation chips; c) The US has devised a $25 billion plan over 5 years for investments in R&D and manufacturing (European Commission, 2021g, p. 83). China and the US both place a high importance on semiconductors as a strategic asset (Ding & Dafoe, 2020). Europe, thus, depends on the US for design and on Asia for fabrication, while enjoying global leadership in the following innovation positions: power electronics, sensors, automotive semiconductors, and advanced chip-making equipment.

In December 2018 an Important Project of Common European Interest (IPCEI) on Microelectronics was launched involving 29 companies from 4 different MSs (Austria, France, Germany, and Italy) plus the UK[11]. The project is contributing to stimulate investments for innovation, Automotive and IoT markets. Manufacturers of chips at leading-edge nodes (TSMC, Samsung, Intel) rely for their technology development on specific extreme ultraviolet (EUV) photolithography machines produced by a unique global supplier, notably ASML (NL), which belongs to the European electronic ecosystem. In fact, ASML does not compete with any other large vendors since they have a monopoly on EUV equipment, which is highly complex to maintain and configure, and is used to produce chips smaller than 7nm (The Economist, 2020).

Additionally, the Electronic Components and Systems for European Leadership (ECSEL) Joint Undertaking, which was set up in 2014[12] and supported close to 80 research projects, was instrumental to advance equipment technology development in miniaturization through the pilot integration of 3nm semiconductor technology. EU suppliers are strong in dedicated processors (micro-controllers) for embedded systems applications in automotive (37% global market share) and industrial uses, including machinery (17% global market share). In March 2021 Intel, the world's largest manufacturer of semiconductor chips, announced that they would open a foundry plant for cutting-edge semiconductors in Europe[13]. This foundry plant, scheduled to be built by 2026, will allow EU businesses to produce their own chips in Europe, based off their own semiconductor designs and is expected to reinforce European supply chains. According to market trends, in which currently logic/foundry players are performing well but analogue/memory market are less certain, Europe is better positioned in the coming years for the development of 5G technology players (for infrastructure and smartphones), logic/foundry, as well as EUV suppliers and specialists in autonomous driving and electric vehicles (de Jong, 2020). In summary, when considering the complexity of the semiconductor supply chain, dependencies must be assessed in terms of risks and selective investment choices should be made, as well as the development of international partnership and alliances. Since chips are the building blocks, the possibility to leverage KETs to advance industry and maintain the area of excellence depends on foreign suppliers.

[11] See the list partners of the IPCEI on microelectronics at: https://www.ipcei-me.eu/partners/.

[12] See the Electronic Components and Systems for European Leadership projects at: https://www.ecsel.eu/projects/pin3s.

[13] See the article "Leading chip-maker answers EU call to scale up European capacity" available at: https://www.euractiv.com/section/digital/news/leading-chip-maker-answers-eu-call-to-scale-up-european-capacity/.

Focus on clouds and edge computing

The broad definition of cloud computing is "*the offer, use and charge for IT services dynamically adapted to demand and supplied through a network*" (BMWi, 2019, p. 5). It encompasses, among other things, infrastructure (e.g., processing capacity, storage space), platforms and software. It represents the KETs of strategic importance to Europe's industrial future, as emphasised in the New Industrial Strategy for Europe (European Commission, 2020v, 2021c, 2021g, 2021r). In particular, the industrial strategy indicated this as an area where resources should be channelled since Europe lags behind (European Commission, 2020v, p. 2). Cloud computing is a technology that combines hardware and software to allow on-demand remote access to a scalable and elastic pool of shareable and distributed computing resources. They offer the possibility to scale up company business processes in flexible ways. By 2025, 80% of all generated data are expected to be processed at the edge (European Commission, 2020m, p. 2). Edge computing generally refers to a form of delivery of cloud computing services in a highly distributed form, closer to where data is being generated or collected, thus moving from the traditional centralised model of data processing to a highly distributed one. Edge nodes are the devices that are connected to a network and provide the intelligence to sense, measure, interpret, and connect to an internet gateway to the cloud. These devices, which include routers, switches, and small/macro base stations, bring computing power even to remote areas such as factories, retail stores, warehouses and allows developers to create applications that increase privacy of sensitive information, enable operations even when networks are disrupted, and substantially reduce latencies, among others (Gonzalez etal.2020). Interoperability is one of the key advantages of cloud computing allowing implementation of Infrastructure as a Service (IaaS) and Software as a Service (SaaS) to streamline how IT administrators utilise various hardware and software components from different vendors (Jacob, 2019, p. 5). For organisations wishing to shift from having data silos to better integrated data gathering and processing, cloud computing would be an essential step towards improving time efficiency and data interpretation. But such a shift may not be possible for all EU MSs, with barriers "*related to data availability, silos, skills, privacy frameworks and impact assessment tools*" (Battisti et al., 2019, p. 10).

Currently, the public cloud infrastructure market is converging globally around four large non-European companies: Amazon Web Services, Microsoft Azure, Google Cloud and Alibaba Cloud. They account for 80% of global revenues in 2021[14]. This is also underscored in the German document on Gaia-X stressing that "*the existing cloud offerings are dominated by non-European providers with significant market power and rapidly upscaling cloud infrastructures. European alternatives do not offer comparable market capitalisation, scalability or breadth of applications; they are active in specialist niches at best*" (BMWi, 2019, p. 5). Vertical integration and bundling of services (i.e., infrastructure and software services) increase the entry barriers for non-incumbent players. Widespread unfair commercial practices, lack of interoperability and data portability between cloud providers create risks of vendor lock-in (Ernst & Young, 2018). This is further exacerbated by an investment gap of €11 billion annually in cloud between US/China and the EU (European Commission, 2020b, p. 18). If the cloud computing market seem closed to European players, opportunities exist in Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and in the future in edge computing. In SaaS, DESI forecasted revenues to grow by 50% between 2019 and 2021(European Commission, 2020g, p. 8). In 2019, SaaS represented almost two thirds of total public cloud revenues generated within the EU market, a trend poised to continue in the future. This strong growth in software services constitutes a major opportunity for European providers to leverage their position in the SaaS market. The unique market opportunity for Europe in the next five years is, however, edge computing. This is a sector in which European enterprises can strengthen their data processing technologies and capitalise on the changes to come.

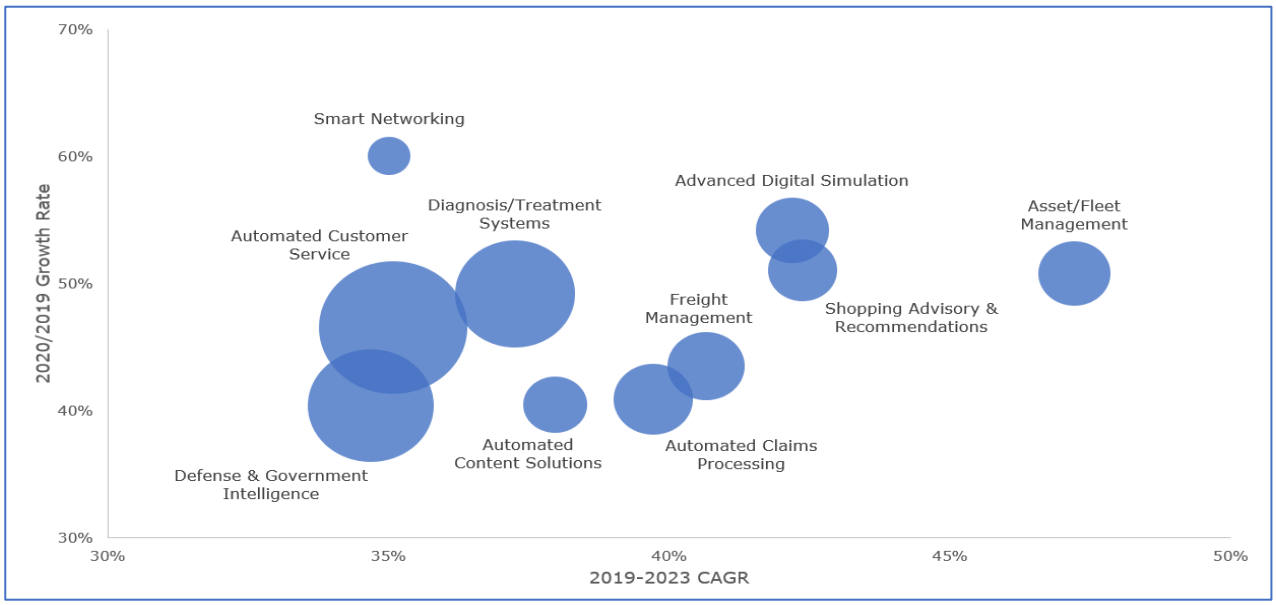
[14] See the press release at: https://www.gartner.com/en/newsroom/press-releases/2020-08-10-gartner-says-worldwide-iaas-public-cloud-services-market-grew-37-point-3-percent-in-2019.

To seize it, Europe can build on its industrial expertise and strength in some areas of the computing value chain, such as business-to-business application, system integration, industrial IoT systems and 5G. According to IDC's forecast, the worldwide edge computing market will reach $250.6 billion (around €206.5 billion) in 2024[15]. Today there is no dominant player in the edge computing market and European players have some strengths to leverage. Given this opportunity, the "European Alliance for Industrial Data, Edge and Cloud"[16] and the cloud initiative Gaia-X (BMWi, 2019)[17] are looking forward rather than back to recover lost grounds. According to Braud et al. (2021), European digital sovereignty must rely on two axes: Gaia-X and the International Data Spaces Association (IDSA) reference architecture model[18]. In the first case, the EU digital sovereignty will be at least substantiated by an EU 'digital jurisdiction' provided by Gaia-X servers, as the cloud services of the system will be required to comply with European regulation. In the second case, IDSA's reference architecture model ensures data sovereignty with the goal of being able to safely share data among participants in a consortium. IDSA is an initiative, driven by the German Industry 4.0 companies and firmly backed by the German federal government, that was launched with the goal of avoiding GAFAM (Google, Apple, Amazon, Facebook, and Microsoft) and BATX (Baidu, Alibaba, Tencent y Xiaomi) data hegemony, while at the same time respecting European values and data protection standards.

AI

The following figure depicts the ten AI use cases most adopted in the EU.

Figure 5: Top 10 AI Use Cases in Europe (fastest-growing spending)



Source: (IDC, 2020).

The data from Advanced Technologies for Industry (ATI 2020) survey shows that the sectors with the highest adoption of AI are the following: discrete manufacturing (such as the automobile or smartphone industry), financial services, healthcare, and telecommunication.

[15] See IDC's article "Worldwide Spending on Edge Computing Will Reach $250 Billion in 2024" available at: https://www.idc.com/getdoc.jsp?containerId=prUS46878020.

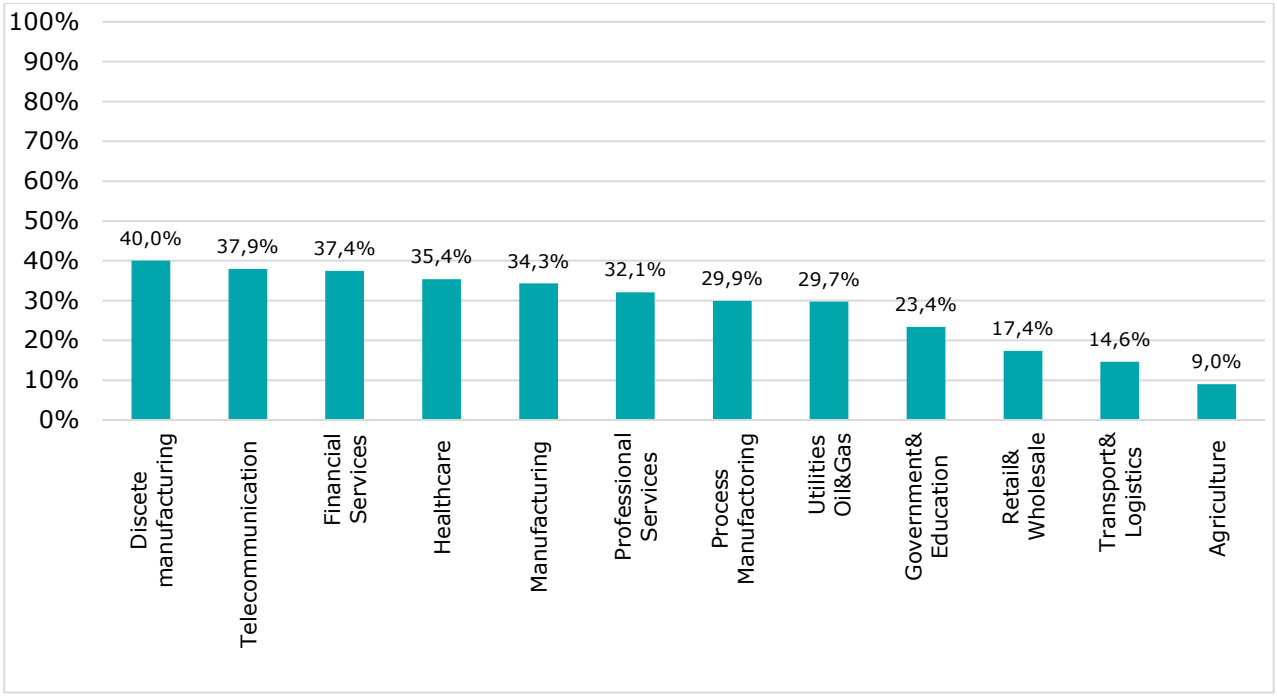
[16] See: "Declaration of the European Alliance for Industrial Data, Edge and Cloud", available at: https://ec.europa.eu/newsroom/dae/redirection/document/78362.

[17] See the article "The Gaia-X Hub Germany'" released by Federal Ministry for Economic Affairs and Energy available at: https://www.bmwi.de/Redaktion/EN/Dossier/gaia-x.html.

[18] See the webpage of the International Data Spaces Association at: https://internationaldataspaces.org/.

These sectors are also the ones where cognitive tasks are being impacted by AI-based systems. In healthcare, both cognitive and physical tasks (the latter in surgery or nursing for instance) are impacted by new AI algorithms or surgical robots. The manufacturing, the industries with a medium level of adoption include pharmaceuticals, and food and beverage, among others. In manufacturing, while mostly physical tasks have been impacted by the spread of intelligent robots cognitive tasks, such as company management, finance, and administration, are also changing. Professional services and utilities and gas companies also experience a medium level of adoption. Finally, Retail, Government and Education, Agriculture, and Transport have currently a low level of adoption although in the latter two sectors, physical tasks are being adapted through AI. Governance and Education instead are expected to witness new developments around cognitive tasks.

Figure 6: AI uptake by sector (% of EU enterprises)



Source: Authors' elaboration based on ATI dashboard. (2020).

The use of AI and big data is strategic for industries to gain better insights on customers and provide better services and care, as well as to optimize the use of resources and organisational performance. It would also support other technological applications, including digital twins. The amount of industrial data is rapidly increasing and is expected to quadruple by 2025. However, according to the State of the Union Address by President von der Leyen at the EP Plenary, currently 80% of industrial data in Europe is collected and never used.

It is exactly at the crossroads between AI adoption and the skills agenda that lays the potential for economic prosperity and for a more cohesive labour market. According to some estimates (Accenture, 2017), AI could increase labour productivity by up to 40% and double economic growth rates in at least 12 developed countries. However, in a report on disruptive technologies the EIB finds that European companies and governments were underinvesting in AI and blockchain as compared to leading regions (EIB, 2021a). Of the €25 billion total investment in these technologies each year, the US and China account for more than 80%, while the EU's share only amounts to 7% or about €1.75 billion (*Ibid.*). The EIB study pointed to several reasons for this "underinvestment", including the limited availability of venture capital and private investment, limited appetite due to high initial investment needs, the lack of knowledge and

low visibility of commercial applications, limited availability of data within the EU and a fragmented innovation ecosystem.

Robotics

Industrial robots are key in helping manufactures address challenges such as constricted labour pools, global market competitiveness, and safety (Stevens, 2021). While industrial robots introduce many advantages such as higher productivity and efficiency there are issues to consider such as the high investment costs, availability of highly skilled workforce, and ongoing maintenance and operational costs. Furthermore, there is a widespread debate that automation (including robots) will negatively impact the labour market, by reducing the number of middle-skill occupations. However, there are findings that indicate that robots are much more integrated into processes that still require manpower, therefore reducing the perceived negative impact on the workforce (Dahlin, 2019). Data produced by the International Federation of Robotics (IFR) demonstrates that operational stock of industrial robots almost doubled in size in 5 years, from 1.4 million units in 2015 to 2.7 million units in 2019. This data shows that at a global level most industrial robots are present in the automotive sector. The countries in the EU with the highest number of industrial robots are Germany, Italy, Spain, France, Poland, and the Czech Republic.

Digital twins

Digital twins are a virtual simulation of a physical process or product and use real-time data to predict and monitor how the physical model will perform. By using knowledge from outcomes simulated by the virtual model to the physical one, digital twins are currently seen as a technology to drive business outcomes, increase efficiency, reduce costs, uncover operational inefficiencies, monitor assets, enable the creation of connected products, and reduce downtime in manufacturing and other industries. Europe's digital twin market size was estimated around $1 billion in 2019 and is anticipated to go past the valuation of $9.5 billion during the forecast period of 2020-2026[19]. As recognised by the Digital Twin Consortium, key sectors that will lead digital twin technology integration include aerospace, defence, infrastructure and construction, healthcare, manufacturing, military, and the natural resource sector, including oil and gas, mining, and energy[20].

The value of digital twins in manufacturing comes from external factors that drive companies to initiate and achieve digital twin projects, including flexibility requirements of the new market, competition pressures on cost, productivity, and quality and the desire to follow a global trend (Neto, 2020). However, the implementation of digital twin technology comes with challenges, including interoperability and up-to-date IT infrastructure, since many times a digital twin must go hand in hand with Big Data, IoT and AI solutions (Integra, 2021). European initiatives, such as the Change2Twin project[21], have already been implemented to support SMEs and mid-caps in the manufacturing sector to deploy digital twins by focusing on funding and mentorship for individual companies. Change2Twin will take advantage of European initiatives and the private sector by working with local Digital Innovation Hubs and technology providers, among others. DIGITbrain[22], an innovation program funded by EU H2020, is another initiative to facilitate the adoption of digital twins by SMEs. The project, which began in 2020, will support more than 20 highly innovative experiments by giving SMEs easy access to digital twins to streamline the manufacturing processes and make predictions on maintenance or machine failures.

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[19] For an estimate of the digital twin market size, see the graphs and commentaries reported at: https://www.graphicalresearch.com/industry-insights/1484/europe-digital-twin-market.

[20] See the digital twin consortium webpage at: https://www.digitaltwinconsortium.org/index.htm.

[21] See the Change2Twin webpage project at: https://www.change2twin.eu/.

[22] See the digitbrain webpage at: https://digitbrain.eu/.

Industry and the Green Deal

The digitalisation of the private sector also has the potential to foster the achievement of the European Green Deal objectives. While Europe has a smaller share of digital firms as compared to other countries, such as the United States, it is a leader for firms that are investing in both "green" technology and digital technology (EIB, 2021b). This, for instance, could be a key pillar for an EU identity that distinguishes itself from both the US and China. As global efforts lean towards climate mitigation and energy saving technologies, this holds a promising position for digital twin in the energy sector. Digital twins in this sector and can be used to simulate, model, and plan complex actions or processes such as the maintenance and operational and physical characteristics of a power or electricity plant (Nexus Integra, 2021). Destination Earth (DestinE) is an example of an EC initiative that aims to use a digital twin to monitor and predict climate change and human impact by simulating the Earth. This initiative plans to allow policymakers to better anticipate and plan for natural disasters, support European green initiatives, provide new knowledge on energy management, and support farming functions in response to extreme weather.

Online platforms

In the domain of online platforms, the dominance by US and China players has been set (Lechardoy et al. 2021). These platforms basically control between 80% and 90% of data generated by European users. They created lock-ins for many European SMEs that hardly multi-home (i.e., use more than one platform) and during the last couple of years strengthened their dominant position globally and in Europe through many Merger & Acquisitions. Finally, due to the pandemic and to governments' failure to develop their own effective track and tracing Apps, Google and Apple partnered and developed a Bluetooth low energy technology for Covid-19 contact tracing. This latest development is seen as a strategy to regain legitimacy and momentum when platforms were under the scrutiny of competition authorities (Cinnamon, 2020), and has been cited as one of the reason why digital sovereignty matters (Floridi, 2020).

2.5. Digital Government

General Overview

It is worth starting this with a quotation of one of our interviewees that asked anonymity for the following statement: "*before talking about digital sovereignty, governments should fix things at home. Regulation is fragmented and contradictory, it creates a lot of red tape for businesses, online delivery is per silos and does not at all reduce administrative burden*".

The public sector has been experiencing a digital transformation that is impacting governance, public service delivery, citizen engagement and budgetary decisions. According to latest eGovernment benchmarking, in the EU currently 78% of public services can be completed entirely online, an increase of more than 10% when compared to two years ago, when only 67% were capable on online completion (Capgemini, 2020). However, this indicator does not provide a clear picture of the digital transition. First, because the digital transition is more complex than just moving services online and this can be observed by looking at the strong differences among MSs. Some are only at the beginning of the transformation, as digitisation has consisted mainly of creating digital versions of existing processes and services. While the top performers are taking a more holistic approach, which consists in developing cross-government platforms – also referred as 'Government as a Platform' – that are beginning to break down organizational silos, save money and change the types of services that can be delivered to the public[23]. Second, and most importantly, as the literature on eGovernment adoption suggests, such supply side indicator has limited

[23] The most prominent example is Estonia, which is completely redesigning its government around digital technology: the Estonia's X-Road platform effectively links all departments' information systems so that citizens can "tell the government once" about a life event, as opposed to having to deal separately with different departments (Pope, 2019).

relevance in predicting adoption by citizens and businesses, which is what should really matter (Codagnone et al., 2015).

Digital technologies provide tools for faster and more efficient processes, which result in concrete benefits in terms of cost savings for the public administration, citizens, and businesses. For instance, the increased number of services that are 'digital by default' are reducing the need to communicate with government via more costly channels. The EC (2014) estimated that at the EU level, a 'digital by default' strategy could save between €6.5 and €10 billion annually. More important than government cost reductions, however, is the opportunity to reduce administrative burdens, which are the costs that citizens and businesses bear to comply with information and registration requirements established by government regulation. These costs can be reduced by making it faster and less expensive for citizens to fulfil their obligations, such as applying for permits or paying taxes. For instance, in Denmark, electronic invoicing saves taxpayers €150 million a year and businesses €50 million a year. If introduced across the EU, annual savings could exceed €50 billion[24]. Meanwhile in Italy, e-procurement systems cut over €3 billion in costs[25].

Use of digital public services

The most realistic indicators for the digital transformation of the public administration are those related to usage and adoption, also included in the factsheet by the EC to monitor the state of play (European Commission, 2020ai). First, despite a steady increase in the last ten years, in 2020 only 56% of European citizens use the internet to interact with public authorities (Eurostat, 2020c).

There is a gap of almost 20 percentage points between this number and the percentage of public services that can be completed entirely online, which again demonstrates the difference between the supply, actual use, and adoption.

The figures vary considerably across the EU MSs, ranging from 13% in Romania to 91% in Denmark. The case of Italy is interesting since it has recently launched several policy initiatives (AGID, 2019) and has only one third of the population using internet to interact with the public authorities. The other three indicators on the usage are also surprisingly low compared to the advances made by the MSs in making public services available online (DESI, 2020): a) on average, 44% of individuals use the internet to obtain information from public authorities in the EU; b) 33% of individuals using the internet for downloading official forms from public authorities in EU; c) 38% of individuals using the internet for sending filled forms to public authorities in EU.

Covid-19 and digital health

Digital solutions for healthcare can increase the well-being of millions of citizens and radically change the way health and care services are delivered to patients, if designed purposefully and implemented in a cost-effective way (Horvitz, 2016). With the adoption of online medical consultations, patient portals, and other care delivery channels enabled by digital innovations, recent trends in the health care sector include shifts from traditional face-to-face care to e-health, mobile health (m-health) and 'ubiquitous health' (u-health), characterised by real-time information collection about the patient (Jung and Padman, 2015). In addition, electronic health records (EHRs) help citizens to quickly access and share their health data with healthcare professionals. Prior to the pandemic, however, the uptake of digital health technologies to directly strengthen public health systems had been unsatisfactory. According to the latest survey on the use of eHealth by general practitioners (GPs) (European Commission, 2018), adoption was still low in the four main categories measured. The exception is the EHR, which is currently available across all EU countries

[24] See Denmark's example described in "Electronic invoicing to the public sector in Denmark (EID)" available at: https://joinup.ec.europa.eu/collection/eprocurement/document/electronic-invoicing-public-sector-denmark-eid.

[25] See the list of initiatives on eGovernment and digital public services available at: https://digital-strategy.ec.europa.eu/en/policies/egovernment.

and most of GPs use it in their practice. Basic health data and information and order-entry functionalities are almost fully adopted in all countries, and in more than half of MSs, most GPs are routinely using clinical decision support functionalities and administrative data. However, the other three categories (i.e., health information exchange adoption, telehealth adoption and personal health records adoption) for which the survey developed a composite indicator scored very low: considering 4=full adoption and 0=no awareness, they scored 2.07, 1.63 and 1.56, respectively. The use of eHealth by citizens and their ability to access their personal health data is also very low and differentiated across and within MSs. As shown by a report adopted by the eHealth Network[26], some countries are still developing national health projects that include patient access to EHR information. Another indication is provided by the eHealth component of the DESI indicator (5b1), which has been very stable between 2014 and 2018 (the last year available). Over this period, only 18% of EU citizens have used health and care services provided online each year, without having to go to a hospital or a doctor (for example, by getting a prescription or a consultation online). Apart from the outstanding countries, such as Finland and Estonia, where almost 50% of citizens use eHealth services, in 2018 only one out of five EU citizens have used such digital services (Eurostat, 2018), while 52% of all citizens would like online access to their medical and health records (European Commission, 2017c). As in the case of other eGovernment services, where there is a gap in availability of services and adoption, most stakeholders acknowledged that the barriers to a digital transformation in healthcare are often nontechnological, but rather organisational and financial (European Commission, 2018c). However, recent studies show that an important acceleration took place within health care systems during the COVID-19 pandemic (Petracca et al., 2020).

The measures in place during the pandemic have led health care providers to resort to digital health applications for granting access to virtual consultations and remote visits and monitoring (Greenhalgh et al. 2020). As a result, during 2020 an unprecedent surge in digital health adoption was observed, with a general scale-up of telemedicine as confirmed by the increased number of telehealth services and e-consultations reported in several jurisdictions (Lonergan et al., 2020).

Electronic Identification

Almost all MSs have developed Electronic Identification (eID) systems, a government-issued document for online identification and authentication, which also grant users' access to eGovernment services. eID systems are considered a key enabler for the development of digital government but their use is still low across the EU (Capgemini, 2020). In addition, the Commission's strategy is to develop interoperable digital public services that work across borders, which are pre-condition for the Digital Single Market. With the introduction of the eIDAS Regulation in 2014, the EC introduced a first cross-border framework to allow all EU citizens access to public services across the EU. However, today only about 60% of the EU population in 14 MSs can use their national eID cross-border. And only 14% of key public service providers across all MSs allow cross-border authentication with an e-Identity system, for example to prove a person's identity on the internet without the need for a password (European Commission, 2021r).

Democratic systems

The digitalisation of the public sector is also transforming the governance of democratic systems, including the relationships between the government and the citizens. This change may arise from better awareness of political and policy issues; easier access to the exercising of democratic rights through e-voting, and from the co-creation/co-production of public services (Misuraca et al., 2020). Several studies in jurisdictions that have tried internet voting reported high levels of satisfaction from voters and/or willingness to use the option again (Warkentin et al., 2018). The literature examining the impact on voter turnout presents mixed results, but new empirical evidence seems to show that offering e-voting has increased turnout

[26] See the eHealth Network summary report available at https://ec.europa.eu/health/sites/default/files/ehealth/docs/ev_20201112_sr_en.pdf.

among abstainers and occasional voters (Petitpas, 2021). A survey conducted for the EC (2018d) as well as results from Eurobarometer[27] show that citizens also have some concerns related to it (e.g., regarding usability, fraud, secrecy, and other security issues). While the impact of internet voting on costs is unclear, as there is no clear consensus in the literature as to the relative cost effectiveness of remote voting systems, such digital solutions can increase the participation of the democratic systems.

2.6. Summing up: main problems/needs/challenges

First, there is need for more funding to, at least partially, fill the underinvestment gaps that are estimated at €125 billion per year for key technologies, compared to global competitors (US / China). Second, actions are needed to tackle new forms of digital inequalities in terms of universal access to adequate broadband and basic digital skills. Third, there is an increasing gap between the demand of digitally skilled employee and/or digital specialists and the supply (i.e., formal higher education, professional training, etc.), while the gender gap in digital jobs is widening. Fourth, Europe must accelerate in most digital infrastructures to fill gaps or maintain leadership. Fifth, the transformation of business and industry suffers from a low take up of some KETs, especially among SMEs. Strategic dependencies in some KETs (semi-conductors, cloud computing, AI), and requires more investments in both start-ups and scale-ups. Lastly, much remain to be done in the domain of Digital Government, to reduce administrative burden, increase uptake by citizens and businesses, improve interoperability and adoption of both eID and EHRs.

[27] Please see the summary of the Flash Eurobarometer 431 "Electoral Rights" available at: https://ec.europa.eu/info/sites/default/files/2016-summary-flash-eurobarometer-431-electoral-rights_en.pdf.

3. POLICY REVIEW AND CRITICAL ASSESSMENT

3.1. Policy review

The Communication "*2030 Digital Compass: The European way for the Digital Decade*" (European Commission, 2021a) builds on the actions defined in the earlier Digital Strategy "*Shaping Europe's digital future*" (European Commission, 2020ac). The Digital Strategy foresees four axes: (1) technology for people, (2) fair and competitive economy, (3) open, democratic, and sustainable society, (4) the international dimension – Europe as a Global player (abbreviated henceforth simply as 'International Dimension'). The Digital Strategy includes many actions on each of these four axes, of which we report those with a legislative component in Table 2. To identify those actions with a legislative component we consulted the EC 2021 Work Programme, and for the status of each initiative, the EP 'Legislative Train Schedule' website was consulted. Please note that the way the legislative initiatives are placed under the four axes is our conceptual choice.

Table 1: Legislative initiatives in the digital field

(1) Technology for people	
Actions with legislative action	**Status**
AI White paper follow up: AI Act	Proposal for regulation (AI ACT, April 2021); Proposal for ePrivacy regulation (January 2017, negotiations are still ongoing in 2021)
Revised regulation on supercomputing	Proposal for Council Resolution adopted in September 2020
Broadband cost reduction directive	The revision of the directive is still at consultation stage
(2) Fair and competitive economy	
Actions with legislative component	**Status**
Data Act	Inception Impact Assessment published May 2021, further feedback and fine tuning expected in Q4 2021
Data Governance Act (DGA)	Proposal for regulation presented in November 2020
Revision of database directive	Evaluation report published in 2018. Review was planned for Q3 2021
Digital Services Act (DSA)	Proposal for regulation (Data Services Act) presented in December 2020
Digital Markets Act (DMA)	Proposal for regulation (Data Markets Act) presented in December 2020
Digital levy	First digital tax package presented in March 2018. The initiative has been negotiated and the new package is expected in October 2021
New design requirements and consumer rights for electronics	A legislative initiative is foreseen, but process not yet started
(3) Open, democratic, sustainable society	
Actions with legislative component	**Status**
Digital Service Act package	Proposal for regulation (Data Services Act) presented in December 2020
Revision of eID regulation / ePrivacy	Proposal for regulation presented in June 2021

The International Dimension	
Actions with legislative component	Status
Foreign subsidies follow up to white paper: Levelling the playing field; Public procurement.	White paper published in June 2020. Two legislative initiatives, based on Article 207 TFEU, on levelling the playing field and public procurement were scheduled for Q3 2021. Commission presented May 2021 a new Regulation to address distortions caused by foreign subsidies in the Single Market

Sources: Digital Strategy (European Commission, 2020ac); EC Work Programme 2021[28]; EP Legislative Train Schedule[29]

The Digital Strategy actions refer to many other policy packages and initiatives with no legislative components including the following: an updated Action Plan on 5G and 6G; a new European cybersecurity strategy; A Digital Education Action Plan; a reinforced Skills Agenda; a reinforced EU governments' interoperability; the Industrial Strategy Package; and a Global Digital Cooperation Strategy. Many (but not all) of both the legislative and non-legislative initiatives listed in the Digital Strategy are also mentioned in the Digital Compass, although in our view the conceptualization of the former is more coherent and systematic compared the four pillars of the latter. The next table attempt to some extent to recompact the two.

Table 2: Digital Strategy and Compass compared

Shaping digital future	Digital Compass
1. Technology that works for people	• Digital skills and highly skilled professionals (Cardinal point #1) • Digital infrastructure (Cardinal point #2) • Human-centric approach to AI (cross-cutting topic)
2. Fair and competitive economy	• Digital transformation of businesses (Cardinal point #3)
3. Open, democratic, and sustainable society	• Digitalisation of public services (Cardinal point #4)
4. International dimension	• Digital autonomy and sovereignty (cross-cutting topic)

In view of the above, we will structure the policy review below to recompact the axes of the Digital Strategy with the four pillars of the Digital Compass.

3.1.1. Technology that works for people

The first objective aims at the development, deployment and uptake of technology that makes a real difference to people's daily lives and includes several actions in different areas, ranging from AI to quantum computing, 5G, cybersecurity and digital skills.

[28] See the Commission Work Programme 2021 at https://eur-lex.europa.eu/resource.html?uri=cellar:91ce5c0f-12b6-11eb-9a54-01aa75ed71a1.0001.02/DOC_1&format=PDF.

[29] See the Legislative Train tracking tool at: https://www.europarl.europa.eu/legislative-train/.

Digital skills and highly skilled professionals

In this domain the EU has taken several actions. The 2021 European Pillar of Social Rights Action plan recognises the importance of digital skills in achieving the overarching goals of increased levels of employment and the reduction of poverty and social exclusion. As part of the second objective that aims at reaching at least 60% of adults attending training courses every year, the Action plan sets the goal that at least 80% of those aged 16-74 should have basic digital skills by 2030, which is considered a precondition for the inclusion and participation in the labour market and society of a digitally transformed Europe. This objective reinforced the ambitions of the European Skills Agenda adopted in 2020 (European Commission, 2020n, 2020q), which proposed that by 2025, 230 million adults should have at least basic digital skills, covering 70% of the adult population in the EU. The EC committed in supporting the uptake of digital skills for all, as well as increasing the STEM graduates, with several actions, including (i) supporting Digital Crash Courses for SMEs and a "digital volunteers" programme to upskill the current workforce in digital areas, (ii) supporting EU ICT-Jump-Start trainings to provide short-term intensive training to tackle ICT skills shortages, (iii) fostering science education in research and innovation actions such as through the development of key competence and assessment framework.

The renewed Digital Education Action Plan 2021-2027, presented in September 2020, aims to support the sustainable and effective adaptation of the education and training systems of MSs to the digital age (European Commission, 2020a, 2020i, 2020p). It sets two priority areas and 13 concrete actions: 1) Fostering the development of a high-performing digital education ecosystem, and 2) Enhancing digital skills and competences for the digital transformation. Among the actions, the priority area includes the launch of a strategic dialogue with MSs to facilitate improved digital education; recommendations for online/distance learning; a European Digital Education Content Framework and check feasibility of a European exchange platform to share certified online resources and link existing platforms. For what concerns the second policy area, the actions include the development of a European Digital Skills Certificate recognised by governments, employers, and other stakeholders across Europe; the introduction of an EU target for student digital competence; and the support for the development of AI learning resources for education & training providers.

Human-centric approach to AI

The EC has launched a series of policy initiatives in the domain of AI starting with the communication "Artificial Intelligence for Europe" (European Commission, 2018a). The European strategy aims to place people at the centre of the development of AI, what has been called "human-centric AI". It is a three-pronged approach to support the EU's technological and industrial capacity and AI uptake across the economy, prepare for socio-economic changes, and ensure an appropriate ethical and legal framework. Transparency is one of the core values promoted by the EU for the development, deployment, and use of AI systems. This focus on transparency is also present in the EP's Framework of ethical aspects of AI, robotics and related technologies (European Parliament, 2020). Building on this background, the Commission followed up in April 2021 with the Communication "Fostering a European approach to Artificial Intelligence" and with a proposal for an Artificial Intelligence Act (European Commission, 2020aa). The proposed regulation divides AI systems into three categories: unacceptable-risk AI systems, high- risk AI systems, and limited- and minimal-risk AI systems. The oversight obligations imposed by the draft regulation on those building and selling high-risk systems in the marketplace are numerous and enforcement could include penalties even heftier than those incurred by violations of GDPR. The AI Act has been highly debated and subject to various critiques that we selectively review below. One critique is that Article 13 (the "Transparency and information provision") and Article 52, which covers the full title IV (the "Transparency obligations for certain AI systems") of the Act, do not precisely define transparency, which still has an unclear meaning (Kiseleva, 2021).

Another critique, building on the critical joint opinion expressed by European Data Protection Board (EDPB) and the European Data Protection Supervisor (EDPS)[30], is that the Act still contains gaps to be filled in three points: the regulation of emotion recognition, the regulation of biometric classification systems, and the protection against commercial manipulation (Malgieri & Ienca, 2021). In these areas high-risk AI systems are not prohibited by default but subject to requirements considered insufficient. The tendency of the AI Act to be based on the same GDPR model has been noticed and, it is claimed, this may be a problem because personal data protection and AI Regulation are fundamentally different (Papakonstantinou & De Hert, 2021a, 2021b). While the GDPR is about fundamental human rights with respect to a single and well-identified activity (i.e., data protection), AI regulation is broader and aims at both protecting individuals and boosting AI development. A legal review scientific article considers some aspects (such as the risk categorisation) appropriate but finds several shortcomings (Veale & Zuiderveen Borgesius, 2021) such as: a) enforcement regime and the risks of maximum harmonisation may pre-empt legitimate national AI policy; b) it is a mix of 1980s product safety regulation, fundamental rights protection, surveillance and consumer protection law; c) the transparency provisions either add little to existing law or raise more questions than answers when their implications are considered.

Digital infrastructures

In the domain of digital infrastructure, the main policy initiatives and/or regulations concern 5G (European Commission, 2016a) and the revision of the regulation on broadband cost reduction (European Commission, 2020ab), Cyber Security in general (European Commission, 2016e, 2017b, 2020l) and in relation to 5G (NIS Cooperation Group, 2019, 2020), the new European Digital Identity (European Commission, 2021n), the proposal for a regulation on High Performing Computing Joint Undertaking (European Commission, 2020w) the strategy on Quantum computing (European Quantum Flagship, 2020), and the Blockchain strategy (European Commission, 2021j). The 5G Action Plan sets 2020 as the target for roll-out of commercial 5G networks and foresees the deployment of 5G infrastructures and services across the Digital Single Market through a mix of private and public investments. The early cybersecurity measures (European Commission, 2016e, 2017b) have been recently updated by the cybersecurity strategy for the digital decade (European Commission, 2020l) and the definition of a new security tool box for 5G networks (NIS Cooperation Group, 2020). These new measures address the need for the security of critical infrastructure that was stressed earlier by the EP (2019). 5G in combination with IoT increase potential risks due to the several different stakeholders involved in the former, while the latter increases the so-called surface of attack. The regulation on High Performing Computing allows for the continuation of the activities of the existing EuroHPC Joint Undertaking and aims at strengthening research and innovation capabilities, the development of a supercomputing infrastructure ecosystem and the acquisition of world-class supercomputers by means of a joint undertaking. Finally, the Blockchain strategy (European Commission, 2021j) is designed to enable innovation, accelerate the adoption of blockchain technologies, and create a balanced and consistent legal framework for blockchain technology and digital assets. As part of the strategy, the Commission, in partnership with the European Investment Fund, has provided €100 million to set up the first European AI/Blockchain Investment Fund. The fund is leveraging additional private investments through venture capital funds. It is estimated that the total investment volume in the first phase will be between €500-700 million. The EU, jointly with MSs, plans to scale up the AI/Blockchain Investment Fund under the InvestEU programme and the Recovery and Resilience Facility.

[30] See the press release at: https://edpb.europa.eu/news/news/2021/edpb-edps-call-ban-use-ai-automated-recognition-human-features-publicly-accessible_en.

3.1.2. Fair and competitive economy

The second axe of the Digital Strategy aims at promoting a frictionless digital single market, where companies of all sizes can develop, market, and use digital technologies, products and services at a scale that boosts their productivity and global competitiveness, and consumers can be confident that their rights are respected. In relation to the Digital Compass, the actions envisaged as part of this second objective can be linked to the third cardinal point, namely the digital transformation of businesses.

Data strategy and data package

The European Data Strategy (European Commission, 2020o), issued in February 2020, aims at establishing a path for the creation of European data spaces whereby more data becomes available for use in the economy and society but under firm control of European companies and individuals. As noted in a recent parliamentary brief (European Parliament, 2020a), the objective of creating European data spaces is related to the ongoing discussion on Europe digital sovereignty. The data strategy proposes the construction of an EU data framework that would favour and support the sharing of data for innovators, particularly in the business-to-business or government-to-citizens domains: by open access to government data in sectors such as transportation and healthcare, privacy-preserving data marketplaces for companies to share data. The strategy aims to make the EU a leader in a data-driven society, with a single market where data can flow freely within the EU and across sectors, with benefits for businesses, researchers, and public administrations. Among the actions foreseen to achieve such goals with a regulatory component was "setting clear and fair rules on access and re-use of data". The two key legislative initiatives following up on the data strategy are the Data Act (DA) and the DGA; the DA will include a review of the rules of the legal protection of databases[31] and, it should deal with the planned revision of the database directive. The DA is still in its early phase, the Inception Impact Assessment was published in May 2021, the consultation with all interested parties to shape the DA is open until 3 September 2021. Feedback will be considered for fine-tuning expected in Q4 2021. As per the revision of the database directive, expected in Q3 2021, the current one dates from 1996 and is in need of an update and adaptation to the new context as highlighted in the evaluation report (European Commission, 2018b). That report pointed out the needed revision to facilitate data access and use, notably to facilitate the sharing of and trading in machine generated data and data generated in the context of rolling out the IoT. The proposal for the DGA was presented in November 2020 and is a key pillar for the vision of data-driven European societies (European Commission, 2020z). The DGA is presented as a way to increase trust in data sharing, strengthen mechanisms to increase data availability and overcome technical obstacles to the reuse of data. The regulation aims at supporting common European data spaces in strategic domains, involving both private and public players (health, environment, energy, agriculture, mobility, finance, manufacturing, public administration, and skills). It has three pillars: it enables greater data sharing among public and private sector entities; it establishes a notification and compliance framework for providers of data sharing services with the aim to create more trustworthy data sharing; and it establishes a (voluntary) registration regime for data-altruist entities. It also sets out a legal framework for the re-use of public sector data which are covered by third parties' rights, namely data covered by IP rights and confidential data of non-personal nature as well as personal data and includes rules regulating international transfers of non-personal data by a re-user that was granted access to such data by the public sector. A sort of GDPR mimesis has been noted in the DGA, visible in the definition of new actors, and in the institution building provisions (Papakonstantinou & De Hert, 2021b). New terms are introduced in Article 2 of the DGA: "Data holders", "data users", "data", or "data sharing" (Article 2).

[31] See the Data Act on the legislative tracking tool available at: https://www.europarl.europa.eu/legislative-train/theme-a-europe-fit-for-the-digital-age/file-data-act#:~:text=This%20legislative%20initiative%20will%20aim,business%2Dto%2Dgovernment%20situations.

They are the counterpart of the GDPR's "data subjects", "controllers", "personal data" and "processing" (in Article 4). It establishes a new authority to monitor all the above (Articles 12, 13 and Chapter V) and for cooperation it suggests a European Data Innovation Board (Article 26), whose name reminds of the GDPR's EDPB, an administrative body endowed with legally binding powers.

It has also been noted that the new rules aiming to regulate international transfers of protected data held by the public sector, in practice may render such transfers impossible (Baloup, 2021). This would compound further the problems with international transfer of data after US Safe Harbour[32] and later the EU-US Privacy Shield[33] were invalidated by the Court of Justice (Schrems I and II case-law, C-362/14 and C-311/18), as illustrated by Kiner (2020). This situation has led to legal uncertainty to the detriment of companies dealing with EU-US data transfers that may result in soft data localization (Chander, 2020). An econometrics study commissioned by Digital Europe shows that by reversing the current trends and harnessing the power of international data transfers, Europe could be €2 trillion better off and gain two million jobs by the end of the Digital Decade (Digital Europe, 2021a).

Levelling the playing field, with a special eye on online platforms

The first legislative initiative addressing fair competition in the domain of online platforms was the EU Regulation on platform-to-business relations (P2B Regulation), aiming at establishing fair rules for a predictable business environment for smaller businesses and traders on online platforms (European Parliament and Council, 2019). The regulation, while recognising the efficiency in access to cross-border markets created by online platforms, argues that that the gateway position of online entails the risk of harmful trading practices. This line of intervention goes further with the proposed Digital Services Act (DSA) (European Commission, 2020x) and Digital Market Act (DMA) (European Commission, 2020y), that the Commission considers centre pieces of the digital strategy. The DSA aims at better protection of consumers' and their fundamental rights, establishing a transparent and accountable framework for online platforms. This in turn fosters innovation, growth, and competitiveness within the single market. The DMA sets some criteria qualifying a large online platform as a so-called "gatekeeper" and aims at ensuring that such gatekeepers behave in a fair way online. In passing it is worth noting that from the other side of the Atlantic both the DMA and the DSA received criticism for representing excessive ex ante precautionary approaches to anti-trust inspired (Portuese, 2021) and as initiatives to just hobble US tech companies (Broadbent, 2020).

3.1.3. Open, democratic, and sustainable society

The last objective of the strategy includes several actions to ensure that citizens are empowered in the ways they interact with public authorities and other services. In relation to the Digital Compass, this section includes policy initiatives and actions that contribute to the fourth cardinal point, namely the digital transformation of public services.

Digital government

The EC has steadily stimulated and encouraged the development of eGovernment across the EU, through both communications and ministerial declarations. The European eGovernment Action Plan 2016 - 2020 (European Commission, 2016f) was launched with the aim of removing existing barriers to the Digital Single Market and preventing further fragmentation in the modernisation of public administrations. The Action Plan sets out seven principles that forthcoming initiatives should observe to deliver significant benefits from eGovernment services.

[32] See the report at: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32000D0520.

[33] See the report at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.207.01.0001.01.ENG.

The achievement of these seven principles by the MSs is monitored and the results presented in the annual eGovernment Benchmark Report. The seven principles are: (1) Digital by Default, (2) Once only principle, (3) Inclusiveness and accessibility, (4) Openness and transparency, (5) Cross-border by default, (6) Interoperability by default, and (7) Trustworthiness and security. The Action Plan then identified 20 concrete actions to accelerate the implementation of existing legislation and the related uptake of online public services, following three policy priorities: modernising public administration with ICT, using key digital enablers; enabling cross-border mobility with interoperable digital public services; and facilitating digital interaction between administrations and citizens/businesses for high-quality public services. A Digital Transition Action Plan (European Commission, 2018d) was published in 2018 examining how to effectively implement the Action Plan 2016-2020 at the local government level. Finally, other policy initiatives include the revised European Interoperability Framework, maintained under the ISA^2 Programme. The EC also proposed legislative actions focused on the so-called "key enablers" and includes the following three important ones. First, the Directive on open data and the re-use of public sector information (Directive 2013/37/EU) replaced the PSI Directive in 2019. Second, in 2018 the Council adopted the Single Digital Gateway Regulation, which aims to provide businesses and citizens with high quality, comprehensive information, effective assistance and problem-solving services and efficient compliance procedures regarding EU and national rules applicable to citizens and businesses when they want to do business and/or to travel to, buy from, work, study or reside in another MS. Third, the Regulation on electronic identification and trust services (Regulation (EU) No 910/2014), also called the eIDAS Regulation, was adopted in 2014 and represented a major step towards a predictable legal framework providing legal certainty beyond national borders for electronic identification (eID) and for electronic trust services (such as electronic signatures, seals, time stamping, delivery services and website authentication). However, given the unsatisfactory results of the regulation (European Commission, 2021u), the Digital Strategy announced that it will review the eIDAS Regulation to improve its effectiveness, extend its application to the private sector and promote it. On 3 June 2021 the Commission published its proposal for a new EU digital ID scheme for online transactions across Europe.

Digital health

The "Communication on enabling the digital transformation of health and care in the Digital Single Market; empowering citizens and building a healthier society" (European Commission, 2018e) was published by the EC in 2018. The Communication identified three priorities: citizens' secure access to their health data, including across borders, enabling citizens to access their health data across the EU; personalised medicine through shared European data infrastructure, allowing researchers and other professionals to pool resources (data, expertise, computing processing and storage capacities) across the EU; and citizen empowerment with digital tools for user feedback and person-centred care, using digital tools to empower people to look after their health, stimulate prevention and enable feedback and interaction between users and healthcare providers. On the first point, the Commission adopted in 2019 a Recommendation on a European EHR exchange format (European Commission, 2019d), which seeks to facilitate the cross-border interoperability of EHRs in the EU. It does so by supporting EU countries in their efforts to ensure that citizens can securely access and exchange their health data wherever they are in the EU.

ePrivacy and eID

While MSs hold primary responsibility for organising and delivering health services and medical care, including the development of digital health, the EC has put forward concrete actions to support MSs in the three above priorities. One example is the Recommendation on a European electronic health record exchange format seeks to facilitate the cross-border interoperability of EHRs in the EU. The Recommendation builds on several initiatives and projects put forward by the Commission and EU countries in their efforts to facilitate the cross-border exchange of health data in the EU.

The proposal for a regulation on ePrivacy was issued already in 2017 (European Commission, 2017a). The rationale was that the EC had started a modernisation of the data protection framework following the adoption of the GDPR. So, the ePrivacy legislation needed to be upgraded and adapted to reflect changing conditions, including the following: applying rules to new players that were not present at the time of previous regulations; stronger rules and protection across all electronic communications; and creating more opportunities for businesses once consent is given. Originally, the ePrivacy Regulation was intended to apply from 25 May, 2018 together with the General Data Protection Regulation (GDPR). Unlike with the GDPR, however, the EU Member States have not yet been able to agree on the draft legislation. The negotiations of the ePrivacy Regulation are still ongoing now in 2021.The current rules on identification for electronic transactions date to 2014 (eIDAS regulation), and the Digital Strategy envisioned its review to improve its effectiveness, extend its application to the private sector and promote it. The proposal for a new regulation was published in June 2021 (European Commission, 2021n).

3.1.4. The International dimension: foreign subsidies

A White Paper on levelling the playing field with respect to foreign subsidies was published by the EC in June 2020 (European Commission, 2020ah). The White Paper follows up on and implements one of the actions envisaged in the EC Communication EU-China[34] of March 2019 about the distortive effects of foreign state ownership and state financing in the internal market. The White Paper envisages three different but complementary pillars ('modules'): a market scrutiny instrument (module 1); foreign subsidies facilitating the acquisition of EU companies (module 2); foreign subsidies in EU public procurement procedures (module 3). All the modules foresee preliminary reviews, in-depth investigations, compulsory notification mechanisms, and redressive measures. As a follow up to the White Paper, two legislative proposals were announced based on Article 207 TFEU, including an impact assessment, with the following working titles for the second quarter of 2021: a) Levelling the playing field b) Public procurement. After the public consultations on the White Paper, the Commission proposed on the 5th of May 2021 a new Regulation to address distortions caused by foreign subsidies in the Single Market, subject to ordinary legislative procedure(European Commission, 2021o).

3.1.5. Industry and SMEs

In 2020 the EC launched the New Industrial Strategy (European Commission, 2020v), which is clearly related to the Green Deal and the digital transformation. Becoming climate neutral is placed at the core of the strategy, which affirms how industrial capacity must be enhanced by digital infrastructure and by a deeper and fairer digital single market. It foresees nine lines of action: (1) Creating certainty for industry; (2) Upholding a global level playing field; (3) supporting industry towards climate neutrality; (4) building a more circular economy; (5) Embedding a spirit of industrial innovation; (6) skilling and reskilling; (7) investing and financing the transition; (8) reinforcing Europe industrial and strategic autonomy; (9) a partnership approach to governance. It is noteworthy that, apart from the discussion of possible revision of special funding mechanisms, there were no clear indication of funds, as well as little mention of digitalisation actions, apart from the initial statement about their importance.

As a result of the COVID-19 effects, the industrial strategy was updated in 2021 (European Commission, 2021r) to ensure that it takes into account the new circumstances following the pandemic crisis. The updated strategy is accompanied by the earlier cited SWD on strategic dependencies (European Commission, 2021g). The updated strategy refers to the recovery plan with its funding mechanisms (European Commission, 2020m, 2021i). These mechanisms, together with the Multi-annual Financial Framework 2021-2027 should provide 'unprecedented financial support to EU's citizens and companies' (European Commission, 2021p, p. 2). The updated strategy focusses on: strengthening single market

[34] See the report at: https://ec.europa.eu/info/sites/default/files/communication-eu-china-a-strategic-outlook.pdf .

resilience; dependencies and open strategic autonomy in practice; and accelerating the twin transition. As far as funding goes, InvestEU is mentioned as the umbrella to work capital support and equity financing to SMEs. For open strategic autonomy the instruments mentioned are, among others, the Trade Policy Review (European Commission, 2017c, 2021q), a proposal to address the potentially distortive effects of foreign subsidies in the Single Market, periodic review of strategic dependencies, industrial alliances and international partnerships and cooperation to address strategic dependencies, launch of alliances on processors and semiconductor technologies, on industrial data, edge and cloud, etc. It also mentions that the EC will continue to support MSs' efforts to pool public resources via IPCEIs in areas where the market alone cannot deliver breakthrough innovation, as has been the case in the areas of batteries (a sector where Europe is very dependent on China and Tesla), raw materials and microelectronics. In the first two areas, one of the interviewees reported that the industry initiatives have been working well: the European Battery Alliance[35] and the European Raw Materials Alliance[36]. Both initiatives have seen the direct involvement of Maroš Šefčovič, Commission Vice-President in charge of Interinstitutional Relations and Foresight.

The Digital Compass clearly stresses the importance of strengthening Europe's cloud infrastructures and increase the production of semi-conductors. The way forward in these two domains is illustrated in earlier cited SWD on strategic dependencies (European Commission, 2021g). For semi-conductors the SWD points out that building a new fab with the latest technology (2nm in 2025/6) would cost €20 billion upfront and €5 billion per annum to operate and is not in the reach of any individual EU supplier today. The solution proposed is the mobilisation of industrial partnership to design proposals to mobilise the IPCEI mechanism. A good sign is seen in the December 2020 'Declaration of the Industrial Alliance for Processors and Semiconductor Technologies'[37]. Recently, in her 2021 State of the Union Speech, President Von der Leyen has sent a strong geopolitical and economic signal by announcing a European Chips Act. The Commissioner Breton then substantiated the announcement, clarifying that the new Act aims at integrating the different national efforts in a European vision and strategy[38], which is articulated around three main dimensions:

1. A European Semiconductor Research Strategy, which recognises that the research capacity is Europe's main strength in the global semiconductor value chain. The new strategy will build on existing research partnership to further push European research ambitions;
2. A collective plan to enhance European production capacity, which aims to support the development of European fabrication plants – "mega fabs" – able to produce in high volume the most advanced (towards 2nm and below) and energy-efficient semiconductors; and
3. A framework for international cooperation and partnership, which aims to diversify Europe's supply chains to decrease overdependence on a single country or region.

Funding mechanisms in relation to the newly announced European Chips Act remain vague as the Commissioner Breton has only stated that the Commission will "explore setting up a dedicated European Semiconductor Fund".

[35] See the presentation and description of the European Battery Alliance, available at: https://ec.europa.eu/growth/industry/policy/european-battery-alliance_en.

[36] See the European Raw Materials website at: https://erma.eu/.

[37] See the "Declaration of the Industrial Alliance for Processors and Semiconductor Technologies" avaiolable at: https://ec.europa.eu/newsroom/dae/redirection/document/78327.

[38] See the report available at: https://ec.europa.eu/commission/commissioners/2019-2024/breton/blog/how-european-chips-act-will-put-europe-back-tech-race_en.

In the domain of clouds, instead, the above-mentioned SWD is more articulated, as indicated below (European Commission, 2021g, pp. 100-101):

- A fairer and more competitive environment through Digital Markets Act;
- Following the Data Strategy, The Green Deal and the Industrial strategies coordinated actions (EU, MSs, industry) are needed to trigger investments and leverage the data paradigm shift and next wave of innovation (i.e., Edge computing);
- The European data strategy goals for the period 2021-2027 to co-invest in European data spaces and a European cloud federation, investments to be channelled through Digital Europe Programme, Connecting Europe Facility 2 and Horizon Europe;
- MSs to launch IPCEI focusing on next generation cloud and edge infrastructure and services and be supported to set them up according to criteria of compatibility with the internal market and state (2014/C 188/02); and
- The launching of the Alliances mentioned in the Industrial Strategy, such European Alliance for Industrial Data, Edge and Cloud launched in 2021 that produced its first declaration[39] and such as the Gaia-X initiative for "a European federated data infrastructure".

As per previous observations, the funding mechanisms remain relatively vague, and many measures are soft (communications, strategies, action plans).

The SME Strategy for a sustainable and digital Europe (European Commission, 2020ad) is based on three pillars: capacity-building and support for the transition to sustainability and digitalisation; reducing regulatory burden and improving market access; and improving access to financing. The strategy builds on the SME 2008 Act (European Commission, 2008), the start-up and scale up initiative (European Commission, 2016b, 2016d), and on several funding mechanisms such as the Competitiveness for Small and Medium Enterprises (COSME) Programme, and SME support actions funded under the Horizon 2020 Programme and the European Structural Investment Funds. The European Regional Development Fund (ERDF) and European Social Fund have reached out to over 900.000 and 500.000 SMEs in Europe, respectively (out of 25 million SMEs existing in Europe). The Strategy recognises that SMEs are not taking full advantages of the digital transition and need further support for the green transition. The actions proposed in this domain are the following: Upgrade the Enterprise Europe Network with dedicated Sustainability Advisors; Develop Digital Crash Courses for SME employees; Launch a "digital volunteers" programme to allow young skilled people and experienced seniors to share their digital competence with traditional businesses; Update the Skills Agenda for Europe, including a Pact for Skills with a dedicated component for SMEs; Expand Digital Innovation Hubs; Allocate at least €300 million to encourage breakthrough Green Deal innovations. The strategy underscores how complying with regulations create administrative burden for SMEs that may cost up to €10.000 year and that this limits access to the single market; only 17% of all manufacturing sector SMEs export within the single market (European Commission, 2020t, p. 6). As instruments, the strategy cites the Communication on the barriers (European Commission, 2020s) and the one on enforcement of single market rules(European Commission, 2020t). Other actions in this domain include, among others, the following: EU SME envoy and network of national SME Envoys to contribute to enforcement of rules; Encourage MSs implement the Single Digital Gateway; Calls on Member States and their contracting authorities to use the flexibility offered by the EU's new procurement framework to enhance opportunities for SMEs; etc.

[39] See the "Declaration of the European Alliance for Industrial Data, Edge and Cloud" at: https://digital-strategy.ec.europa.eu/en/policies/cloud-alliance.

For access to finance the actions the following are needed:

- Support to Initial Public Offerings of SMEs with investments channelled through a new private-public fund, to be developed under the InvestEU programme starting 2021 under the Capital Markets Union;
- Introduce a first-of-a-kind risk/reward mechanism to boost the size of venture capital funds and crowd in private investments for scaling up through the ESCALAR initiative; and
- Finally, the scale up Communication (European Commission, 2016d) and the supporting SWD (European Commission, 2016b) provide some additional interesting elements.

While in terms of business creation the EU is on par with the US, too few of them survive the first 2-3 years in Europe: the percentage of firms that grow by less than 5% or not at all is over 45% in Europe compared to 37% in the US (European Commission, 2016d, p. 2). One of the main causes is identifying and complying with regulatory and administrative rules and formalities. Understanding tax, company, labour law and other requirements is a real challenge, especially for a start-up with limited resources or expertise. Administrative burden and lack of access to finance are also reported as causing only 0.3% of SMEs to own European patents and, when considering European and/or national patents, only 0.8% of SMEs own patents in the EU versus 10.4% of large firms (European Commission, 2016b, p. 5).

3.1.6. Funding needs and mechanisms

The EIB quantifies the EU investment gap to reach the potential benefits from digital transformation in the order of €65 billion per year (EIB, 2016, 2020, 2021b). The SWD, that identified the financial recovery needs (European Commission, 2020b, p. 18), on the other hand estimated that Europe investment gap vis-à-vis US and China for the digital transformation is of €125 billion per year. Projected statically to 2030, it means a need for €1250 billion (or about 1.3 trillion). In terms of R&D expenditures as percentage of GDP, Europe is continuously outperformed by other major economic powers. In the EU, R&D intensity reached 2.19% in 2019, compared to 2.82 % in the US, 3.28% in Japan, or 4.53% in South Korea in 2018 (Obendiek, 2021, p. 5). These gaps concern several specific domains. There is an investment gap of €11 billion annually in cloud computing between US/China and the EU (European Commission, 2020b, p. 18). The US and China together account for over 80% of the €25 billion of annual equity investments in AI and blockchain technologies, while the EU27 only accounts for 7% of this global amount, investing around €1.75 billion. The total investment gap in AI and blockchain technologies in the EU of about €5–10 billion per year (EIB, 2021a). Europe is home to only 3 of the top 25 AI clusters worldwide and AI clusters worldwide and has only a third as many AI companies per million employees as the US (European Commission, 2021d, p. 4; IPSOS, 2020). The EU plan to mobilise €11-€12 billion for electric vehicle batteries[40] compared to the €30 billion to be invested by South Korea alone will invest much more[41] and to €4 billion that will be invested by China's leading supplier CATL[42]. In addition, one of the interviewees commented that, as *"in each Member State there are legacy players that are politically powerful and well positioned. State subsidies to incumbents may end up being used simply to keep them alive and no new big digital companies will emerge"*.

[40] See the article "Hydrogen and electric batteries and the open strategic autonomy of European industry" available at: https://www.i-com.it/en/2021/03/16/hydrogen-and-electric-batteries-and-the-open-strategic-autonomy-of-european-industry/ (Reported in Timmers, 2021).

[41] See the article "A $35 Billion Plan for Korean Battery Giants to Catch China" available at: https://www.bloomberg.com/news/articles/2021-07-08/a-35-billion-plan-for-korean-ev-battery-giants-to-catch-china. (Reported in Timmers, 2021).

[42] See the article "EV-battery giant CATL to boost capacity with $4.5bn investment" available at: https://asia.nikkei.com/Business/Automobiles/EV-battery-giant-CATL-to-boost-capacity-with-4.5bn-investment. (Reported in Timmers, 2021).

The EC has taken several measures to address such investment gaps for a digital transition, which are summarised below. In its different funding mechanisms and in the new multi-annual budget, together with the green transition, the digital transition is a key objective of the Commission. The five main financial instruments for the digital transitions are:

1. Digital Europe Programme;
2. Connecting Europe Facility – Digital infrastructure;
3. Horizon Europe,
4. ERDF; and
5. Recovery and Resilience Facility.

First, as part of the new EU's long-term budget for 2021 to 2027 of €1.211 trillion, the Digital Europe Programme will provide funding supporting projects in five key capacity areas: in supercomputing, AI, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs. With a planned overall budget of €7.5 billion, it aims to accelerate the economic recovery and shape the digital transformation of Europe's society and economy, bringing benefits to everyone, but to small and medium-sized enterprises. Digital Europe Programme also foresees €700 million to build top digital university and network them. MSs must, however, match it with another €700 million. Apparently, however, disagreement between MSs is blocking this.

Second, one of the three strands of the Connecting Europe Facility, the EU funding instrument to promote growth, jobs, and competitiveness through targeted infrastructure investment, is dedicated to digital infrastructures. The programme has a total budget of €2.065 billion and the actions foreseen include the deployment of very high-capacity networks (VHCNs), including 5G systems; provision of very high-quality local wireless connectivity in local communities; coverage of 5G systems on all major transport paths; deployment of new backbone networks; implementation of digital connectivity infrastructures related to cross-border transport and energy projects.

The third instrument is Horizon Europe, the EU's key funding programme for research and innovation with a total budget of €95.5 billion. The investments related to digital transition are contained in the second and third pillar of the programme. Cluster 4 of the second pillar is dedicated to funding research and innovation in key digital technologies including quantum technologies, AI and robotics, next generation internet, and advanced computing and Big Data. While within the third pillar of the programme, the European Innovation Council (EIC)[43], which has a budget of more than €10 billion for 2021-2027, provides support from early-stage scientific research or breakthrough technologies to the development and scaling up of innovative start-ups and SMEs. The EIC Accelerator, through the EIC Fund, will support SMEs, start-ups, with financial support through grant funding (up to €2.5 million) and investments (up to €15 million).

The fourth instrument financing the digital transition is the ERDF, as part of the Cohesion Policy. The fund will invest €226 billion in the European Regions in the period 2021-2027, following the five policy priorities of the EC. As digitalisation is one of these, ERDF investments will focus on digitalisation of services for businesses and citizens, and rollout of the high-speed broadband. The support will go where it is most needed, i.e., areas where there is a weak take-up of digital technologies or no, or very slow, or very expensive, broadband access or where there is not enough commercial potential to attract private investors.

The last instrument is the Recovery and Resilience Facility, a centrepiece of the NextGenerationEU programme, which makes a total of €672.5 billion in loans and grants available to support reforms and investments undertaken by Member States.

[43] See the European Innovation Council's website at: https://eic.ec.europa.eu/index_en.

The aim is to mitigate the economic and social impact of the coronavirus pandemic and make European economies and societies more sustainable. The EC requested that each Recovery and Resilient Plan presented by Member States should include a minimum of 20% of expenditure dedicated to foster the digital transition about € 134 billion). The Commission has strongly encouraged Member States to put forward investment and reform plans in the following areas related to digital policies: roll-out of rapid broadband services, digitalisation of public administration, data-cloud capacities and sustainable processors, and education and training to support digital skills. EU governments have recognised the importance of the Digital Decade targets and set out strategies to achieve those in their National Recovery and Resilience Plans (NRRPs). It must be noted, however, that the level of funding linked to each area and the specificity of the NRRPs varies across countries and targets (Deloitte, 2021). In this respect, one of our interviewees affirmed that there is little transparency and true European orientation in the way MSs are using these funds.

3.2. Critical assessment: from the Compass to the Map and beyond

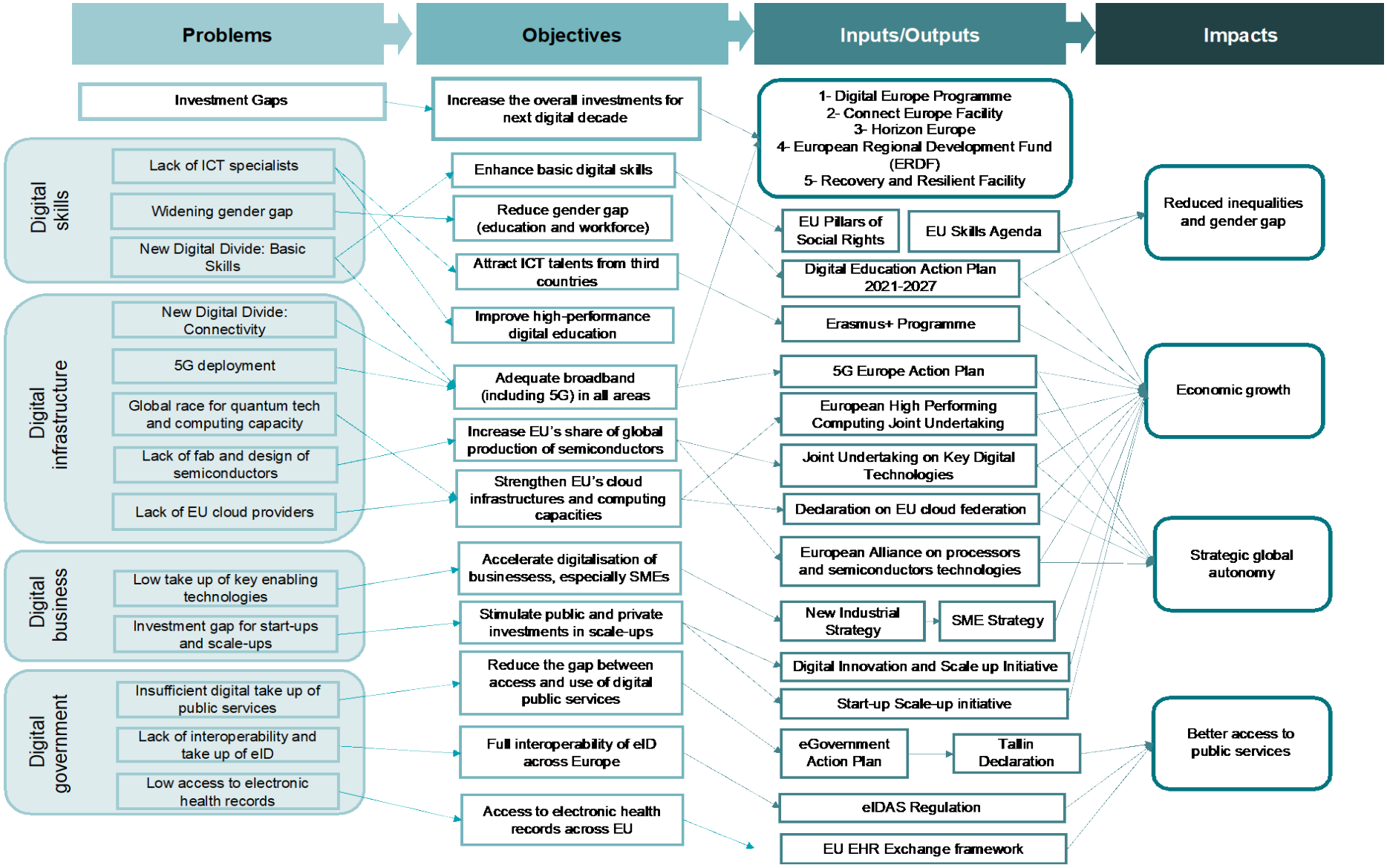
3.2.1. Intervention logic and mix of instruments assessment

The Compass lacked a clear Map that we graphically reconstructed (see graph in next page). It must be clearly stressed that the intervention logic presented here is our ideal reconstruction of the links that should exist between the various relevant policies. The Digital Compass does not present any such logic structure and we imposed it through our policy review.

The reconstruction is based on the key problems identified in Chapter two (see summary in section 2.6) and on the policy review conducted in the previous section. It is a high-level and simplified intervention logic for it does not include activities, and collapses together inputs and outputs, as well as expected outcomes and impact. The reasons for this simplification are both practical and based on logic. First, joining in one single intervention logic measures spanning across several policy domains by necessity requires sacrificing granularity (including activities and distinguishing between outcomes and impacts). Second, putting together inputs and outputs is logically justified by the nature of most policies reviewed and by the issue of lag time. In many cases the input is an announced strategy/action plan or legislative initiative, and the output is just their adoption that may have already occurred, in which case the distinction is meaningless. In other cases, the input is announced but the output not yet adopted, so it makes sense to put both under the same heading. If inputs were always defined as funds, then distinguishing them from the outputs (how they have been used and what they produced) would make sense. Yet, as reviewed in paragraph 3.1.6 and summarised in the next table), funding inputs are mentioned less than other instruments, and in any case, they would produce their outputs with a lag time.

The left-hand side of the reconstructed intervention logic starts from the key problems identified and classified following the four cardinal points of the Digital Compass. At the right-hand side, the impacts are summarised in four main topics, which reflects the four objectives of the Shaping Europe's Digital Future Strategy. In addition, at the top of the figure, there is an overarching theme referring to the European investment gaps for digital technologies compared to other global competitors. This challenge is cross-sectorial and is relevant for all four cardinal points. The objective for the next digital decade is a substantial increase of investments, both from the public and the private sector, that allows people and businesses to seize the potential of the digital transformation. For this section, the main funding instruments are presented as inputs in a single box, and some of them are then used to achieve the policy initiatives listed below as outputs for each of the four cardinal points. These five main funding instruments contribute to all the high-level impacts presented.

Figure 7: Reconstructed intervention logic



The table below, based on the policy review, assesses the extent to which the most important policy packages rely on funding mechanisms as opposed to policy initiative, legislative initiative, and alliances/partnerships. The table clearly shows a preponderance of policy and legislative initiatives as compared to funding and alliances. A good and integrated policy framework would be one where these components are better combined and balanced.

Table 3: High-Level assessment of instruments and measures

Funding Low	Policy initiative High	Legislative initiatives High	Alliances Low
1. Connecting Europe Facility – Digital infrastructure 2. Digital Europe Programme 3. European Regional Development Fund (ERDF) 4. Horizon Europe 5. Recovery and Resilience Facility	1. 2030 Digital Compass 2. 5G for Europe: An Action Plan 3. Blockchain strategy Digital Education Action Plan 2021-2027 4. Digital Transition Action Plan 5. European data strategy 6. European eGovernment Action Plan 2016 – 2020 7. European Pillar of Social Rights Action plan 8. European Skills Agenda 9. New Industrial Strategy 10. Recommendation on a European electronic health record exchange 11. Revised European Interoperability Framework 12. Shaping Europe's digital future 13. SME Strategy for a sustainable and digital Europe	1. Artificial Intelligence Act (proposal 2. Data Governance Act (proposal) 3. Digital Market Act (DMA) proposal 4. Digital Services Act (DSA) proposal 5. Directive on open data and the re-use of public sector information 6. eIDAS Regulation 7. EU Cybersecurity Act 8. Regulation on High Performing Computing Joint Undertaking 9. Regulation on platform-to-business relations 10. Single Digital Gateway Regulation	1. Declaration of the Industrial Alliance for Processors and Semiconductor Technologies 2. Digital Skills and Jobs Coalition 3. European Alliance for Industrial Data, Edge and Cloud

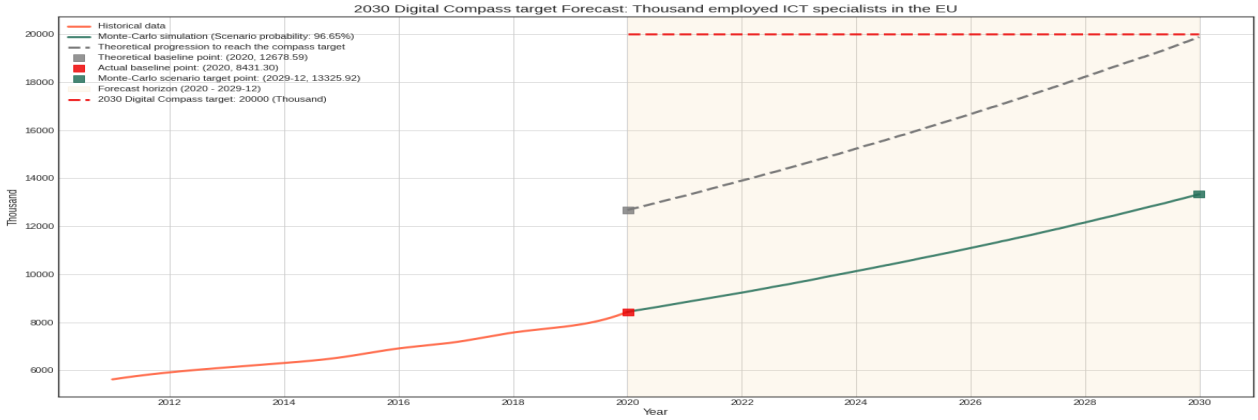
Funding Low	Policy initiative High	Legislative initiatives High	Alliances Low
	14. Strategy on Quantum computing 15. Tallinn Ministerial Declaration on eGovernment 16. White Paper on AI – A European Approach		

Source: Author's own elaboration

3.2.2. Critical analysis of the Compass targets

We now assess quantitatively and qualitatively the target objectives and corresponding indicators defined in the Digital Compass. Where data allowed it, we performed Montecarlo simulations[44] that are reported in this paragraph. For the targets that did not have available or sufficient data for a simulation, we present qualitative discussion[45]. Here we provide a simple and intuitive explanation for the general readership of how to interpret the reported simulations looking at the example concerning the ICT specialists' target.

Figure 8: Example of forecast for one target



Source: Authors' elaboration based on Eurostat (2021f), online data code: isoc_sks_itspt.

[44] Monte Carlo is a popular simulation technique that uses many repeated random samplings to produce numerical data. The underlying concept is to use randomness to solve problems that might be deterministic in principle. This allows to modelling phenomena with significant uncertainty in inputs. The forecast simulations could be performed only with the timeline indicated in the various graphs, because at least a minimum of historical data points is needed. First, enough historical data is needed to introduce some convexity in the forecast and corrects the monotonic "behaviour" of past data that does not account for possible uncommon behaviours. In the simulation, in fact, future points are forecasted as a combination of a "drift" that is driven by the average (i.e., mean of the log returns) and a "shock" that is random but can still be characterized by the standard deviation of the log returns. Second, over a short temporal time, without sufficient historical data, illusionary pattern may be produced.

[45] The simulation was not possible for the following targets: **5G coverage in populated areas**: lack of available historical data; **Production of semiconductors**: the only available data is an aggregation of Europe, Middle East, and Africa; **Edge/cloud**: lack of available historical data for "*climate neutral highly secure edge nodes*" (in addition, the baseline is 0 as the technology is just emerging); **Quantum computing**: lack of available historical data. In addition, the baseline is 0 as the technology is just emerging; **Take up of digital technologies (Big Data; AI)**: data available only for 2020, therefore impossible to make a forecast. **Digital late adopters (SME with basic level of digital intensity)**: the Digital Intensity Index (DII) is available but the 12 indicators that compose the index are not publicly available and could not be used to make accurate forecasts. **Access to medical records (e- records)**: lack of available historical data. **Use of digital ID solution**: lack of available historical data.

The actual baseline point is the number of specialists employed in 2020 (red dot). The Monte-Carlo simulation (green line) tells us that (i) by 2030 the target reached with probability 96.63% is 13.3 million specialists (green dot) and (ii) which should the theoretical baseline in 2020 to reach 20 million by 2030 (grey dotted line). In this example even under the more favourable forecast, the target would not be reached.

a. Skills

The box below reports the three targets defined for the skills pillar.

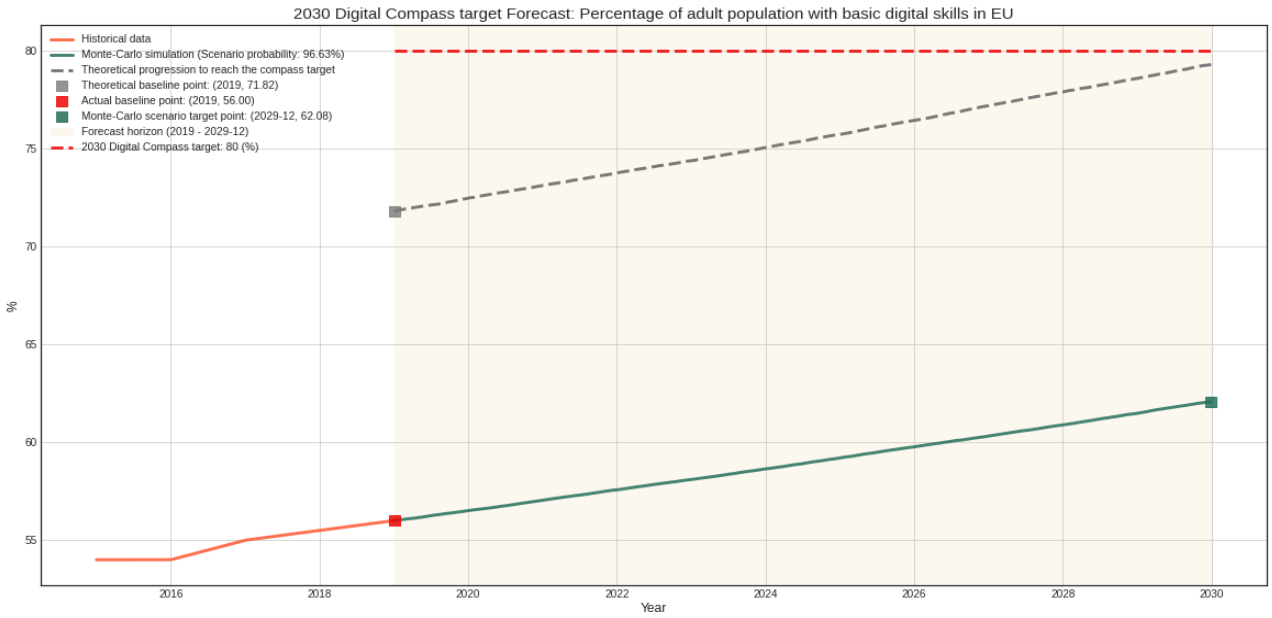
Box 1: Digital Compass targets for digital skills by 2030

Target #1: 80% of adult population with basic digital skills

Target #2: 20 million employed ICT specialists in the EU

Target #3: convergence of men and women in ICT specialists

Figure 9: Forecast of the % of adult population with basic digital skills



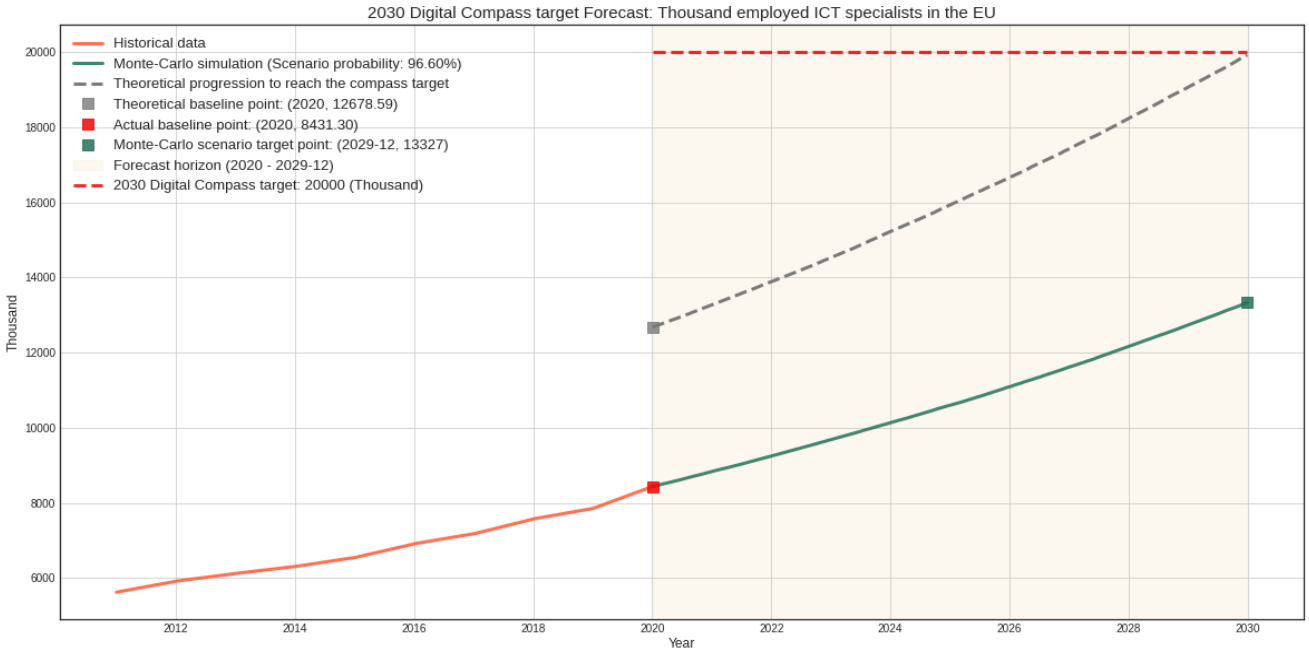
Source: Authors' elaboration based on Eurostat (2021e), online data code: isoc_sk_dskl_i.

As shown above, if the trend observed in the time series of Eurostat was projected to 2030, there would still be a substantial gap to reach the desired target. Based on its current trajectory the proportion of adults with basic digital skills is expected to reach around 64% by 2030 in absence of any further reforms or investments. The Monte-Carlo simulation shows that to reach the 80% target by 2030, in 2019 the percentage should be of about 73% already as opposed to the actual 56%.

The number of people employed as ICT specialists grew by 50 % during the period from 2011 to 2020 (from 5.5 to 8.4 million units). However, between 2019 and 2020, the progression path became steeper (with a rate of 75 % compared to the average annual growth rate of 5.2% over the decade. From the Monte-Carlo simulation in Figure 10, if such a trend continues regularly in the next nine years, there will be around 13.3 million ICT specialists in 2030, which is still 7 million below the target set by the Digital Compass.

Achieving the target will require a significant acceleration in the number of ICT specialists employed across the Member States over the next few years. Without a strong policy shock the target is unlikely to be achieved.

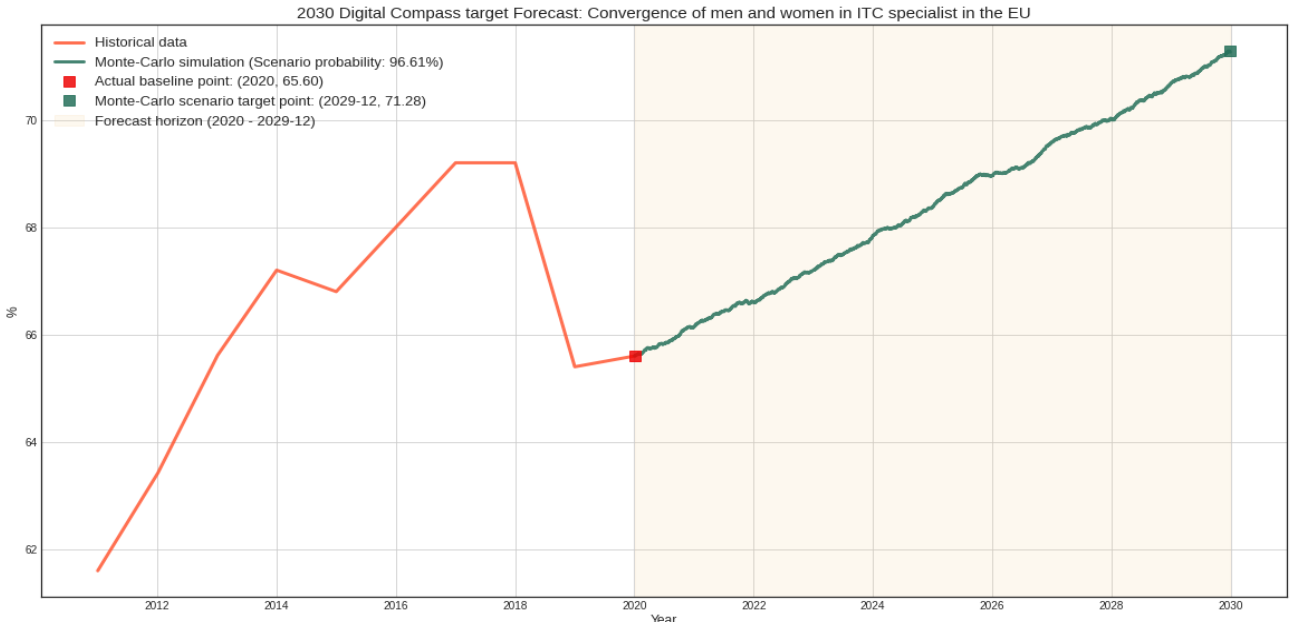
Figure 10: Forecast of the ICT specialists employed in the EU



Source: Authors' elaboration based on Eurostat (2021f), online data code: isoc_sks_itspt.

The gender gap in ICT specialists, as shown in the figure below, will hardly be closing in the next decade. The Monte-Carlo simulation forecasts that the gap in favour of men will increase by up to 20%. In this respect the Digital Compass target is generic and modest and the policy measures inadequate.

Figure 11: Forecast of difference in % between male and female as ICT specialists



Source: Authors' elaboration based on Eurostat (2021f), online data code: isoc_sks_itspt.

Therefore, significant investments are needed to tackle the digital skills gap and reach the three targets. There are several instruments put in place at EU level for the budget 2021-2027 that will provide opportunities for Member States to support such developments.

For instance, Member States will have to allocate 20% of the funds from the Recovery and Resilience Facility on the digital transition, which include the development of digital skills.

However, how this budget will be spent it will depend by each country's Recovery Plan and implementation of the projects.

b. Digital infrastructure

The box below reports the three targets defined for the digital infrastructure pillar.

Box 2 Digital Compass targets for digital infrastructure by 2030

Target #1: Gigabit for everyone, 5G everywhere

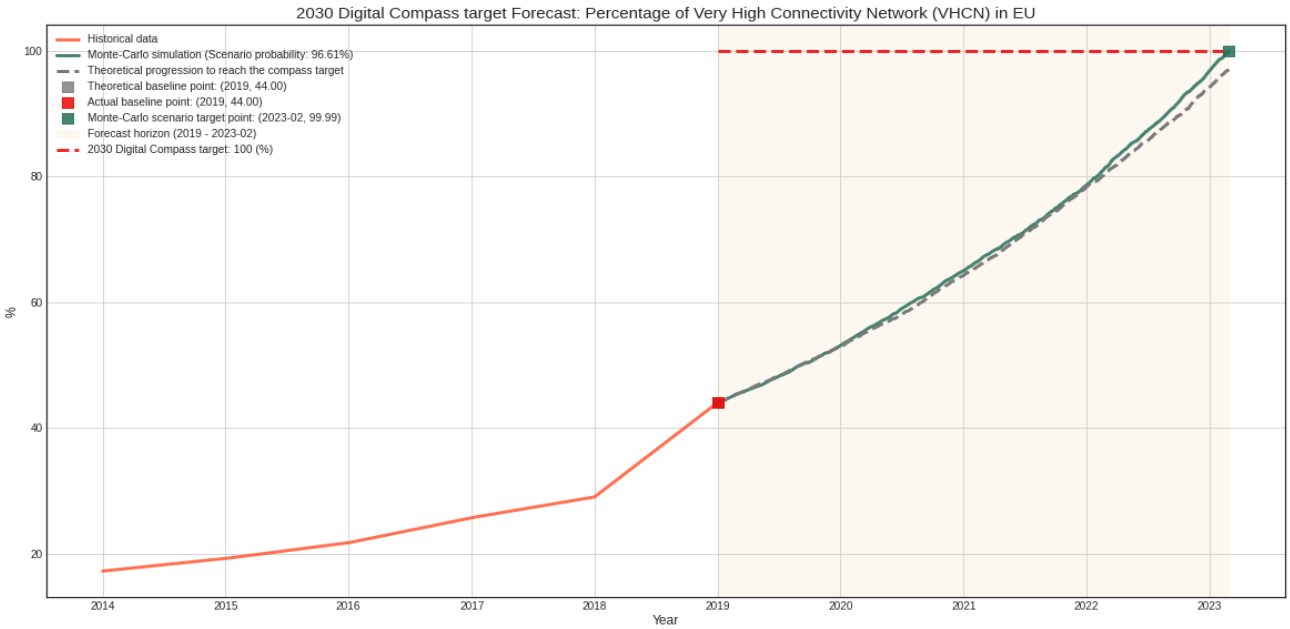
Target #2: Double EU share in global production of semiconductors

Target #3: Deploy 10,000 climate neutral highly secure edge nodes

Target #4: Build first computer with quantum acceleration

The first target, although ambitious, seems to be **feasible** based on the current trends of Member States. The current basepoint is at around 44% of the population, with the goal of 100% having access to these networks. According to the forecasts shown below, the EU may be on target even before 2030.

Figure 12: Forecast on households to be covered by a Very High Connectivity Network



Source: Authors' elaboration based on Eurostat & European Commission DG CNECT (2021), online data code: SDG_17_60.

For what concerns the second target on semiconductors, there is not enough data available to form accurate quantitative projections. However, the target for 2030 appears to be **quite ambitious** considering the gaps in funding (discussed in the qualitative assessment) and the current minor role that Europe plays as compared to China and the US. Currently, Europe has about 10% of the world's market share in semiconductor and is 10 percentage points from reaching the target. With regards to the target on edge nodes, where **no data** are available for a forecast, the time required to add edge

nodes must be taken into consideration not only funding but also the topology, or the structure of the network, which can have varying sizes and will be composed of different interconnected components.

Finally, the fourth target was achieved in June 2021, when Europe's first quantum computer, Q System One[46], was launched by IBM in Germany with *German Chancellor Angela Merkel describing the new technology as "promises tremendous innovative achievements" and referring to its "key role for digital and technological sovereignty"*. The target, to develop the first European computer with a quantum accelerator is **feasible** and in fact, may not be ambitious enough to make Europe a leading contender in the global race of quantum computing. Furthermore, the computer, while managed by Fraunhofer-Gesellschaft (Europe's leading organization for applied research), was built by IBM, a U.S. tech company, continuing Europe's dependence on non-European technology providers.

c. Digital business transformation

The box below reports the three targets defined for the digital business transformation pillar.

Box 3 Digital Compass targets for digital business transformation

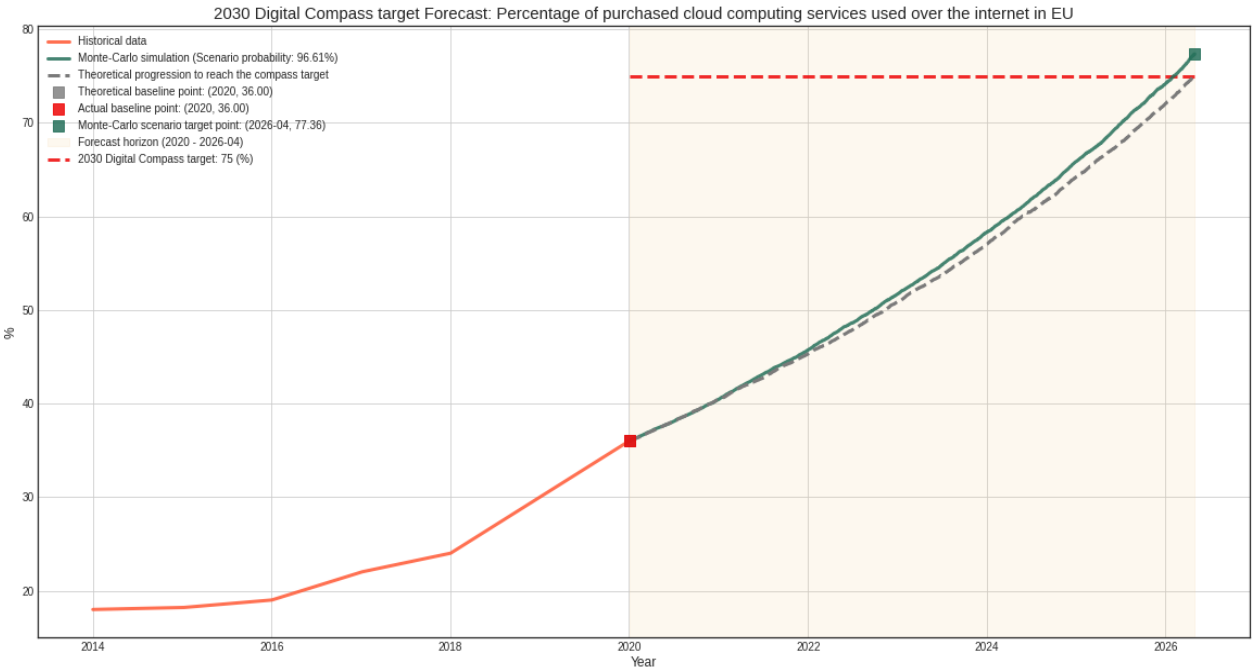
Target #1: 75% of EU companies using Cloud/AI/Big Data

Target #2: Double EU unicorns

Target #3: More than 90% of SMEs reach at least a basic level of digital intensity

According to our forecast, the first target seems within reach.

Figure 13: Forecast of purchased cloud computing services by European enterprises



Source: Authors' elaboration based on Eurostat (2021d), online data code: isoc_cicce_use.

However, this may be an optimistic forecast as it does not fully take into consideration barriers of implementation, especially for SMEs. For what concerns AI and big data, an assessment can be made

[46] See the IBM webpage on Q System One at: https://www.research.ibm.com/quantum-computing/system-one/.

looking at some recent single data points. As of 2020, only 13% of enterprises analysed big data from any source (including social media, geolocation, and smart devices).

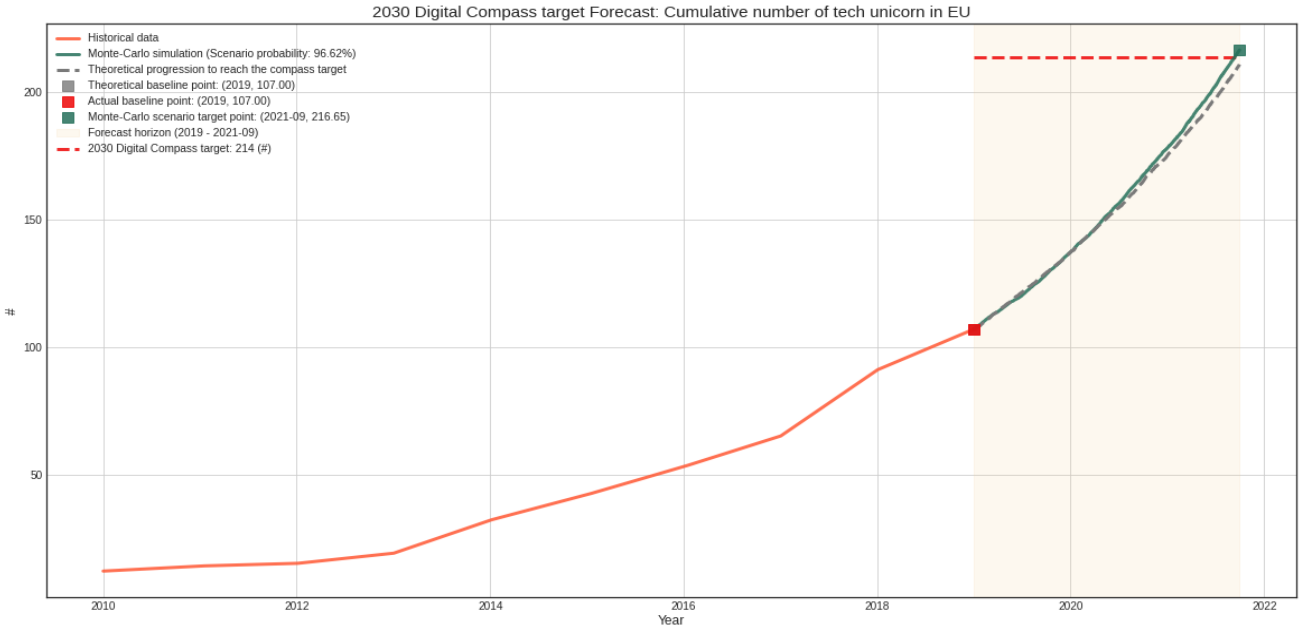
This is 64 percentage points lower than the goal and appears to require a significant acceleration of SMEs adopting this practice in the coming years.

For AI, as of 2020, only 7% of enterprises in the EU (with at least 10 people employed) used AI applications. It appears, thus, to be the most ambitious part of the first target due to the current low uptake.

As for the second target, our forecast indicates that doubling the number of unicorns from 107 to 214 is beyond reach, as our simulation suggests that there may be at most 150 European unicorns by 2030.

In this case, given the very limited number of observations, the double exponential smoothing of the historical data is more reliable than the Monte Carlo Simulation[47].

Figure 14: Forecast of number of tech unicorns



Source: Author's elaboration based on Statista & Tech Nation Report 2020.

Finally, for the third target there are not sufficient observation points to produce robust forecast. However, to gain perspective we can comment statically two observation points. Since 2015, the number of SMEs with a basic level of digital intensity[48] has only increased from 52% to 60% in 2019. In view of this observation, the goal of 80% by 2030 seems ambitious unless a strong acceleration takes place supported by important measures.

d. Digital government

The box below reports the three targets defined for the digital government.

Box 4 Digital Compass targets for digital government

[47] Under conditions of very few data points, considering the unknown external effect by the market, we opted for a more conservative approach and comment the scenario that implies the original natural trend given by the linear progression.

[48] The digital intensity index (DII) categorises the number of digital technologies that are used by a company into very low, low, high, and very high levels based on a 12-point system. Enterprises with at least a low level of digital intensity, or basic level, have 4 or more points.

Target #1: 100% online provision of key public services available

Target #2: 80% of citizens use digital ID solution

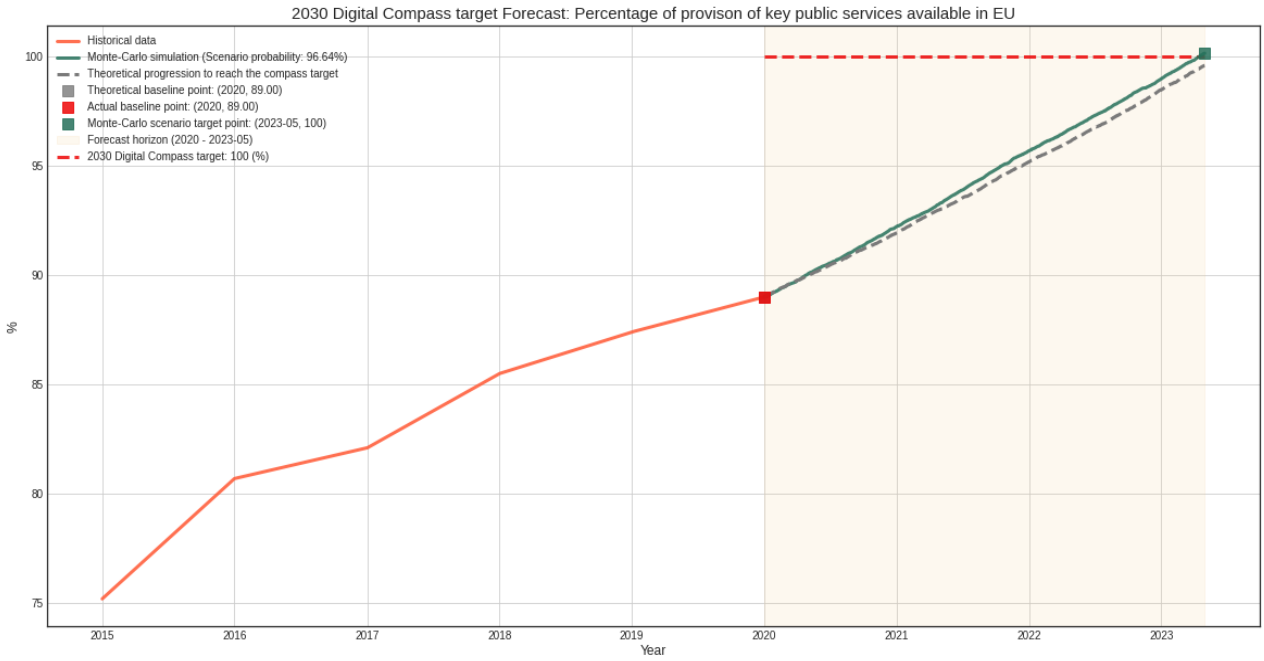
Target #3: 100% of European citizens have access to EHR

In this case the first target is a clear case of indicator reification and is not useful at all for policy as we have fully detailed elsewhere (Codagnone et al., 2015). The most substantial criticism of the validity of this indicator concerns the relation between the supply of online public services and their usage by citizens. It can be observed that countries/agencies with very sophisticated websites have low levels of use and vice versa. The literature on eGovernment adoption suggests that such supply side indicator has limited relevance in predicting adoption by citizens and businesses that is what should really matter. Adoption depends on users' social and individual characteristics, and on traditional behavioural attitudes to technology and the Internet in general. It also depends on the extent to which government offer online truly beneficial services for citizens and businesses, and not simply services that concern administrative obligations.

Furthermore, a service can be online without that a real reorganisation occurred. High scores in EU supply-side benchmarking of eGovernment have contributed to increasing the institutionally perceived quality but not necessarily the real quality and utility of eGovernment services. As explained by one of our interviewees, such target may have the side effect to maintain silos and buy more services from the same tech giants that supporters of digital sovereignty would like to displace. Better targets would be: % of citizens and businesses using eGovernment services; % of citizens and businesses using elective eGovernment services as opposed to services that fulfil administrative mandatory obligations.

According to the latest eGovernment Benchmarking, today already 89% of key public services can be completed entirely online, a sharp increase when compared to five years ago, when only 75% were capable on online completion (Capgemini, 2020). Considering that the Covid-19 pandemic has been an important driver for governments in moving public services online, such positive trend is expected to continue and the target of 100% online provision of key public services may be reached already around 2024.

Figure 15: Forecast of provision of key public services online



Source: Author's elaboration based on DESI 2020.

For what concerns the second target, the use of digital ID solutions has also increased in the last years and during the pandemic EU governments have been strongly encouraging the adoption of eID as a necessary condition to access public services. As figures on this indicator are not yet available at the EU level, we can look at a case of one MS in which we can observe the sharp increase in the use of eID before and after the pandemic. In Italy, from 2016 to 2019 the individual users of eID increased by four million units in three years, while in the last year the users increased by 20 million[49]. If other Member States have seen similar trends in the last year, the target of 80% of users by 2030 is realistic.

Finally, the achievement of the third target for EHRs will mainly depend on the individual Member States that are lagging. There are no official statistics on the access by citizens to EHR. However, according to the latest survey on the use of eHealth by GPs (European Commission, 2018d), EHR is currently available across all analysed EU countries and nearly all GPs (96%) use it in their practice. Basic health data and information and order-entry functionalities are almost fully adopted in all countries, and in more than half of them most GPs are routinely using clinical decision support functionalities and administrative data routinely. It seems that reaching the goal of 100% of GPs using EHRs will be achieved before 2030. However, the target relates to citizens' access to EHRs and there are **no official statistics** on this indicator.

3.2.1. Overall critical assessment

To start with, we consider some exemplar inconsistencies in the policy initiatives worth pointing out, and then we move to other more general assessments. First, the SME strategy promises to reduce administrative burden on SMEs while many of the proposed acts might increase it. Second, the Digital Product Passport (DPP), which is discussed in detail in section 3.3, may increase administrative burden on businesses without having a clear link with the other parts and targets of the Digital Compass.

[49] See the presentation and description of the Italian Public Digital Identity System available at: https://avanzamentodigitale.italia.it/it/progetto/spid.

Third, the target of reaching 100% of online public services may be self-defeating with respect to the goal of digital autonomy. It might push public agencies to speed up the adoption of technological solutions to reach the target. However, this rush may lead public administrations relying on the services of those tech giants that the more hardliner proponents of digital sovereignty would like to curb. Furthermore, they may do it by reproducing a silos approach that reduces the potential benefits for citizens and businesses. Fourth, unless there is a specific EU strategy on linking digitalisation and green for scale-ups, it seems difficult that increasing the number of companies with a market capitalisation exceeding €1 billion (unicorns) can be combined with the reduction of carbon emissions. Finally, there is lack of sectorial and very operational analyses of value chains to identify strengths and weaknesses, as well as strategic control points where to focalise efforts.

Second, it seems that funding mechanisms are less prominent as compared to policy and legislative initiatives. In many cases, references are made to new funding mechanisms or the use of existing possibilities to allow for state subsidies that are yet to be operationalised. For instance, stakeholders lamented a lack of financial support for upgrading digital skills that are a pillar for the modernisation of European industry. More funds for SMEs and scale-ups are needed, considering that the number of European scale-ups is still less than a third of those in the US. This to some extent explains why Europe is only home to 12% of unicorns globally, with half of those in the UK.

Third, there are three areas, mostly outside the remit of the EU, where MSs have the responsibility to improve the path towards the 2030 digital targets. These are: public administration (in this context eGovernment), health (in this context digital health), and educational systems (in this context further digitalisation of schools, new curricula, and courses to increase both digital skills in general and produce more graduates in various topics related to the digital transformation and related new technologies).

Finally, the proposed regulations should consider thoroughly the costs they may impose on businesses both in terms of administrative burden and conformity tests and audits. For instance, the proposal for the AI Act, if adopted, could be challenging for most companies (Digital Europe, 2021b). According to Obendiek (2021), for instance, the EU has focussed significant efforts on regulation to remedy the negative consequences of its weak position in digital governance. While many of these regulations will increase protection of civil liberties and consumers' rights, they are unlikely to enable Europe to regain a global position in online platforms or cloud computing. The current debate on the digital transformation is characterised by the polarisation between those who consider any regulation as stifling innovation and detrimental to the digital transformation, and their opponents favouring stronger regulation. This opposition translates into the juxtaposition between the application of the precautionary principle (Cohen, 2016) and the use of cost/benefits assessment (C. R. Sunstein, 2003, 2005a, 2005b, 2007). The key challenge for Europe is to strike the right balance between these two poles.

3.3. The case of Digital Product Passports

3.3.1. Policy context, objectives, and expected impacts

The concept of **Digital product passports** (DPPs) was introduced in the Sustainable Products Initiative (SPI) and has been gaining political attention, as it was also briefly described in the Digital Compass as a potential digital solution to meet the ambitious agenda set out by the European Green Deal (European Commission, 2019c) and the new Circular Economy Action Plan (CEAP). In the Digital Compass (European Commission, 2021a, see box at p. 3) the DPP is presented as a '*Digitally enabled green solution*', based on smart management of product-related data across the product lifecycle.

The DPP aims to increase transparency of products between companies and consumers and is envisioned to consist of an online platform on which users could access information on the sustainability of products including the origin, composition, repair, and dismantling options. A more ambitious version of the DPP would also include information on the product's full environmental footprint including all social condition of the production along the value chain. The aim of the DPP is to both the lack of information and to promote a circular economy, and thus support a low carbon transition (Adisorn et al.2021).

The Green Deal is a strategy to transform the EU into a climate neutral and circular economy while making the economy competitive and society more prosperous and fairer. To meet Green Deal objectives, product policy needs to keep climate and environmental impacts linked to resource and energy use, production and use of products within planetary boundaries. This means reducing the overall life-cycle climate and environmental footprint of the products placed on the EU market, achieving longer product lifetimes such as through more durable and reparable products, increasing circular material use rate, reducing waste and achieving higher recycling rates. The CEAP provides a future-oriented agenda for achieving a cleaner and more competitive Europe by aiming to achieve 2030 climate and energy efficiency goals and climate neutrality by 2050. The CEAP announced a sustainable product policy legislative initiative to make products fit for a climate neutral, resource efficient and circular economy, reduce waste and ensure that the performance of frontrunners in sustainability progressively becomes the norm. Against this background the SPI aims at producing a directive that will set out a new product policy framework that will go beyond the current scope of the Eco-design Directive by widening the scope from energy related products to the broadest possible range of products. Among the foreseen contents of the SPI initiative there is the intention of *'establishing EU rules for setting requirements on mandatory sustainability labelling and/or disclosure of information to market actors along value chains in the form of a digital product passport'* (European Commission, 2020y, p.3). The DPP is mentioned, in a somehow disjoint fashion with respect to the overall document, in the Digital Compass (European Commission, 2021a, see box at p. 3).

While currently there is not one clear, integrated EU policy instrument that acts as a centralised database for the information of products or dictates sustainable manufacturing, it must be noted that in the domain of product policy there are already several regulations in place: Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals, known as REACH (European Parliament and Council, 2006); Framework for eco-design requirement of energy-related products (European Parliament and Council, 2009); WEEE directive on waste electrical and electronic equipment (European Parliament and Council, 2012); New Regulation repealing Directive 2010/30/EU on energy label (European Parliament and Council, 2017b); New RoHS directive on restriction of the use of certain hazardous substances in electrical and electronic equipment(European Parliament and Council, 2017a); New directive on packaging and packaging waste (European Parliament and Council, 2018).

Furthermore, in this domain there are many other EU level provisions and countless of voluntary initiatives in place (Adisorn et al., 2021). While these regulations act together to provide tailored guidance, a consistent implementation of these policy interventions is required to optimise the efficiency and contribution the circular economy and synergies of these legislative instruments can provide additional reinforcement of standards (European Commission, 2019d). Currently there is some coordination taking place, such as the development of the EU Ecolabel and GPP criteria, by providing information on the product overlap of these legislative instruments.

The Sustainable Development Initiative (SDI) and DPP are currently at the stage of the Inception Impact Assessment (European Commission, 2020ag)[50], with the consultation having closed on 9 June 2021 with 193 responses[51]. The Inception Impact Assessment will align with the objectives of The Green Deal and of Circular Economy Action Plan (CEAP) (European Commission, 2020u), proposing changes to legal framework to achieve the objectives of the latter. Furthermore, it will be reinforced by Council Draft Conclusions on Making the Recovery Circular and Green (Council of the EU, 2020). Other ancillary initiatives focusing on consumers include the communications on strengthening the role of consumers in the green transition (European Commission, 2020d) and on strengthening consumer resilience for sustainable recovery(European Commission, 2020ae).

According to the Inception Impact Assessment (IIA) (European Commission, 2020y, p. 4) the administrative burden imposed on economic operators involved in placing products on the EU market would be limited and would be reduced if the measures are taken at EU especially for manufacturers active on several national markets. Note that, as observed earlier, SMEs are seldom present in multiple European markets and would not benefit from economy of scale. Furthermore, the IIA underscore that implementation costs for companies will depend on the availability of IT tools, secondary data, helpdesk and training, all aspects where SMEs are at a disadvantage compared to large enterprises.

3.3.2. Responses to the public consultations

We performed a very preliminary Natural Language Processing on the textual responses to the consultation (including the responses expressed through a full paper). Our analysis shows positive attitudes by non-business entities but concerns or outright negative attitudes from businesses. Businesses' concerns are about administrative burden, conformity costs, and protection of IP. Digital Europe, for instance, articulated its response to the consultation in a position paper that makes three main arguments (Digital Europe, 2021c). First, digital products are already covered by the various provisions we mentioned earlier (Eco-design Directive, the RoHS Directive, the REACH regulation, the WEEE Directive, etc.) and the Commission, according to Digital Europe, should demonstrate any additional needs that are required within the regulatory framework for products. Second, consumers should not be overwhelmed with information, and the DPP should focus on providing information that is relevant for the target group. Third, to protect businesses IP rights, certain information (e.g., repair instructions) should not be shared widely but only with professionals. Fourth, the DPP should build on existing tools (i.e., the EPREL database, environmental labels, and so on) as to minimise the administrative burden on companies and avoid increasing the cost of sustainable products.

[50] See the dedicate section in the EC website at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en .

[51] The consultation responses are available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative/feedback_en?p_id=8532104 .

3.3.3. A behavioural assessment of the DPP

Considering the policy initiatives aimed at involving consumers in the efforts towards a more sustainable and climate neutral economy (European Commission, 2020d, 2020ae), a final assessment from a behavioural perspective is in order. Based on our experience in behavioural experiments testing labels and other product information vehicles (see for instance Codagnone et al.2016), it seems uncertain and possibly contestable that the DPP will help consumers make more sustainable choices. The lessons derived from our experience in behavioural experiments (Codagnone et al., 2016) are that to really inform and influence consumers, labels or other forms of product information should be implemented: limiting complex numerical information to reduce cognitive overload; using clear text and graphics because people tend to think "*if it is hard to read then it is hard to do*"; adopting classification systems with only one single format. Given the objective of the DPP and the amount of information needed to cover the entire value chain, even if in digital format, it is unlikely that DPPs will meet the above criteria and really inform consumers and shape their choice architecture.

4. DIGITAL AUTONOMY FROM RHETORIC TO REALISM

4.1. A contested concept

About four years ago Emmanuel Macron talked about strategic autonomy in his speech at La Sorbonne (Macron, 2017). Since then, the expressions strategic autonomy, digital autonomy, digital sovereignty, and technological sovereignty have figured prominently both in speeches and policy documents (Timmers, 2021). Although these expressions have become prominent in politics and geopolitics, these concepts have been rarely scrutinised in academic research, with some exceptions (Couture & Toupin, 2019; Möllers, 2020; Mueller, 2020; Pohle & Thiel, 2020; Timmers, 2018a, 2018b, 2019a, 2019b, 2021). According to Paul Timmers, strategic autonomy is the capacity of states to decide and act upon essential aspects of one's longer-term future in the economy, society, and their institutions (Timmers, 2018a, 2018b, 2019a, 2019b, 2021). Accordingly, strategic autonomy is the mean to realise the goal of digital sovereignty (Timmers 2018a). There are three different discourses that justify the search for digital sovereignty in Europe. The first is an appeal to the pristine concept of sovereignty in both politics and geopolitics, where it means the power enjoyed by a governing body to rule over itself within a given territory, free from any interference by outside sources or bodies (Grimm, 2015). The clearest emanation of this discourse are proposals for data localisation law. The second discourse is ethical with the aim to protect consumers by offering technological services that respect user rights and domestic laws and norms. The third discourse emerges from concerns about future economic prosperity, competitiveness, and supply chains resilience. As seen, there are key strategic sectors where Europe heavily depends on its global competitors, such as in the domain of online platforms, semiconductors, cloud computing. It is a fact that sovereign states are challenged by the digital transformation and there is a clash between companies and states that, according to Floridi (2020), is the most visible and asymmetric. States depend on companies for all that concerns digital power, including when it comes to defence from cyber-attacks. States, however, have the countervailing power to regulate the digital. Again, we have the two conflicting narratives that regulation may hinder innovation and that a lack of it can create dire societal risk. In practice, the reality is that companies shape the nature and speed of change whereas governments can influence the direction of change.

4.2. Does it matter and can we afford it?

The dominance of non-European online platforms has given these platforms a privileged access to a trove of data. The first question is: does it matter? Some argue that this competitive advantage is not strategically relevant, since being part of the global flows of data produces gains for everyone (MGI, 2016). Others, like Weber (2017), argue that if data are the key raw material of the 21st century, it may be a source of decline for Europe to be a net exporter of data and net importer of finished services produced using such data. The question, however, is whether it is feasible to regain control on online platforms. In other words, can Europe afford it? Another domain where Europe is highly dependent on foreign technology giants is the current cloud computing market, to which the same question applies: is it feasible to regain control? A first answer in a recent contribution by Timmers is that "*in many areas, there is not so much to take back […] Europe never had control of, let alone the lead in, digital platforms; the EU cannot look back on a time that it had control over cloud service*" (2021). Digital sovereignty does not come for free and as already mentioned in chapter 3, the investment gap to reach the potential benefits from digital transformation has been estimated between €65 billion (EIB, 2016, 2020, 2021b) and €125 billion per year (European Commission, 2020b, p. 18). Certainly, some of Europe's weaknesses and dependencies matter. However, Europe must make selective and realistic choices, while at the same time assess and constantly monitor the risks entailed in those areas where gaps cannot be covered.

Specific threats to sovereignty should be identified to decide which are worth being brought back under control through integrated policy interventions, and which should only be assessed and monitored. For instance, it is unrealistic to fill gaps in online platforms and cloud computing, but it is still worth intervening to ensure civil liberties and protect consumers and business rights by creating a level playing field; without, however, the expectation that the proposed regulation (DSA and DMA) will enable the EU to regain control. In the case of semi-conductors, for instance, Europe cannot pursue strategic digital autonomy in semiconductors following the US strategy of reshoring and bringing back leading-edge contract chip making to US soil (Kleinhans, 2020). The US can do it as they dominate the fabless segment and can integrate it with chip fabrication and operate such fabs at full capacity. 'European integrated device manufacturers do not rely on leading-edge fabs and Europe lacks a strong fabless industry, so the question is 'who would utilise leading-edge European fabs?' (Kleinhans, 2020). In semi-conductors Europe faces three challenges: how to leverage existing strengths through strategic industrial policy? How to secure access to foreign suppliers through digital trade policy and digital diplomacy? How to contribute to create resilience in the global value chain?

4.3. Open strategic autonomy and digital diplomacy

Digital autonomy requires important financial resources, the capacity to design and produce, the use of new technology and skills excellence. It also requires, however, a new form of diplomacy in the digital domain to build alliances and partnerships. The first step in this process requires the EU to redefine its position as a digital actor in the global digital arena. Europe has been trapped in the past five years between the two extremes of the sovereigntist Chinese and the laissez-faire US approaches to digital policy (Obendiek, 2021). These two stylised and ideal-typical model are well defined and described (O'Hara & Hall, 2018). Libertarian Silicon Valley Open Internet values are still held by minority players, whereas for the big companies they remain simply rhetorical instruments (Zuboff, 2019). The Chinese model promotes its own tech giants (Baidu, Tencent and Alibaba) which work under close governmental control. These companies are hungrier, less complacent, more vigorous, more eager for competition, and less constrained by mission statements and core values than their US or European counterparts. The adoption of the GDPR (Politou et al., 2018) was a defining moment for Europe for "*This new data protection ecosystem stems from the strong roots of another kind of ecosystem: the European project itself, that of unifying the values drawn from a shared historical experience with a process of industrial, political, economic and social integration of States, in order to sustain peace, collaboration, social welfare and economic development*" (Ethics Advisory Group, 2018, p. 6). It seemed that Europe adopted a principled Digital Social model. Doubts that Europe's digital social model was hiding a new emerging protectionism were raised in key magazines and newspapers[52]. That this risk was perceived externally is indirectly shown by efforts made by Brussels-based think tanks to remark that Europe was not protectionist and was aware of the downside of protectionism and autarky (ERT, 2021; European Commission, 2020k). In 2021, however, the new concept of Open Strategic Autonomy (OSA) emerged in the debate, with the official opening coming in the February 2021 Communication on the new Trade Policy Review (European Commission, 2021q) and subsequently included in May 2021 in the update of the New Industrial Strategy (European Commission, 2021s). In the Trade Policy review, OSA is defined by three axes: resilience and competitiveness, sustainability and fairness, and assertiveness and rule-based cooperation. It is an open approach in that it does not aim to build a Fortress Europe but is still strategic.

[52] See: The Economist article "Has covid-19 killed globalisation? at: https://www.economist.com/leaders/2020/05/14/has-covid-19-killed-globalisation ; and the Wall Street Journal article "Is Europe Ready to Defend Itself?" available at: https://www.wsj.com/articles/is-europe-ready-to-defend-itself-11546623417.

In the digital domain, a good example of this new approach is the presentation of the national cloud strategy by the French Minister of Economy Bruno Le Maire[53]. The application of this new concept calls for a new digital diplomatic strategy of global cooperation rather than attempting to shield Europe from the outside (Obendiek, 2021, p. 1). Especially with respect to transatlantic relations, the change of the US administration offers a new window of opportunity. As AIDA Chair Dragoș Tudorache states: "*As we prepare, at the European level, multiple and complementary pieces of legislation setting the rules of the digital world, we need to also start promoting our views, values, and rules around the world. For the EU to become a global geopolitical actor, we need to adapt our foreign policy and external action to the digital future, and a key component of this is strengthening the digital transatlantic partnership. The EU and the US are both founded on the values of freedom, human rights, democracy, and the rule of law. These values need to serve as cornerstones for the global digital future*." (AIDA, 2021d, p. 3). Some of the regulation reviewed so far is not received immediately and intuitively well in the US and needs to be accompanied by digital diplomacy. Moreover, it has been noted that: "*the EU needs to forge strong alliances worldwide with likeminded partners and overcome regulatory divergences revolving around privacy rights, data flows and taxation. Soft governance mechanisms may be more amenable to securing international consensus on AI governance than hard law approaches*" (AIDA, 2021a, p. 3). After the years of harder stances on digital autonomy and sovereignty there is now a window of opportunity to re-establish global digital alliances especially with Europe's historic partner. In conclusion, the EU should now strive for Open Digital Autonomy by defining well integrated policies that combine more funds, regulation when needed but without excess, global strategic partnership and alliances, and a new and innovative approach to digital diplomacy that leverages European strengths also in areas such as the setting of global standards (Timmers, 2020).

[53] See the presentation, available at: https://www.economie.gouv.fr/files/files/Thematiques/numerique/Transcript_presentation_strategie_nationale_cloud.pdf.

5. CONCLUSIONS AND RECOMMENDATIONS

In the previous chapters, an extensive analysis of current situations and trends in the four pillars of the Digital Compass and of the most relevant policy packages and legislative initiatives was presented. These have been integrated with a thorough conceptual, quantitative, and qualitative assessment of the target objectives in 2030. Finally, the issue of Digital Autonomy has been discussed in detail. The conclusions and recommendations provided below are selective and focus on the most evident and strategic issues according to our judgment. This concluding chapter first presents some general conclusions, then focuses on sector-specific conclusions and finally provides key recommendations.

5.1. General conclusions

1. **A coherent map is needed.** The policies and legislative initiatives for the Digital Decade still lack an overall coherent map that clarifies the synergies between the policy packages and avoid inconsistency of objectives and targets. Our draft intervention logic is just a starting point.
2. **Competition, industrial, and digital policies should be better harmonised**. Currently these policies are not sufficiently integrated and more work is needed to combine the objectives of protecting citizens and taming big businesses with an industrial policy that will boost European industry and help create large and new European companies.
3. **Policies are not based on an integrated mix of instruments**. Both in the overall map and in single policy packages the interventions should better balance the different instruments: agendas and plans, regulation, funding, and alliances and joint initiatives.
4. **Need to further ponder the potential costs regulation.** Some of the proposed regulations should pass more stringent and thorough SMEs tests.
5. **Funding mechanisms and investments may not be enough to reach the targets**. The investment gaps in Europe compared to the global competitors should be complemented by additional funding mechanisms in key strategic areas. However, it seems that several policy initiatives do not yet recognise this key problem. The recently announced European Chips Act should thus consider this in its design and implementation to be effective.
6. **Realistic choices and risk monitoring mechanisms are lacking**. In view of (5) above, it is of the uttermost importance that high-level agendas and roadmaps are complemented by very concrete and operational value chain analysis to identify strength and weaknesses, strategic control points and to make selective and realistic choices. This includes the following: a) focus efforts and resources to retain existing strengths and gain position in innovative domains where no global incumbents have yet emerged; b) specific threats to sovereignty should be identified to decide which are worth being brought back under control; and c) assess and constantly monitor risks in those areas where gaps cannot be realistically filled.
7. **Digital autonomy needs proactive digital diplomacy**. Finally, open digital autonomy requires more effort and innovation in the domain of digital diplomacy, especially with our historical transatlantic partner. The European global influence cannot be limited to regulations that shape the international business environment, elevating standards worldwide, as claimed by Bradford (2020). It must be complemented by active digital diplomacy and the search for international alliances that, while spreading the key European values, also pragmatically tries to secure relations, especially where Europe has dependencies and gaps that cannot be removed. This point was expressed by the 2021 State of the Union Speech by President Von der Leyen, who launched the 'Global gateways' scheme that aims to "create links, not new dependencies".

With an overall allocation of €79.5 billion, the new Global Europe programme will cover the EU cooperation with all third countries, except for the pre-accession beneficiaries and the overseas countries and territories from the geographic programmes. Thus, it may represent an important contribution to move from ambition to action in leading the Digital decade and promote the role of the EU as a trusted and priority partner worldwide.

5.2. Specific conclusions

1. **On skills.** Not only literature sources, but also all the interviewed experts and stakeholders considered a digital skilled population and an increasing pool of digital specialist as the key pillar for prosperity in the 21st century. Yet, our quantitative forecast indicates that the three targets of the Digital Compass for 2030 are over ambitious. In addition, because of the Covid-19 crisis, there is also a risk that the gap between man and women employed as ICT specialist will widen. The funds currently available are inadequate to reach these targets, and companies (especially SMEs) are not investing enough in retraining personnel. Finally, the formal institutions of higher education are slow to adapt to the new market demands and there are still an insufficient number of newly graduated digital specialists.
2. **On digital infrastructure.** Among the four targets under this cardinal point, the conclusions are mixed. First, according to our forecast, the 'Gigabit for everyone, and 5G everywhere' target can be reached by 2030, especially for what concerns the coverage of VHCNs for all European households. Second, the target 'Build first computer with quantum acceleration' was achieved in June 2021. Third, for the target 'Deploy 10,000 climate neutral highly secure edge nodes' there is no available data for a quantitative forecast. Edge computing is a promising area for Europe. However, considering the efforts required to add edge nodes in terms of funding, topology, as well as the structure of the network, the target for 2030 seems over ambitious. Lastly, for what concerns the production of semi-conductors there is a lack of available data. However, it appears to an ambitious target and our specific conclusions on semi-conductors and on edge computing are summarised in the next point dedicated to industry and SMEs.
3. **On industry and SMEs.** On industry and SMEs, we have devoted a particular focus requiring a more articulated set of conclusions:
    a. **Targets # 1 and # 3.** For the target "75% of EU companies using Cloud/AI/Big Data", data were available to produce a forecast only for the use of cloud computing, where the Target seem reachable, although the data does not enable to distinguish between large companies and SMEs. Based on the 2020 baseline, European enterprises, and especially SMEs, are lagging on the use of AI and Big data and reaching the target set by the Digital Compass seems ambitious. The Digital Europe Programme allocates € 2.1 billion for AI in the next seven years, which is limited compared to Europe's global competitors.
    b. **SMEs support.** The target 'More than 90% of SMEs reach at least a basic level of digital intensity' is ambitious but could have a large impact considering that the European economy is dominated by SMEs. Overall, the importance of SMEs should have been emphasised in the Digital Compass and other policy measures. There is still a large gap of digital intensity between SMEs and large enterprises. The figures from 2019 show that the percent of large enterprises employing ICT specialists (76%) is more than 5 times higher the ratio of SMEs employing ICT specialists (14%). In addition, only 20% of enterprises provided training in digital skills to personnel, 68% of which were large enterprises and only 15% SMEs. Similarly, the use of cloud computing is close to 40% among large

companies, and below 15% for SMEs. Finally, SMEs are more exposed to the risk of additional administrative burden and compliance costs once some of the ongoing legislative proposal will be adopted (i.e., the AI Act, and the DPP).

c. **Unicorns (Target # 2).** Without new funding mechanisms and governance, the target of doubling European unicorns (from 107 to 214) will be difficult to reach. While there are some positive developments in some sectors (e.g., digital finance), in others, such as digital health, fragmentation of regulation and lack of a digital single market in healthcare may hamper the creation of new unicorns. Overall, this target has not been analysed in detail by the Digital Compass and a clear strategy for creating new large European digital companies is lacking. A concrete strategic analysis of Europe's strengths and weaknesses should accompany this target and make it less generic. Strategic areas should be defined and supported by the EU.

d. **Semi-conductors (Target #2 under digital infrastructure).** The target "Double EU share in global production of semiconductors" is both unrealistic and not strategically focussed. There is not enough data available to form accurate quantitative projections for the semiconductor target, but it appears ambitious considering the gaps in funding (discussed in the qualitative assessment) and the current minor role that Europe plays as compared to China and the US. Currently, Europe has about 10% of the world's market share. The analysis of the value chain, however, shows that this market is very complex and there are no global independent players. Europe still has some strong assets in design, machinery chip production, and with integrated players working for the automotive industry, which is one of the industrial strengths of the continent. Therefore, it is more important to strategically decide where to concentrate efforts rather than generically defining a 20% of production target. It is also important not to look only at incumbent but also find ways to support innovative companies to become unicorns. In this context, the recently announced European Chips Act will have to better define the strategic goals under this target. For instance, the focus on a Semiconductor Research Strategy is a positive starting point, as it recognises the main European strength in this sector.

e. **Edge computing.** The cloud computing market is dominated by hyperscalers and it is beyond Europe's reach to reverse the situation. Edge computing, on the contrary, is an open market with no incumbents, where Europe may play an important role and avoid dependencies on third countries. The Gaia-X initiative is a positive example of how the EU digital sovereignty will be at least substantiated by an EU 'digital jurisdiction' provided by Gaia-X servers, as the cloud services of the system will be required to comply with European regulation. However, there are concerns about the execution of the initiative, as there is a common interest, but a common final goal is not clearly defined. As with other Public Procurement of Innovative Solutions initiatives that have a positive overall impact on an industry knowledge, Gaia-X also risks to miss the opportunity to facilitate the creation of European unicorns.

f. **High-performance computing.** The recently adopted regulation on establishing the European High Performance Computing Joint Undertaking (EuroHPC) allocated a large budget of €7 billion for the 2021-2027 period devoted to the development of high-performing computers. It will strengthen the already strong European research excellence in this domain and will probably help the emergence of world level new research centre.

It must be noted, however, that these centres will remain upstream in the R&D value chain and without further downstream investments, there is a risk of missing the opportunity to create competitive large companies in this sector.

4. **On digital government**. The first target '100% online provision of key public services available' is conceptually flawed. What matters is not how many services are available online, but rather the extent to which these are used by citizens and businesses. It would also be important to measure to what extent the online public services are for complying with obligations (filing taxes) or rather are elective services enabling citizens and businesses to go about their lives and economic activities. In addition, a target that was discussed years ago but seems now forgotten is how much administrative burden is reduced for citizens and businesses by online public services. Finally, this target may push public agencies that want to receive quick institutional recognition to simply move online their services in silos fashion. In this way, urgency may force them to purchase services by third country's large tech companies, going against the overall European strategic objective of becoming less dependent. An additional element to consider in this regard is the need to consider the public sector not only as a provider of services, rather as an enabler for facilitating the adoption and use of technologies, especially trough public procurement of emerging technologies, such as AI. In this respect, the upcoming Adopt AI Programme of the European Commission, which is a new programme to reinforce the uptake of AI in the public sector is welcome. Moreover, it does not seem clear how the targets proposed are connected to the initiatives foreseen in the Digital Europe Programme to accelerate the deployment and best use of technologies in areas of public interest. For instance, the successful implementation of the Digital Transformation Platform ecosystem supporting the interoperability of Data and services and the Interoperability incubator for testing and piloting GovTech services, as well as the cross-border implementation of the once-only principle would be crucial for effective innovation of the European public sector and thus evaluation of their impact in relation to the overall programme of actions should be guaranteed. Finally, the other two targets included in the Digital Compass ('80% of citizens use digital ID solution'; '100% of European citizens have access to EHR'), if achieved, would greatly contribute to improve the functioning of the public administration and of healthcare systems, as well as to increase the welfare of citizens and efficiency for businesses. There were no data available to produce a quantitative forecast, but it seems that both targets may be reached by 2030.

5.3. Recommendations

As anticipated in the introduction, on 15th September 2021, European Commission's President Ursula von der Leyen, addressed the EP with the State of the Union speech. In her words, "*Our Union will be stronger if it is more like our next generation: reflective, determined and caring. Grounded in values and bold in action. This spirit will be more important than ever over the next twelve months.*" This statement summarises the set of ambitious actions proposed in the Letter of Intent sent to David Sassoli, the President of the EP, and Prime Minister Janez Janša, as the Presidency of the Council of the EU. In this letter, the President of the European Commission details the actions the Commission intends to take in the following year by means of legislation and other initiatives.

With specific regard to the priority of "A Europe fit for the digital age", the following initiatives are proposed:

1. European Cyber Resilience Act;
2. European Chips Act;
3. Roadmap on security and defence technologies;
4. Legislative proposal on building an EU space-based global secure communication system;
5. Review of competition policy: – fit for new challenges;
6. Proposal for a Council Recommendation on improving the provision of digital skills;
7. Legislative proposal on a Single Market Emergency Instrument; and
8. Legislative proposal on multimodal digital mobility services.

While here we cannot enter an analysis of this set of proposed initiatives without having access to the details, nonetheless, we will briefly comment on them, in view of the analysis conducted so far, and then present five key recommendations.

The intention to reinforce cybersecurity and space defence aspects of the European 'Digital Sphere' [points (A) and (D) in the list above] are important horizontal pre-emptive and instrumental measures that, however, do not ensure by themselves the power and capacity needed to be an autonomous digital global player. On the other hand, the roadmap on security and defence technologies [point (C), in the list above] could open new opportunities for European industry, if it is reinforced with a clear plan and supported by a strategic value chain analysis. The announced European Chips Act [point (B), in the list above] will probably aim at supporting the Digital Compass target of doubling Europe's share of chips production by 2030. Here, we can only repeat what we discussed at length in various parts of chapters 2, 3 and the conclusions. Strategic choices are needed rather than generically pursuing the 20% target. The review of competition policy [point (E), in the list above] should try to combine the objective of protecting citizen/consumers with that of supporting European industry and especially SMEs. It should avoid introducing new requirements that the foreign tech giants have the capacity to cope with creating instead more barriers for European innovators. The announced proposal for the provision of digital skills is obviously good news [point (F), in the list above], if funding instruments and governance mechanisms ensure that innovation in formal education and professional training (including on the job) respond to market demands, keep in consideration the issue of emerging inequalities and risk of job losses, and have a common European inspiration. Lastly, the intention of the EC is to accelerate and facilitate the launch of multi-country projects [point (G), in the list above] to reach the targets set in Digital Compass. The projects should aim to fill existing gaps and remove or attenuate existing dependencies. And, obviously, orchestration and governance should be efficient but also transparent while pursuing a European wide inspiration.

While the details of the proposed actions included in the Digital Policy programme, as well as the operationalisation of the Digital Europe Programme are not completely defined, below we present six general recommendations.

1. **Inter-institutional working group on strategic value chain analysis and foresight.** Set up, under the vice-Presidency for Inter-Institutional and Foresight, a working group with representatives from the ITRE Committee, DG Grow, and DG Connect to elaborate a strategic value chain analysis of the strength and weaknesses of European industry, selecting the strategic control points where to focus investments and the gaps that cannot be filled and should be monitored as risks and mitigated also through digital diplomacy (see recommendation 5). The areas to focus on should be semi-conductors, edge computing, batteries, and high-performing computing. The working group should also set principles,

standard, and guidelines to be followed in the launching and implementation of multi-country projects, with the goal of helping unicorns emerge from them;

2. **Test SME decrease of administrative burden.** Ongoing proposed legislative acts and future initiatives should include a more stringent SME test to avoid increasing administrative burden and compliance costs. The review should also assess the extent to which requirements hamper true European innovators rather than effectively taming foreign tech giants;

3. **Funding for SMEs and scaling up.** While many instruments are in place, new funds and easier funding mechanisms should be targeted to a) help SMEs fill the gap evidenced in the level of digitisation; and b) help innovative SMEs to scale up and become unicorns. Gaps and difficulties in accessing the funds are the main challenges identified, ultimately slowing down innovation in the continent. Funding to KETs, including AI and high performing computing, should be expanded, and better focussed on SMEs and potential scale-up needs. It is key that the Commission coordinates in a more efficient manner with Member States to support through guidance and tools the access to AI financing by SMEs, start-ups, potential scale-ups, and corporate business. Substantial work is to be done and requires the engagement of a comprehensive range of stakeholders, including SMEs and start-ups, as well as public sector organisations, and industry on robotics, AI and other computing and digital network technologies. The EU is already a key powerhouse in research. However, there is room for improving the interaction between the research activities and the European industry. Both the digital technical infrastructure such as connectivity, high-performance computing systems and testing environments, as well as the data infrastructure within Europe, need to be further strengthened to compete at global level;

4. **Digital skills.** As far as skills and competence gaps, it would be crucial to emphasise the need for training digital functional specialists, including in the public sector, that can, at the same time, understand the technology issues, but also support in the management of details at techno-policy level. While the EU has in fact a strong community of research on AI, it is not evenly distributed throughout all the EU regions. More work is therefore needed to bring talents to all regions of the EU and make sure that a virtuous cycle can be established, facilitating the transfer of knowledge between research and practice, identifying specific actions that should be developed for creating the enabling conditions and bridge the gaps with policy makers. There is a need for technical expertise to be built up with the European Standards Organisations to test how to develop and apply AI standards. To address the digital skills gap, there is a need to develop new specialised education programmes or modules in cutting-edge digital technologies;

5. **Better digital government and healthcare.** Public and healthcare online services must reduce the administrative burden for both businesses and citizens and provide better life chances for everyone. Cooperation and efforts between the Commission and Member States should make European wide eID and access to EHRs a reality. Efforts in this area and on other domains related to data should lead to the creation of a 'Single Digital Gateway'. This is a pre-condition to improve the life of citizens, to make our firms more efficient and more generally for leading the Digital Decade. There is a need for one single point of access to information, administrative procedures, and an assistance to services for citizens and businesses to move across EU borders; and

6. **Inter-institutional working group on digital diplomacy.** Set up a working group including ITRE Committee and relevant European Commission's services, including the European External Action Services (EEAS) and the Service for Foreign Policy Instruments (FPI), as well as DG INTPA, DG NEAR, and DG Connect, to develop a joint Action Plan on Digital Diplomacy. The international dimension of digital policy, regulations, and investments is assuming a key role both to export the European model and to pragmatically cultivate those alliances needed for the gaps and dependencies that Europe cannot cover alone, but that jointly can be addressed successfully, to make the world a better place for the future generations in Europe and across the globe.

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LIST OF INTERVIEWEES

Five stakeholders were consulted via semi-structured interviews for this analysis. No direct quotes from the stakeholders were included in the report and instead the insights from the interviews were integrated to further reinforce and enrich the study.

	Stakeholder & Profile	Date Interviewed
1	**Cecilia Bonefeld-Dahl** is Director-General of DIGITALEUROPE and is a member of the board of Directors of Gaia-X, of the European Commission's Industrial Forum, and of the B20 Digital Transformation Taskforce.	28/07/2021
2	**Paul Timmers** is currently a Research Associate Oxford University, Adjunct Professor European University Cyprus, Visiting Professor Rijeka Univ, Board Digital Enlightenment, Supervisory Board eGovernance Academy Estonia.	17/07/2021
3	**Klaus Beetz** is the CEO of EIT manufacturing.	10/09/2021
4	**Willem Jonker** is the CEO of EIT digital.	14/09/2021
5	**Marijn Janssen** is a professor in ICT & Governance at the Technology, Policy and Management Faculty of Delft University of Technology.	15/09/2021
6	**Gabriela Viale Pereira**, Assistant Professor at the Centre for E-Governance at Danube University Krems	21/09/2021

This study on “Europe's digital decade and autonomy” aims to deliver an independent expert opinion and an assessment of the 2030 targets set by the Digital Compass and the overall Commission’s Digital Strategy.

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